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Innovation for inclusive development and transformation in South Africa

EDITED BY
Charles Hongoro, Cyril Adonis & Konosoang Sobane

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Innovation for inclusive development and transformation in South Africa

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Peer review declaration

The publisher (AOSIS) endorses the South African 'National Scholarly Book Publishers Forum Best Practice for Peer Review of Scholarly Books'. The manuscript underwent an evaluation to compare the level of originality with other published works and was subjected to rigorous two-step peer review before publication, with the identities of the reviewers not revealed to the editor(s) or author(s). The reviewers were independent of the publisher, editor(s) and author(s). The publisher shared feedback on the similarity report and the reviewers' inputs with the manuscript's editor(s) or author(s) to improve the manuscript. Where the reviewers recommended revision and improvements the editor(s) or author(s) responded adequately to such recommendations. The reviewers commented positively on the scholarly merits of the manuscript and recommended that the book be published.

Research justification

Science, technology and innovation (STI) are generally accepted as major drivers of growth and can help address poverty and directly improve the well-being of different groups in society. However, many countries are facing the challenge of attaining economic growth that is socially inclusive and equitable. Under certain circumstances, STI can reinforce social exclusion and inequalities. This book explores discourses around directionality and the need or importance of innovation for inclusive development (IID) in order to address policy questions that explore the relationship between IID with inequalities in income and opportunities. Nevertheless, IID as a concept is itself fraught with contestations around its conceptualisations, as well as how it is constructed and framed. Therefore, the book seeks to unpack the concept of IID and what it means in a country such as South Africa – a country characterised by endemic poverty, deepening inequality and high levels of unemployment.

We declare that the material in this book is largely original and is based on a critique of existing literature to expose specific issues or bolster specific arguments about the role of IID in equitable and inclusive development.

The book contributes to the understanding of IID and its application in low- and middle-income countries, and it uses a specific example to demonstrate technical and contextual factors that affect its impact. Most studies on IID have been done in developed countries, and the intention of this book is to fill this knowledge gap and raise an understanding of the enablers and constraints of its application.

This book is based on a series of chapters that are authored based on a systematic review of relevant literature, empirical work on local innovations and a series of policy dialogues on IID, which the Human Sciences Research Council (HSRC) conducted in the last 10 years.

Our work is not based on reworking of a specific PhD manuscript but based on various bodies of work on IID.

All chapters are run through iThenticate, and we have tried as much as possible to ensure that the chapters are properly referenced and that overlap is at acceptable levels.

This book has been written by various scholars who understand the various notions of IID and how it can possibly be applied and the relevance of such knowledge for policy, programmes and practice. The book's target audience is academics and specialists in the field of various notions of IID.

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Contents

Abbreviations and acronyms, figures and tables appearing in the text and notes xiii
List of abbreviations and acronyms xiii
List of figures xvi
List of tables xvi
Notes on contributors xix

Chapter 1: Addressing economic, social and environmental challenges in South Africa 1
Cyril Adonis, Konosoang Sobane & Charles Hongoro
Innovation for inclusive development: Addressing the triple challenge of inequality, poverty and unemployment 2
Rationale for the book 3
Innovation and the global development agenda 5
Global perspectives on innovation and inclusive development 6
What do we mean by innovation? 7
Inclusive development 11
Innovation for inclusive development 12
Purpose of the book 12
Conclusion 13

Chapter 2: Innovation for inclusive development and economics: Interpretations and policy implications 15
Mario Scerri
Introduction 15
Innovation for inclusive development and economic theory 17
The scope of exclusion 20
The national system of innovation 22
Policy implications for South Africa 25
Conclusion 30

Chapter 3: Gender dimensions of science, technology and innovation in Africa: Legal and policy barriers to inclusive innovation 31
Patricia Kameri-Mbote & Nkatha Kabira
Introduction 31

Female exclusion from science, technology and innovation as a creature of gendered science 33
The man of law 33
Gendered science 35
Defining science 35
Inclusive innovation 36
Exclusions in science 36
Legislative framework on science, technology and innovation internationally, regionally and locally 37
International 38
The patent cooperation treaty 38
Agreement on trade-related aspects of intellectual property rights 38
Swakopmund protocol on the protection of traditional knowledge and expressions of folklore – 2010 38
Malta declaration on networking the commonwealth for development 39
Regional 39
Inter-African convention establishing an African technical cooperation programme of 1975 39
Local 40
The Kenyan Science, Technology and Innovation Act 28 of 2013 40
The Kenyan Industrial Property Act 3 of 2001 40
The Kenyan Copyright Act 12 of 2001 40
Policy framework on science, technology and innovation in Africa 41
Policies supporting science, technology and innovation in Africa, internationally and in Kenya 41
African Science, Technology and Innovation Policy Initiative (ASTIPI) of 2007 41
Consolidated Science and Technology Plan of Action (2005) 41
Science, Technology and Innovation Strategy for Africa (2024–2014) 42
The East African regional science, technology and innovation policy 42
Barriers and enablers to innovation 43
Barriers to innovation 43
Inadequate resources/capacity 43
Political factors 44
Socio-cultural factors 44
Lack of incentives or reward systems 44
Fear: Belief that innovation is inherently risky 44

Lack of creative thinking training 45
Inadequate understanding of existing challenges 45
Enablers of innovation 45
Increased research and knowledge management 45
Incubation hubs 46
Formulation of science, technology and innovation policies and plans 46
Increased innovative infrastructure 46
Socio-political and cultural factors 46
Conclusion 47

Chapter 4: Engendering innovation for female empowerment in post-apartheid South Africa 49

Sithembiso L. Myeni & Aubrey Mpungose

Introduction 49
Gender and development 50
Innovation, inclusive development and gender 53
A note on the methodology 54
Gender inequalities in South Africa: Evidence from recent data 55
The status of innovation in South Africa and the role of females 58
White Paper on Science and Technology of 1996 59
To what extent do South African innovation systems and policies target and include females? 61
Mainstreaming gender in the national systems of innovation: The potential role of transformative innovation policy 62
Conclusion 64

Chapter 5: A transdisciplinarity approach to citizen science and grassroots innovation 67

Hester du Plessis

Introduction 67
Background to citizen science and grassroots innovation 68
Innovation per definition 70
The transdisciplinary approach 71
Citizen science 74
Grassroots innovation 78
Science literacy as pre-condition for grassroots innovation 80
Technology in support of actions involving citizen science and grassroots innovations 81
Conclusion 83

Chapter 6: Innovation and the public service: Facilitating inclusive industrial and social development **85**

Paul Plantinga

Introduction 85
South African case study 87
Mapping organisational diversity 88
Changing legitimacy and routines 89
Inclusive development as priority 91
South African policy and programmes 93
Universities and research councils 93
Innovation agencies and hubs 96
Innovation funders 98
Regulatory and oversight entities 100
Discussion 103
Conclusion 108

Chapter 7: The value of developing inclusive innovations for disaster risk communication and management in developing countries **111**

Wilfred Lunga & Konosoang Sobane

Introduction 112
Disaster risk reduction and disaster risk communication conceptualisation 112
Disaster risk communication 114
Examples of inclusive disaster risk reduction innovations 115
Practical guidelines on designing inclusive disaster risk communication 118
Conclusion 123

Chapter 8: Potable water and improved sanitation in South Africa: Extending access by innovation for inclusive development **125**

Stephen Rule

Introduction 125
Global limitations in access to potable water and improved sanitation 126
Global efforts to increase access to water and sanitation 128
Innovation for inclusive development and water provision in South Africa 130
Innovation for inclusive development and sanitation in South Africa 133
Discussion 135
Conclusion 136

Chapter 9: Towards an inclusive measurement programme for innovation in the informal sector of South Africa **137**

Nazeem Mustapha, Glenda Kruss, Il-haam Petersen, Oluseye Jegede & Nicole van Rheede

Introduction 138
History of innovation measurement 139
A focus based on a 'linear model of innovation' 139
History of measurement of innovation in South Africa 140
What constitutes a measurement programme for the informal sector? 141
Scope 141
Phenomena of interest 141
Measurement strategies 142
Towards a measurement programme inclusive of the needs of the informal sector 142
Reconsidering *what* we measure 142
Adapting the *Oslo Manual* guidelines, as a starting point 143
Adapting a local innovation and production systems approach to the South African informal sector context 144
Informal production unit 145
Sources of information for innovation 147
Channels of diffusion of innovation 147
National, provincial and municipal industrial policies 147
Basic infrastructure for production 148
Social and economic factors 148
Political and legal factors 148
Formal and informal support organisations 149
Formal and informal financing organisations 150
Formal and informal training and learning organisations 150
Innovation intermediaries 151
Reconsidering *how* we measure 151
A phased strategy to measuring innovation in the informal sector at a national level 151
A mixed methods local innovation and production systems methodology 152
Measuring innovation without a suitable sampling frame 154
A more suitable classification of economic activities in the informal sector 154
Exploring the understanding of innovation 156
The importance of qualitative methods 156
The importance of cognitive testing 157

Using the measurement of innovation in the informal sector at a local level as a development tool 157
Reconsidering who we include in the measurement programme 158
Conclusion 159

References 163
Index 187

Abbreviations and acronyms, figures and tables appearing in the text and notes

List of abbreviations and acronyms

AAAS	American Association for the Advancement of Science
ADB	Asian Development Bank
AI	artificial intelligence
AJIC	*African Journal of Information and Communication*
AU	African Union
BA	Bachelor of Arts degree; bachelor's degree
B-BBEE	*Broad-Based Black Economic Empowerment Amendment Act 53 of 2013*
BMGF	Bill and Melinda Gates Foundation
BOP	base of the economic pyramid
BRICS	Brazil, Russia, India, China and South Africa
CANRAD	Centre for the Advancement of Non-Racialism and Democracy
CC	Competition Commission
CDIP	Committee on Development and Intellectual Property
CeSTII	Centre for Science, Technology and Innovation
CIPC	Companies and Intellectual Property Commission
CIS	Community Innovation Survey
CSA	Citizen Science Alliance
CSD	Central Supplier Database
CSIR	Council for Scientific and Industrial Research
CSOs	civil-society organisations
DCMD	direct contact membrane desalination
DPE	Department of Public Enterprise
DRR	disaster risk reduction
DSI	Department of Science and Innovation
DST	Department of Science and Technology
DTIC	Department of Trade, Industry and Competition
DUI	Doing, Using and Interacting
EC	European Commission
ERD	Economics and Research Department

GDP	gross domestic profit
GEAR	Growth, Employment and Redistribution
GHS	General Household Survey
HBN	Honey Bee Network
HLS	Harvard Law School
Hons	honours degree
HR	human resources
HSRC	Human Sciences Research Council
ICT	information and communication technology
IDC	Industrial Development Corporation
IDRC	International Development Research Centre
IERI	Institute for Economic Research on Innovation
IFC	International Finance Corporation
IID	innovation for inclusive development
IK	indigenous knowledge
IP	intellectual property
IPR	intellectual property rights
IPR	*Intellectual Property Rights from Publicly Financed Research and Development Act 51 of 2008*
IPS	innovation, policy and science
IR	Information Regulator
IRM	independent reporting mechanism
IT	information technology
LFS	Labour Force Survey
LICS	learning, innovation, and competence building system
LIPC	local innovation and production classification
LIPS	local innovation and production systems
LLB	Bachelor of Laws degree
LLM	Master of Laws degree
MA	Master of Arts degree; master's degree
MDG	millennium development goals
MPN	most probable number
MSME	micro, small and medium enterprises
NDP	National Development Plan
NEDLAC	National Economic Development and Labour Council
NEPAD	New Partnership for Africa's Development
NGO	non-governmental organisation
NICIS	National Integrated Cyberinfrastructure System
NRF	National Research Foundation

NSI	National System of Innovation
OECD	Organisation for Economic Co-operation and Development
PARI	Public Affairs Research Institute
PFMA	*Public Finance Management Act 1 of 1999*
PhD	Doctor of Philosophy degree; doctoral degree
PoPIA	*Protection of Personal Information Act 4 of 2013*
PRG	Pollution Research Group
PSI	public sector innovation
QLFS	Quarterly Labour Force Survey
R&D	research and development
RADLA	Research and Doctoral Leadership Academy
RDP	Reconstruction of Development Programme
RRI	responsible research and innovation
RSA	Republic of South Africa
RTI	Research Triangle Institute International
S&T	science and technology
SAHRC	South African Human Rights Council
SANReN	South African National Research Network
SAP	structural adjustment packages
SARS	South African Revenue Service
SASQAF	*South African Statistical Quality Assessment Framework of 2008*
SDG	sustainable development goal
SDGs	sustainable development goals
SEDA	Small Enterprise Development Agency
SESE	Survey of Employers and the Self-Employed
SIC	standard industrial classification
SIDA	Swedish International Development Cooperation
SME	small and medium-sized enterprise
SNA	System of National Accounts
SNS	social network service/system
SODIS	solar water disinfection
SOE	state-owned enterprises
SPII	support programme for industrial innovation
StatsSA	Statistics South Africa
STEPS	Social, Technological and Environmental Pathways to Sustainability
STI	science, technology and innovation
TADF	Technology Acquisition and Deployment Fund
TIA	Technology Innovation Agency

TIH	The Innovation Hub
TIP	transformative innovation policy
TTO	technology transfer offices
TVET	technical and vocational educational training
UCT	University of Cape Town
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNISDR	United Nations Inter-Agency Secretariat of the International Strategy for Disaster Reduction
US	United States
USA	United States of America
UV	ultraviolet
VIP	ventilated improved pit
VoIP	voice over internet protocol
WIPO	World Intellectual Property Organization
WRC	Water Research Commission
WRI	World Resources Institute
YTIP	Youth Technology Innovation Programme
ZAR	South African rand

List of figures

Figure 2.1:	Disciplinary foundations for inclusive innovation research studies.	19
Figure 2.2:	The layers of human capabilities provision.	28
Figure 4.1:	Average household income per capita by gender and race of the household head.	56
Figure 4.2:	Unemployment by race and gender.	58
Figure 8.1:	Mr Blessing Mncube of VulAmanz demonstrating the use of the water filtration device.	131
Figure 9.1:	Local innovation and production system framework adapted for the informal sector.	146
Figure 9.2:	Measurement strategy for innovation in the informal sector.	153
Figure 9.3:	Process for conducting a census of businesses in a local area.	154

List of tables

Table 2.1:	The shadow economies of Africa (as % of GDP in 2007).	25
Table 4.1:	Evolution of gender and development approaches.	52
Table 4.2:	Household poverty estimates by race and gender of the head of the household (breadwinner).	57
Table 4.3:	Goals of the *White Paper on Science, Technology and Innovation of 1996*.	60
Table 6.1:	Case study examples mapped to routines, legitimacy and capacity, with inclusion actions.	104
Table 6–A1:	Taxonomy of organisations and routines.	109
Table 8.1:	Sources of drinking water in South Africa, 2016.	127
Table 8.2:	Types of sanitation facilities used in South Africa, 2016.	128
Table 8.3:	POU microbiological results.	132
Table 9.1:	Some notable deviations from the *Oslo Manual*.	144
Table 9.2:	Alternative industry classification based on the local innovation and production systems framework.	156

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Chapter 1

Addressing economic, social and environmental challenges in South Africa

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Innovation for inclusive development: Addressing the triple challenge of inequality, poverty and unemployment

In 2010, the World Bank estimated that 4.3 billion people (62% of the world's population) were living on less than US$5 per day. National household survey data from 110 countries reveal that these people who are said to constitute the base of the economic pyramid (BOP) made up 72% of the 5 575 million people recorded by the surveys and that an overwhelming majority of the population in Africa, Asia, Eastern Europe, Latin America and the Caribbean are home to nearly all the BOP (Hammond et al. 2007). According to the Organisation for Economic Co-operation and Development (OECD), exclusion and relative poverty are also challenges for advanced economies and obstacles to growth opportunities for all economies. It further notes that income inequalities have risen to unprecedented levels in many OECD countries recording their highest level for the past half-century. In OECD countries, the average income of the richest 10% of the population is about nine times that of the poorest 10%, up from seven × 25 years ago (OECD 2021). For this reason, policy-makers globally are confronted with the challenge of fostering economic growth while ensuring that the gains remain socially inclusive.

It is generally accepted that science, technology and innovation (STI) are major drivers of growth and can help address poverty and directly improve the well-being of different groups in society (OECD 2012). While the gains from STI benefit everyone under certain conditions, the OECD (2015) acknowledged that these gains might unfortunately reinforce social exclusion in other cases. It is for this reason that the relations between innovation and inequalities in income and opportunities raise some important policy questions and have led to the emergence of what is referred to, among others, as IID (OECD 2015).

It is also worth noting that the 2030 Agenda, unanimously adopted at the United Nations (UN) Sustainable Development Summit in September 2015, positioned STI as the key means of implementation of the UN's sustainable development goals (SDGs). Furthermore, on the African continent, the 23rd Ordinary Session of African Union (AU) Heads of State and Government Summit adopted a 10-year Science, Technology and Innovation Strategy for Africa (STISA-2024) in June 2014. In his foreword to the STISA-2024 document, Dr Martial De-Paul Ikounga, Commissioner for Human Resources, Science and Technology AU Commission, notes that (AU 2014):

> The strategy is part of the long-term people-centred AU Agenda 2063, which is underpinned by science, technology and innovation as multi-function tools and enablers for achieving continental development goals. The Agenda calls for the diversification of sources of growth and sustenance of Africa's current economic performance, and in the long run, lifting large sections of our population out of poverty The strategy, further fosters social transformation and economic

> competitiveness, through human capital development, innovation, value addition, industrialisation and entrepreneurship. (p. 8)

South Africa, which, if one would argue, is by most accounts the most unequal country in the world, is on the brink of the cutting edge of innovation policy and has prioritised the development of a coherent, comprehensive cross-government national strategy for IID. Kruss et al. (2017) note that while the country has, since the advent of democracy, created a complex development policy framework that has straddled multiple national government departments, the responsibility for innovation policy has been vested with the Department of Science and Innovation (DSI), which is strategically re-orientating its STI policy around the objectives of IID. Accordingly, the DSI defines IID as (Department of Science and Technology [DST] 2016, cited in Kruss et al. 2017):

> [/]nnovation that addresses the triple challenge of inequality, poverty and unemployment and enables all sectors of society, particularly the marginalised poor, informal sector actors and indigenous knowledge holders to participate in creating and actualising innovation opportunities as well as equitably sharing in the benefits of development. (p. 2)

To this end, the newly proposed *White Paper on Science, Technology and Innovation of 2019* on STI sets out the long-term policy direction for South Africa to use STI to accelerate inclusive economic growth, make the economy more competitive and improve people's daily lives (DST 2019). It aims to help South Africa benefit from global developments such as rapid technological advancement and geopolitical and demographic shifts, as well as respond to the threats associated with some of these global trends. Therefore, STI is critical to the realisation of South Africa's development goals as set out in the National Development Plan (NDP), which aims to eliminate poverty and reduce inequality by 2030. To achieve these aims, the NDP also entrenches the importance of a capable developmental state for the country's social and economic development (United Nations Development Programme [UNDP] 2020).

In addition to this, DST is leading efforts to develop an STI for SDG Action Plan. It is envisaged that STI and the National System of Innovation (NSI) could support the SDGs by generating and packaging data, generating knowledge and analysis for policy, planning and delivery, assisting with the development and localisation of technological solutions and accommodating the demonstration, testing and diffusion of technological solutions. The notion of inclusivity is especially prominent in SDGs 4, 8, 9, 11 and 16.

Rationale for the book

The intersection between innovation and inclusive development, together with the different conceptualisations of the concept of IID, is attracting the

interest of an increasing number of scholars and policy-makers. The interest is illuminated among stakeholders who are focused on building innovation systems by strengthening the institutional and infrastructural environments considered necessary to make innovation flourish. In South Africa, in particular, successive post-apartheid governments have made advances towards enhancing innovation capacity as key to the realisation of its developmental agenda and to deal with the structural legacies of historical injustices. Within this context, the adoption of an inclusive approach to development has become key and has resulted in deliberate efforts by entities such as the DSI to pursue socio-economic development in South Africa through innovation that is intended to achieve inclusive development. An example is the Socio-Economic Innovation Partnerships Programme, which emphasises the promotion of sustainable human settlements through the development and deployment of STI.

While the concept of IID has become increasingly prominent in academic, research and innovation policy circles, it is fraught with contestations around its conceptualisations, as well as how it is constructed and framed. It is, therefore, imperative to unpack the concept of IID, and what it means in a country such as South Africa, which is characterised by endemic poverty, deepening inequality and high levels of unemployment.

At an international level, there are several books and research reports on IID by OECD, World Bank, International Development Research Centre (IDRC) (Canada), Swedish International Development Cooperation (SIDA) (Sweden), Danida (Denmark) and Norida (Norway); international scholarly networks such as Globelics; and other institutions with a global footprint. These mostly deal with different aspects of innovation policies such as innovation and sustainable development, innovation and agriculture, innovation and inclusive development, and innovation and entrepreneurship. These publications demonstrate the gap in the market for a South African book that unpacks the notion of innovation for the purpose of achieving inclusive development. While there may be common areas between South Africa and other countries' IID enablers and constrainers, there are certainly South African-specific IID enablers and constrainers. This is as a result of South Africa's context, policies, support, infrastructure, markets and political will. There is thus a marked gap in the market for a book on IID in South Africa. The multi-pronged South African perspective of the book offers a critical analysis of IID in South Africa that will enhance the understanding of this phenomenon with respect to theory and practice. This book will provide a fact-based understanding of IID, as well as its opportunities and challenges. The critical analysis of some IID policies and initiatives will demonstrate what makes IID fail/succeed, the impact thereof and how the challenges are addressed or successes sustained. This information will be of great value to policy-makers/decision-makers,

innovation practitioners, researchers, government officials and postgraduate students in the field of innovation.

Innovation and the global development agenda

The 2030 Agenda for Sustainable Development that the UN member states adopted in 2015 is currently at the forefront of global development and provides a road map for the attainment of peace and prosperity for people and the planet, now and into the future. It was the culmination of decades of work to foster a global partnership aimed at eradicating poverty and other deprivations, reducing inequality and stimulating economic growth while also addressing the challenges of climate change and preserving our oceans and forests. The 2030 Agenda was preceded by the adoption of the Millennium Declaration at the UN headquarters in New York in 2000. At its core were eight measurable millennium development goals (MDGs) that aimed, among others, to reduce extreme poverty and hunger, promote gender equality and reduce child mortality by 2015. While significant progress had been made towards achieving the MDGs, this had been uneven (Sustainable Development Goals Fund n.d.). By 2010, an estimated 15.5% of the world population suffered from hunger, and it was concluded that many countries, particularly on the African continent, were unlikely to meet the targeted two-thirds reduction in child mortality by 2015 (Overseas Development Institute 2010). At the same time, the reduction in maternal mortality had been slow and mortality remained alarmingly high (WHO 2019).

As the expiration of the Millennium Declaration and its MDGs was approaching, discussions and consultations on a post-2015 global development agenda ensued. This culminated in the adoption of the 2030 Agenda for Sustainable Development, which consists of seventeen ambitious, yet attainable and interdependent, SDGs cutting across issues such as gender equality, education, culture and health care. These are to be achieved by 2030 without compromising the ability of future generations to meet their own needs. Both inclusion and innovation feature prominently on the 2030 Agenda. The former is mentioned 46 times and the latter is mentioned 26 times in the official 2030 Agenda document entitled, *Transforming Our World: The 2030 Agenda for Sustainable Development* (UN n.d.). According to Van Gent (2017), the emphasis on inclusion, in particular, is reflected in SDGs 8, 10, 11 and 16. Sustainable development goal 8 is to promote sustained, inclusive and sustainable growth with employment creation; SDG 10 is to empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other statuses; SDG 11 is to make cities and human settlements inclusive, safer, resilient and sustainable; and SDG 16 aims to promote peaceful and inclusive societies, as well as inclusive institutions (Van Gent 2017).

Amid concerns over uneven progress and that the world was not on track to deliver on the SDGs by 2030, world leaders gathered at an SDG Summit in September 2019 to renew their commitment to the implementation of the 2030 Agenda. There they launched a political declaration called *A Decade of Action* and urged all stakeholders to dramatically increase the pace and scale of implementation efforts to deliver the SDGs by 2030 (High-level Political Forum on Sustainable Development 2020). This coincided with the emergence of the COVID-19 pandemic, which reversed some of the gains that had been made and added to the declaration's urgency.

Global perspectives on innovation and inclusive development

Internationally, the OECD led by its Directorate for Science, Technology and Industry has been at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population (OECD 2012). Similarly, over the last few decades, the World Bank played a pivotal role in helping countries build their innovation capacities through both lending and non-lending activities that focused on support for public and private research and development (R&D); strengthening entrepreneurial capabilities; providing financial support for early-stage start-ups and fostering linkages between actors in the innovation system (Independent Evaluation Group 2013). A prime example in this regard is *infoDev*, a World Bank Group multi-donor initiative that supports innovation and entrepreneurship by investing directly in start-ups and existing companies in developing economies through the International Finance Corporation (IFC) (Independent Evaluation Group 2013).

The realisation that research is needed to better understand how, through creativity, learning and problem-solving, people in informal settings seek to overcome adverse conditions preventing access to formal economic activities, the provision of basic public services, improved livelihoods and so on inspired the creation of a research programme on IID at the IDRC in 2011 (IDRC 2011). The programme is also intended to contribute to building new bridges between innovation studies and development studies and to support the development of new frameworks, methodologies and metrics for studying innovation, particularly in informal settings (Santiago 2014).

The IID also enjoys a strong presence in the Nordic region through official development cooperation agencies of the various governments. For example, the SIDA focuses on providing support for research and innovation systems. Through its research cooperation, it partners with universities and research institutions, which are shown to have a crucial role in the emerging innovation systems in low-income settings and provide entry to the challenges regarding

innovation (SIDA 2015). Its Danish counterpart, the Danish International Development Agency (Danida), is responsible for implementing Denmark's policy on development cooperation and humanitarian action from 2017 called *The World 2030*. One of the policy's four strategic objectives is inclusive, sustainable growth and development.

The interest in IID has also led to the establishment of networks and institutions with a global footprint. Prime among these are Globelics and the Social, Technological and Environmental Pathways to Sustainability (STEPS) Centre. The former is an international network of scholars who apply the concept of 'learning, innovation, and competence building system' (LICS) as their analytical framework and who are dedicated to the strengthening of LICS in developing countries, emerging economies and societies in transition (Johnson & Andersen 2012). The latter is hosted in the UK by the Institute of Development Studies and the Science Policy Research Unit at the University of Sussex and works as part of a Global Consortium with hubs in Africa, China, Europe, Latin America, North America and South Asia. In addition to this, in countries like India where challenges faced by rural people and communities have been unmet by innovations in the formal sector as defined by the NSI framework, IID has resulted in effective solutions to these development challenges (Nelson 1993).

The IID faces serious challenges in its attempts to make a positive impact on the global development agenda. According to George, McGahan and Prabhu (2012), these challenges are:

> [*D*]ualities as drivers of innovation because they can provide constraints in a context that either traps individuals into a negative spiral of destitution and poverty or can incentivize individuals to be creative and find novel solutions to their problems. It is these global challenges that shape, in large part, whether a particular population is likely to remain disenfranchised or not. If we assume that developing economies and the contexts in which disenfranchised individuals operate are resource-constrained, then the global challenges are part of the mechanisms that create or relax such constraints. (pp. 674–675)

While these challenges are numerous, some are more common than others. Challenges around financial capital relate to the fact that it does not provide a necessary and sufficient condition for inclusive innovation (Bradley et al. 2012). While this, as well as other challenges such as government regulation and technology know-how, can constraint innovation, George et al. (2012) remind us that they can also serve as useful triggers for innovation and form the basis for new opportunities.

What do we mean by innovation?

Innovation, which can be broadly defined as the attempt to try out new or improved products, processes or ways to do things, has become a buzzword

in the global development arena. Innovation involves the application of a new or improved product, process, service, organisational or marketing strategy that addresses a specific societal challenge or challenges (OECD 2015). According to Fagerberg, Srholec and Verspagen (2010), innovation is often regarded as an enterprise carried out by highly educated and skilled labour in R&D-intensive companies with strong ties to leading centres of excellence in the scientific world. In addition to this, Bradley et al. (2012) assert that while development and entrepreneurship often conceive of poverty as a resource allocation problem in which a lack of capital prevents the poor from increasing their income through entrepreneurship and innovation, capital alone is not a 'silver bullet' for the problem of poverty in developing economies. In response to these observations, an alternative perspective of innovation that goes beyond the high-tech first-world view outlined has gained increasing currency in recent years.

In terms of this alternative perspective, innovation is seen as an aspect of most if not all economic activities and therefore of relevance to the developing world as well (Bell & Pavitt 1993; Fagerberg et al. 2010):

> It includes not only technologically new products and processes but also improvements in areas such as logistics, distribution and marketing. Moreover, the term innovation may also be used for changes that are new to the local context, even if the contribution to the global knowledge frontier is negligible. In this, broader sense, innovation may be as relevant in the developing part of the world as elsewhere. (p. 2)

Related to this has been an emphasis on inclusion, which is underpinned by the belief that while technologically driven socio-economic development may have led to the improvement of the lives of many poor people, it has not only failed to eradicate poverty and eliminate exclusion but may have in fact exacerbated it, particularly in less developed economies. This growing concern of economic development accompanying increasing socio-economic disparities among groups in less developed economies has led to notions of 'inclusive innovation' and 'inclusive development' firmly becoming part of the development agenda. For Johnson and Anderson (2012), inclusion refers both to sharing the amelioration of material living conditions and to a broader participation in processes of change. According to Kumar et al. (2013), inclusion may take place at five levels:

- **Regions** or geographical spaces previously bypassed and the people within that region may get served by the innovation.
- **People** who were previously excluded because of ineligibility, inability to afford, and lack of awareness, capacity or appropriate skills are provided access to an extremely affordable and effective innovative solution.
- **Environmental conditions** that have adversely affected access to certain social needs can be tackled with the help of new solutions that make it possible for the needs of the community to be met.

- **Sectors** that are neglected because of low level of productivity, high cost, poor quality or a combination of various factors could be made buoyant by specific technological, cultural, institutional or educational innovations.
- **Skills** that are eroding fast because of lower demand, lower productivity, increased hazards, a combination of these or other reasons could be revived by innovations that help to overcome these challenges.

Despite its increasing presence in development discourse, agreement as to what exactly constitutes inclusive innovation is far and in between. For example, the OECD (2015) defined inclusive innovation as the 'opening-up' or 'broadening out' of innovation, innovation activities, projects, services, products and processes to serve the welfare of the poor and other marginalised groups. According to George et al. (2012), inclusive innovation encompasses the development and implementation of new ideas, which aspire to create opportunities that enhance social and economic well-being for disenfranchised members of society. It also needs to be added that there is not one approach to inclusive innovation and that a variety of inclusive innovation approaches have been and continue to be advanced in response to concerns about the uneven development consequences of mainstream approaches to promoting innovation systems (Smith 2013) and in efforts to increase access to innovation for a large segment of their population, which is outside the formal economy and formal innovation system (Cozzens 2010). These include, among others, frugal innovation, grassroots innovation and pro-poor innovation. The lack of clear differentiation between these different approaches to inclusive innovation only adds to the conceptual murkiness that accompanies the concept.

According to Paunov (2013), frugal innovation aims to improve the welfare of low- and middle-income groups, particularly in developing countries by reducing the complexity and cost of a good and its production so that the opportunities for consumption by non-affluent customers are increased. Others, like Von Zedtwitz et al. (2015), refer to this as reverse innovation. Khan (2016), on the contrary, views frugal innovation as an approach geared towards realising social sustainability (i.e. the development of programmes and processes that promote social interaction and cultural enrichment) and fulfilling the UN SDGs. According to Brem and Wolfram (2014), the necessary starting point of any frugal innovation is not a product but rather a problem that needs to be solved. This is similar to what is referred to as Jugaad innovation. According to Radjou, Prabhu and Ahuja (2013):

> Jugaad is a colloquial Hindi word that roughly translates as 'an innovative fix; an improvised solution born from ingenuity and cleverness.' Jugaad is, quite simply, a unique way of thinking and acting in response to challenges; it is the gutsy art of spotting opportunities in the most adverse circumstances and resourcefully improvising solutions using simple means. Jugaad is about doing more with less. (p. 4)

In an attempt to give conceptual clarity to frugal innovation, Weyrauch and Herstatt (2017) conducted a multi-method study involving managers from companies and researchers for research institutes. Based on the results, they concluded that frugal innovation consists of three elements, namely, substantial cost reduction, concentration on core functionalities and optimised performance level.

Another iteration of inclusive innovation is what is known as pro-poor innovation, also referred to as innovation for the bottom of the pyramid (Paunov 2013). A pro-poor innovation system can be defined as 'a multi-stakeholder social learning process that generates and puts to use new knowledge, which expands the capabilities and opportunities of the poor' (Berdegué 2005, p. 9). According to the 2008 World Development Report, particular attention should be paid to rural innovation in developing countries because it is in rural areas where most of the poor live (World Bank 2008). Based on the assumption that pro-poor rural innovation is more likely to occur through small-scale ventures and entrepreneurs rather than industrial R&D, Sonne (2010) advances the concept of pro-poor entrepreneur-based innovation to more concretely focus on innovation pertinent to economic development and poverty alleviation. She asserts that such entrepreneur-based innovative activities are essential for the continuous development of, and poverty alleviation in, rural areas, by creating employment opportunities and improved goods and services (Sonne 2010). Because rural development policies have tended to focus on small-holder agriculture and the fact that most rural poor are landless poor and therefore unlikely to benefit greatly from agriculture-based policies (Sonne 2010), it is important for the development policies to actively promote pro-poor entrepreneurship and innovation strategies, taking into account the particular characteristics of poor regions and communities (United Nations Conference on Trade and Development [UNCTAD] 2012).

Grassroots innovations are community-led solutions aimed at meeting the challenges that low-income groups face. While they may facilitate entrepreneurship in previously marginalised groups and may help them participate in circuits of economic activities, these types of innovations often struggle to scale up and spread beyond small niches (Paunov 2013). According to Cozzens and Sutz (2012), the transformative and capacity-generating potential of grassroots innovations, particularly in informal settings, revolves around the following five criteria: (1) newness, (2) adaptation, (3) interactiveness, (4) knowledge content and (5) learning, scaling-up and diffusion. Paunov (2013) highlights the fact that grassroots innovations, in many instances, do not involve technology-based innovations to goods and often extend beyond the good or service itself to include business models that allow substantial product cost reductions, as well as ways to address specific challenges such as lack of access to information on new products and

their use in lower-income markets. Mainstream innovation is often expressed as the imperative to catch up with or keep up with an apparently universal techno-economic frontier driven by universities, public R&D labs and innovation departments at companies (Smith et al. 2016). This has implications for the inclusion of lower-income groups who are likely to have little access to capital as well as the skill and formal technical education required for technology-based innovations. The allure of grassroots innovations for these groups, therefore, resides in the fact that the barriers to participation are substantially reduced because innovations are less technology driven, they do not require much formal education or technical skill and they are rather based on local or IK. It further follows that in order to maximise the potential that grassroots innovation has for inclusive development, it requires development thinking to shift towards catalysing and leveraging community knowledge and creativity, as well as the resources needed to promote grassroots innovation (Hanna 2010).

Inclusive development

According to Johnson and Anderson (2012), development was deemed to happen mainly because of economic growth, and there was no need to give any specific attention to matters of inclusion in this regard. This was the basic premise underpinning trickle-down economics, that is, growth at the top would naturally flow down to those at the bottom and was epitomised by the Washington Consensus, a set of free market economic policy prescriptions considered to constitute the 'standard' reform package promoted for developing countries by Washington DC-based institutions such as the International Monetary Fund and the World Bank. Indeed, one would have been forgiven for assuming that any discussion about inclusion within the context of development may seem superfluous as one would assume that development is naturally associated with inclusiveness. However, the linear causal link between economic growth to social inclusion broadly failed in the Global South, particularly in Latin America, where it was extensively implemented and where it was criticised for failing to reduce inequalities (George et al. 2012). More worrying is the observation that economic growth in less developed economies has gone hand in hand with growing poverty among social and ethnic groups (Johnson & Andersen 2012). As a result, inclusivity has become an explicit development policy priority in an attempt to counter the perversion of growth.

While there is no agreed-upon and common definition of inclusive development, there appeared to be consensus judging from policy statements of various countries, from discussions on development policies at international and regional forums and from studies and reports of academic and policy researchers (Ali & Zhuang 2007). According to Anderson and Johnson (2012),

inclusive development is a process of structural change that gives voice and power to the concerns and aspirations of otherwise excluded groups. The UNDP embedded inclusive development in the notion of agency and defined it as '[...] development that marginalized groups take part in and benefit from, regardless of their gender, ethnicity, age, sexual orientation, disability or poverty' (in Cozzens & Sutz 2012, p. 11).

Hickey (2013), on the contrary, emphasises the importance of going beyond a narrow understanding of development as a primarily economic process to one with an integral focus on the achievement of equity and the rights of citizenship because forms of politics that have underpinned inclusive forms of development differ in significant respects from those associated with economic growth. In conceptualising inclusive development, he further suggests a shift beyond the focus on 'poverty' and 'the poor' and argues that a discourse on poverty can make it difficult to think politically and may distract from a focus on achieving the fuller goal of social justice implied by the term 'inclusive development' (Hickey 2013).

Innovation for inclusive development

> 'Innovation for inclusive development seeks to improve living conditions and creates employment opportunities for the poor through the development of new products, services, processes and business models aimed at resource-poor communities.' (UNDP 2020, p. 11)

According to Daniels, Ustyuzhantseva and Yao (2017), IID operates by enabling the participation of marginalised people in the mainstream economy and facilitating their involvement in innovative and development activities. Kraemer-Mbula and Wamae (2010) assert that IID offers one avenue to address the growing challenges such as poverty, inequality and exclusion of large segments of the population from national socio-economic and development activities. In addition to addressing developmental challenges such as providing access to drinking water, eradicating neglected diseases or reducing hunger, many development-enhancing innovations have the potential to also address social challenges (OECD 2012). The OECD (2012) further notes that IID can facilitate the exploitation of traditional knowledge or an adapted use of modern technology that most people can afford. By so doing, IID can potentially promote grassroots entrepreneurship and help integrate previously marginalised groups into circuits of economic activities (OECD 2012).

Purpose of the book

Many economies across the globe are cognisant of the persistence of economic inequalities, characterised by the presence of relatively large segments of marginalised population groups who do not have access to innovation and are

therefore outside the formal economy and formal innovation systems (Cozzens 2010; Prahalad 2012). There is a wide acknowledgement of the value of strategic efforts to make innovation inclusive as a way of facilitating inclusive development and redressing the exclusion of large segments of the population from national socio-economic and development activities (Kraemer-Mbula & Wamae 2010; Marcelle 2014; UNCTAD 2014).

The role of STI in facilitating development has seen its expression in continental strategic plans. Africa's Agenda 2063 and the 2030 Agenda position STI as a key driver in the implementation of the SDGs. The 23rd Ordinary Session of AU Heads of State and Government Summit adopted a 10-year Science, Technology and Innovation Strategy for Africa (STISA-2024) in June 2014. The strategy is underpinned by STI as enablers for achieving continental development goals. The Agenda calls for the diversification of sources of growth and sustenance of Africa's current economic performance and, in the long run, lifting large sections of our population out of poverty. The strategy places a strong focus on social transformation and economic competitiveness, through human capital development, innovation, value addition, industrialisation and entrepreneurship.

In line with this, the DST in South Africa has been pursuing inclusive innovation for development. While there are noticeable efforts towards IID, there is a lack of conceptual clarity on the concept characterised by contestations around its conceptualisations, as well as how it is constructed and framed. It is, therefore, imperative to unpack the concept of IID and what it means in a country such as South Africa – a country characterised by endemic poverty, deepening inequality and high levels of unemployment.

This book unpacks the concept of IID and explores how it is applied in different domains that are strategic for inclusive transformation. The multi-pronged South African perspective of the book offers a critical analysis of IID in South Africa that can potentially enhance the understanding of this concept with respect to theory, policy and practice. It provides a fact-based understanding of IID as well as its opportunities and challenges. The critical analysis of some IID policies and initiatives demonstrates factors that are essential for the success or failure of IID, the impact thereof and how the challenges are addressed or successes sustained. This information is of great value to policy-makers/decision-makers, innovation practitioners, researchers, government officials and students in the field of innovation.

Conclusion

The strategic relevance of this book can be seen from both national and international perspectives. Nationally, the book seeks to fill the knowledge gap on IID in all its manifestations at the policy, programmatic and practice

levels in South Africa. While a lot has been written about innovation in general, not much has focused on innovation to transform society through the inclusion of previously disadvantaged and marginalised actors and communities in the current system of innovation. IID is essentially about innovation that facilitates the realisation of the NDP and the inclusive realisation of the seven bold priorities of the government, namely:

1. economic transformation and job creation
2. education, skills and health care
3. consolidating the social wage through reliable and quality basic services
4. spatial integration, human settlements and local government
5. social cohesion and safe communities
6. a capable, ethical and developmental state
7. a better Africa and world.

The seventh priority relates to the international perspective given the strategic role of South Africa in Africa and the world through its membership in various strategic blocks such as BRICS (Brazil, Russia, India, China and South Africa). South Africa is strategic to Africa's development not only because of its geographical location but also because of its level of development as a middle-income country that has more opportunities for innovation because of its advanced physical and social infrastructure. The book reflects on the South African experience of IID and then projects it to the rest of Africa and other low- and middle-income countries with a pragmatic realisation that the success and failure of IID heavily depend on the country's contexts. The current situation where innovation is largely from the North is unsustainable, and the COVID-19 pandemic has exposed this challenge as poorer countries are struggling to vaccinate their citizens. While most developed countries have seen marked improvements in COVID-19 vaccination coverage, by August 2021 less than 3% of Africa's population had been vaccinated because of challenges of supply and access to vaccines. Commodity security for dealing with such pandemics requires South-South cooperation, and South Africa has a continental commitment to spearhead innovation in various sectors of Africa's development.

To realise inclusive innovation and sustainable development in South Africa and Africa in general, capacity building for innovation is essential. The book seeks to contribute to the existing body of innovation knowledge that is accessible not only to policy-makers, government officials, researchers and practitioners but also to academics in various fields whose purpose is mainly to develop future innovators in schools, colleges and universities. Although the bulk of the materials for the book was drawn from the South African context and the policy dialogues conducted by the HSRC, South Africa, it remains relevant to the wider African and global context.

Chapter 2

Innovation for inclusive development and economics: Interpretations and policy implications

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Introduction

One of the more succinct definitions of innovation for inclusive development (IID) is provided by the Organisation for Economic Co-operation and Development (OECD) (2015, p. 9) as 'innovations that support the welfare and entrepreneurship opportunities of lower-income and excluded groups'. It is fundamentally a pro-poor initiative mainly aimed at adapting and developing technologies for consumption by the indigent and at stimulating the capacity for grassroots innovation by the poorer sections of the economy (OECD 2015; World Bank 2010). It is important at the very outset to examine the rationale behind the concept of inclusive development as it is open to different interpretations, and clarity on which interpretation is adopted is critical both for analysis and for policy. There are two possible bases for this rationale that, while

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related, are quite distinct and, at least implicitly, stem from radically different theoretical lenses on the economy and economic development. The first reading of the rationale for inclusive development is based on generally accepted values of social justice, in terms of an implicit premise that poverty is abhorrent and that the inclusion of those who are excluded from the formal economy is the most sustainable of all poverty alleviation strategies. The second reading is that the exclusion of portions of a country's population from its formal economy is detrimental to its growth and development prospects, and that the inclusion of the excluded is not only the objective of development planning but should also be its main instrument. The first approach is typically placed within debates on the redistribution aspect of fiscal policy whose success in alleviating poverty is often contingent on economic growth. The second approach, broadly stemming from evolutionary economics, places the human at the core of the economy and sees the upliftment of the general conditions of life as one of the key drivers of development policy.

In economics, the concepts of inclusive development and, more specifically, IID are very recent arrivals, both in economic theory and as a guide to policy. Heeks et al. (2013, 2014) trace the origin of IID as a specific discourse, around which a rapidly increasing number of academic publications and policy documents emerged, from 2007 onwards with the coining of the term by Utz and Dahlman (2007). The conceptual antecedents can, however, be traced as far back as Schumacher's (1973) work around appropriate people-centred technology. Inclusive development, within which studies on IID can be located, eventually emerged as a counter-discourse to the global hegemony of the neoliberal doctrine since the 1990s, as an attempt to incorporate human rights into economic policy and as one of the strategic paths in addressing various global ecological crises (Gupta et al. 2015). It arose as a field of development theory around the turn of the millennium in response to the endemic issues of global inequality, poverty and underdevelopment. There are numerous interpretations of inclusive development in the literature that have emerged over time (Gupta et al. 2015). The three main focus areas that run through the various interpretations are addressing inequality as exclusion, the inclusion of the excluded in the determination of national local socio-economic policy formulation and implementation, and reducing the differentials in human capabilities, *a la* Sen (1997, 1999), which are largely determinant of the life chances of human beings.

The initial argument in this chapter is that IID lies at the outskirts of mainstream economic theory and practice. This is mainly because of the peripheral position that development economics holds *vis-à-vis* mainstream economics, the short history of inclusive development within development economics and the failure to date of the systems of innovation approach to economic dynamics to challenge effectively the neoclassical/neoliberal hegemony over the discipline (Scerri 2020). This argument will be elaborated in the following section of this chapter.

There are two core aspects to the positioning of innovation of inclusive development in theory and practice. The first is that the scope of IID should be reviewed in light of the Fourth Industrial Revolution (4IR) and the accelerating rise in the numbers and categories of those who are excluded from the formal economy. The categories of the excluded have now been extended to cover an embattled proletariat and a rapidly expanding precariat class both of which are emerging within the context of the rapid obsolescence of trades and skills sets and professions, which marks the present and future of the 4IR. The second aspect is the current positioning of the system of innovation approach to economic dynamics within the context of mainstream economic theory. The argument developed in this section is that the excessive focus on the narrow version of the NSI has generally restricted the ambit of innovation studies to a sub-sector of the general economy. This focus on the narrow version further disadvantages policy-oriented studies on IID. This expanded scope of the excluded now requires that studies on IID be brought in towards the core of economic theory as an immanent component of economies around the world and that its policy implications be revisited to take into account the new variations of the categories of the excluded sections of society.

The exploration of the range of appropriate policy options, with a specific focus on South Africa, constitutes the third section of this chapter. This exploration proceeds within the framework of the broad version of the system of innovation approach and covers various levels of inclusion of communities and classes as direct recipients of innovations, as producers of innovations and as participants in the formal shaping of the NSI. This would, for example, entail a possible expansion of the helix model of science, technology and innovation (STI) policy formulation to include organised labour (Scerri 2019b).

This chapter concludes with a brief summing up of the positioning of IID studies within the mainstream of economics and the implications of that positioning for the scope of policy formulation and the effectiveness of its implementation. The prospects for the relocation of policy on IID towards the core of national economic planning are briefly explored in the conclusion.

Innovation for inclusive development and economic theory

Scerri (2020) argues that the mainstream economics consists of a paradoxical combination of neoclassical economics as the discipline and neoliberalism as the discourse. The merger of these two fundamentally incompatible bodies of theory has consistently prevailed against schools of thought such as evolutionary economics in general and the system of innovation approach to economic dynamics in particular, from effectively challenging the dominant discourse in economics. The mainstream discourse has successfully supplied

a libertarian agenda with the apparent scientific rigour of the neoclassical paradigm, a rationale that Hayek (1942, 1943, 1944), a leading intellectual of liberal economics and one of the progenitors of neoliberal economics, famously pejoratively dismissed as 'scientism'. Foucault (2004) discusses the discursive divergence between ordo-liberalism, which sees the welfare effects of the market economy as contingent on controls exercised by the state, and anarcho-liberalism that advocates the minimal state and a free rein for capital. Both of these schools of thought were still effectively contending varieties of capitalism until the 1980s, but the collapse of the Soviet Union in 1993 and the disappearance of an alternative economic order brought about the current dominance of anarcho-liberalism, nowadays more commonly called neoliberalism.

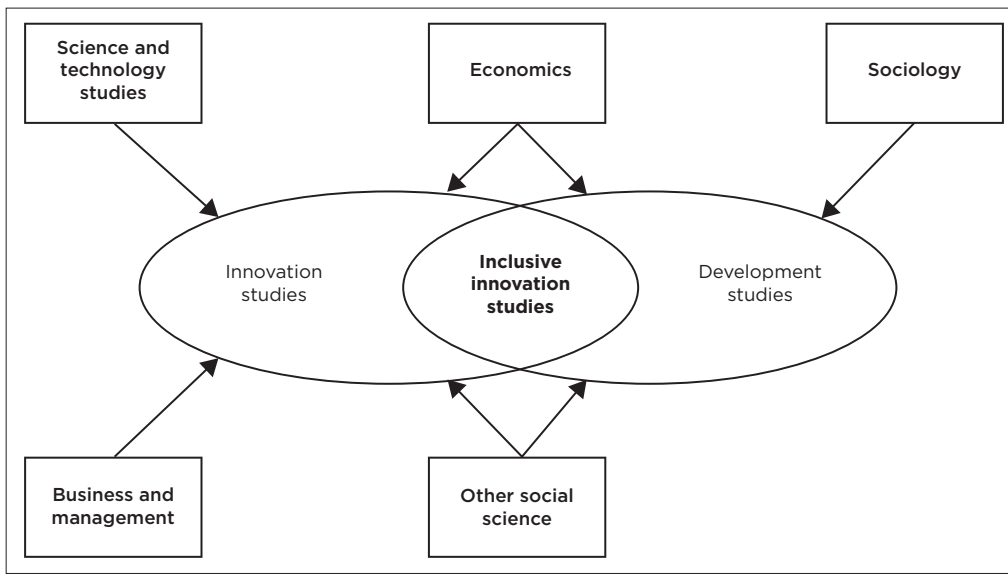
Foucault (1970) argues that the formation of a discipline requires the establishment of demarcation lines, a perimeter that decrees what belongs within a discipline, which objects of study are the legitimate ones of concern and what lies outside the discipline. Neoclassical economics has extremely restrictive demarcation lines, with the exclusion of analytical approaches from sociology, political science, history and philosophy from its domain. Paradoxically, the development of the neoliberal hybrid enabled the discourse to extend the perimeters of neoclassical economics while retaining the semblance of scientific rigour to most other areas of the study of human behaviour. Stigler (1984, p. 311) claimed that 'economics is an imperial science: it has been aggressive in addressing central problems in a considerable number of neighbouring social disciplines, and without any invitations'. This status was further enhanced by the way in which Stigler and Becker (1977) and Becker (1993) utilised human capital theory to explain all of human behaviour, a claim that Fine (1999, p. 413) criticises as proceeding 'usually from a position of ignorance of, and contempt for, the contributions made from other social sciences'.

The extreme restrictiveness of the underlying assumptions of the neoclassical paradigm, especially with regard to that of full and free information and a simplistic notion of rational behaviour, leaves very little space for the consideration of endemic poverty and other types of exclusion from the formal economy. Where such phenomena are considered, they are ascribed to 'imperfect' markets, 'market failure' and a range of externalities. Issues of class, race, gender, ethnicity, location and other criteria for exclusion are effectively dismissed as aberrations that impede the rationality of markets. It is a fundamental assumption that markets, left to their own devices, would ensure optimal allocations of resources, factor price equalisation, maximum consumer welfare and generally eradicate unemployment and poverty. The effects of history, cumulative development and path dependence are generally excluded in the analysis of economic welfare, apart from some models using human capital theory. The exclusion of history, political science, sociology and

modern anthropology from the neoclassical paradigm allows for the claim of the universality of mainstream economics across time and space.

The sidelining of innovation studies and inclusive development in economic theory is depicted in the disciplinary map drawn by Heeks et al. (2013) to locate the disciplinary foundations of inclusive innovation studies (Figure 2.1). This diagram shows both the disciplinary distance of inclusive innovation studies from economics and implicitly the distance of economics as a discipline from a range of other disciplines in the social sciences, management studies and the humanities. Development economics started off from the premise that developing economies were a special case of economy, not simply ones that were lagging behind developed economies on some universal development trajectory. Over time, however, development economics has fallen out of favour within the mainstream and has been consigned to the periphery of academia, even in developing economies, with the emerging dominance of neoliberal economics since the end of the 1980s (Chang 2003). Paradoxically, the enrichment of traditional development economics with the shift towards development studies (Sen 2001) has further marginalised this field of study in economics.

The policy implications of orthodox economics with regard to exclusion and its consequences are quite simple and fall into two categories. The first and primary concern is to liberalise markets as far as possible in order to allow for the inclusion of all sectors of society in the formal economy as inherent in



Source: Heeks et al. (2014, p. 184).

FIGURE 2.1: Disciplinary foundations for inclusive innovation research studies.

the norms of 'market rationality'. The second category consists of policies designed to address the few cases of public goods and external economies as in the case of basic education, basic health care, sanitation and other similar areas where neoclassical economics would predict that the 'free rider' problem and the inability to appropriate all of the returns on investment would lead to less than optimal provision through the market.

The inclusion of innovation in addressing exclusion often tends to fall within the language of orthodox economics, almost as an implicit default option, which is to an extent prevalent in studies on the economics of innovation. Nelson and Winter (1982) shed light on this tendency when they draw a distinction between 'formal' and 'appreciative' theory where the former refers to logically, often mathematically, constructed theory, and the latter refers to the practice of economics, the way in which empirical facts are interpreted and policy is formulated. Policy formulation rarely refers explicitly to theory but often rests on 'common sense', which is implicitly grounded in the current core of formal theory. Policy formulation, as interpretative theory, tends to gravitate around established formal theory, and critiques of policy also often tend to be couched within the generally unstated framework of conventional wisdom.

Inclusive innovation studies and IID policies should inevitably be grounded, even if implicitly, in a theoretical base that is radically opposed to that of mainstream economics. The problem, however, is that if the theoretical framework for IID is not explicitly stated and the core of an alternative body of formal theory is clearly identified, policy prescriptions around IID will inevitably tend to assume the current orthodoxy as the default referential body of economics. The consequence of this prevalent tendency is that studies on IID will lie on the periphery of economics, and associated policy will be relegated to what is seen as a subset of the economy. There are two aspects of studies on IID, which may be explored in order to break this theoretical bind. The first is the scope of exclusion that indirectly defines the criteria for inclusion. The second is the particular version of the NSI and the definition of innovation that are adopted as the framework for study and policy.

The scope of exclusion

The scope of inclusive development, including inclusive innovation, as an area of study and a reference frame for policy, is implicitly defined by the choice of who is excluded. This is not easy to pin down in the literature. Starting from Lenoir's (1974) restricted definition of the excluded in society, the category of exclusion has grown rapidly to cover almost every imaginable type and cause of social exclusion with economic exclusion as one of the more

important subsets. The extent of the category has become so wide that it has drawn the critique that the concept is theoretically weak and has become the repository of a number of loosely related phenomena. Sen (2000) adopts a human capability approach (Sen 1997, 1999) to develop a theoretical framework, which is coherent enough to render the myriad aspects of exclusion intelligible from a specific perspective. Starting from an Aristotelian concept of freedom, Sen's idea of human capability may be broadly defined as the freedom to attain one's life potential. While Sen saw human capital as a sub-category of the much wider concept of human capabilities, it can be argued that the two concepts are fundamentally different, almost antithetical (Scerri 2019a, 2020). In this regard, Bowles and Gintis (1975) maintain that:

> The allocation of workers [...] and the definition of 'productive worker attributes' simply cannot be derived, as the human capital theorists would have it, from a market-mediated matching of technically defined skills with technically defined production requirements. Issues of power, and ultimately of class, enter on a rather fundamental level. (p. 77)

The critique that Bowles and Gintis base on class formation can also be applied to other types of structural exclusions based on race, gender, ethnicity, location, etc. Fine (1999, pp. 413–414) offers a succinct critique of the theoretical rigour of human capital theory and the dangerous implications of its widespread acceptance and deployment for policy formulation in a wide range of fields. Human capital has become a catch-all black box where all aspects of human behaviour from skills, to tastes, to interpersonal relationships can be tossed into a return on investment analysis while begging the question of their social formation and construction through power relations. By contrast, human capabilities theory tends to abjure easy generalisations in its consideration of the complexities of human development, the path dependent nature of its power configurations and its essential historical specificity.

From the perspective of human capabilities theory, exclusion may be understood both as the prevention from the attainment of capabilities and as an obstacle to the deployment of existing capabilities. Literature on the first type of exclusion focuses on exclusion from basic rights, such as access to education, health care, sanitation and housing on the basis of criteria such as race, ethnicity, gender and location. The second type of exclusion is not frequently considered, but its addition can considerably widen the scope of exclusion. It is a relatively recent phenomenon and refers to the growing endemic structural unemployment of those who have traditionally secure access to the various requirements, such as education, health care and security, which are essential for the sustained development of capabilities. Standing (2011) refers to this class as the precariat who, while generally skilled, live a life of joblessness or unpredictable employment which severely shortens lifetime

planning horizons.[1] The precariat is a 21st-century outcome of the historically unprecedented form taken by capital in a post-1980s neoliberal global economy and in the concomitant shape of the 4IR where the accumulation of surplus value is threatening the current capitalist mode of innovation (Scerri 2014) itself. The structural nature and the growth of this class are now so significant that the notion of a universal basic income is being seriously considered in a number of countries.

The emergence of the coronavirus disease of 2019 (COVID-19) pandemic has affected the foundations of the global and national economies in most of their structural aspects and has caused the ranks of the precariat to swell quite considerably because of a number of related reasons. In the first place, there was the constraint on the supply of labour, except in the case of employment which can be maintained from home. Otherwise, most factory-based production or intensive contact service provision, such as in the case of the tourism sector, was severely hampered by restrictions on the manner in which labour can be deployed and the shortfall in demand. Furthermore, there are sectors of the economy which will take considerable time to recover given the human proximity required for their existence. Another more systemic factor to consider is the acceleration of structural unemployment and the growth of the precariat class, as the incentive for faster digitalisation, automation, robotics and artificial intelligence (AI) grows with the pandemic. Given these various trends, it is reasonable to expect that the exclusion of a significant portion of the population will be endemic worldwide, not only in developing economies. This points to a rapidly approaching future where the majority of the population are increasingly excluded from the core of the 21st-century economy, with a rapid erosion of the power to determine life chances and the fulfilment of human potential in terms of human capabilities. Under these conditions, it becomes increasingly apparent that conventional economic theory and its policy implications no longer serve the growing global phenomenon of economic exclusion which is manifested in poverty and the rapid growth of the precariat class in most economies, regardless of their level of development.

The national system of innovation

The focus of literature on IID is, almost entirely, on technological innovations, whether as the development of appropriate technologies for the poor and rural communities or the development of the capacity of the poor, often rural,

1. The notion of the precariat has been criticised as irrelevant for developing economies, where precarious life is often the norm, in spite of the rapidly growing middle class across Africa. Munck (2013) has been particularly critical of the conceptual integrity of the concept, especially in its positioning as a new dangerous class. It does, however, have a resonance with the fragility of an emerging middle class in developing economies and the implication of that fragility for development prospects.

communities to develop their own frugal technology. In effect, this places studies on IID within the context of the narrow version of the NSI approach. The two main differences between narrow and broad versions of the approach essentially lie in the definition of innovation and in the emphasis placed on informal institutions.

The narrow version sees innovation as technological change, whereas the broad version sees innovation as any new way of organising economic activity that is seen as preferable to the status quo (Schumpeter [1943] 2010). Lundvall (1992) offers perhaps the most appropriate definition of the broad version of the NSI as:

> [*T*]he elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge [...] and are either located within or rooted inside the borders of a nation state. (p. 12)

Thus, adopting the notion of knowledge as the cornerstone of the concept rather than restricting its definition to technology.

An interpretation of the difference between the narrow and broad versions of the NSI may be expressed as a distinction that is drawn between what may be called the system of science and technology (and technology-related innovation) and the broader system of innovation.[2] Lundvall (2016) strongly affirms the fundamental role of the broad version of the system of innovation when he states that:

> Without a broad definition of the national innovation system encompassing individual, organizational and interorganizational learning, it is impossible to establish the link from innovation to economic growth. A double focus is needed where attention is given not only to the science infrastructure but also to institutions/organizations that support competence building in labour markets, education and working life. (pp. 9–10)

The focus on the 'learning' rather than the 'knowledge' economy, which underlies Lundvall's definition of the broad version of the NSI, is particularly relevant with the historically unprecedented demands for new and accelerated types of learning in the time of the 4IR. This is highlighted in the 2018 analysis of the World Economic Forum (WEF 2018) which holds out more hope for the net effect on jobs and professions, contingent on accelerated and novel modes of learning, than the earlier document (WEF 2016).

2. See Cassiolato and Lastres (2008) for a comprehensive discussion of the distinction between the narrow and broad versions of the national system of innovation concept. They see the narrow version as composed of the research and development (R&D) sub-sector, comprising state research institutions, universities and private sector R&D departments and the production and innovation sub-sector that diffuses, deploys and adapts technological innovations in production. The broader version considers the placement of these sub-sectors in a broader context in relationship to demand, macroeconomic and other policies, legal frameworks and the global context.

The other element that differentiates the two versions is the relative consideration of formal and informal institutions. The narrow version tends to focus on institutions as organisation, laws and explicit rules and regulations. It is almost entirely confined to the formal economy, and its metrics allow for easy cross-system comparability in terms of R&D and innovation measures. It does not, however, easily portray the specific nature of a particular system of innovation as organisational architectures and topographies tend to be structurally similar across national systems, as are laws and, to a somewhat lesser degree, governance systems. The specificity of systems of innovation can only be captured through an exploration of the informal institutional underpinning of systems of innovation, those established routines and practices, and those often unspoken norms of interpersonal relations, which are often at least as binding as formal rules and regulations.

This is where historical contingency really starts to matter in the understanding of specific systems of innovation. For example, it is only through an understanding of the evolution of the informal institutional grounding of systems that we can study and assess the extent and effect of the informal, or shadow, economy. This economy is itself a sign of exclusion and by definition an area of the NSI where the significance of formal institutions pales in relation to that of informal ones. As long as the informal economy constitutes a relatively small proportion of the economy, it may be expedient to push its consideration into the periphery of national policy. However, when the informal sector constitutes a substantial and systemic component of the national economy (see Table 2.1), it may be seen as being constituted by its own subnational system of innovation with its own non-codified rules governing interpersonal and inter-community rules of engagement.

Phiria et al. (2016) pointed out the highly significant role of the informal economy in absorbing employment and the consequent requirement to study the interaction of the informal with the formal economy and to design inclusive innovation policy to promote its development and absorption into the formal economy. The extent of the informal economy is a significant indicator of the extent of exclusion, and it is in developing economies that the shadow economy is most pronounced. This is not to say that exclusion is absent within the informal or shadow economy. In fact, various forms of exclusion may be assumed to be probably more intransigent within the shadow economy in the absence of the checks provided by legal systems which apply in the formal economy.

Table 2.1 provides a clear picture of the significance of the informal section of the economy in Africa. Even allowing for a degree of voluntary existence in the informal economy, the percentages shown in Table 2.1 provide a strong indication of the degree of exclusion in African economies and thus highlight the necessity to bring policies on IID to the core of economic planning.

TABLE 2.1: The shadow economies of Africa (as % of GDP in 2007).

Country	%	Country	%
Algeria	31.2	Libya	30.9
Angola	42.1	Madagascar	38.5
Benin	49.1	Malawi	39.4
Botswana	31.9	Maldives	28.6
Burkina Faso	39.6	Mali	39.9
Burundi	39.6	Mauritania	35.1*
Cameroon	31.4	Mauritius (lowest)	21.9
Cape Verde	33.4	Morocco	33.1
Central African Republic	45.1	Mozambique	39.8*
Chad	42.2	Niger	40.4*
Comoros	39.4	Nigeria	56.2*
Côte d'Ivoire	47.0	Republic of the Congo	44.6
Democratic Republic of the Congo	46.7	Rwanda	40.1*
Egypt	33.1	Senegal	41.7
Equatorial Guinea	30.1	Sierra Leone	42.9
Eritrea	41.4	South Africa	25.2
Ethiopia	35.1	Sudan	34.1*
Gabon	47.3	Swaziland	40.7*
Gambia	40.9	Togo	34.9*
Ghana	38.3	Tunisia	35.4
Guinea	39.2	United Republic of Tanzania	53.7
Guinea-Bissau	41.6	Uganda	40.3
Kenya	29.5	Zambia	43.9
Lesotho	28.8	Zimbabwe (highest)	62.7
Liberia	44.2	Average (out of 49 countries)	39.0

Source: UNCTAD (2016, p. 14).
Key: GDP, gross domestic profit; *, average for 1999–2006.

Policy implications for South Africa

In most of the policy-oriented literature on poverty and exclusion, a dichotomy is drawn between social exclusion and economic exclusion and consequently social policy and economic policy. This dichotomy is strictly tenable only within the neoclassical/neoliberal frame of reference. From the perspective of classical economics and, even more so, evolutionary economics, this would be a false dichotomy. Generally, the implicit policy position of mainstream economics is that of poverty alleviation and inclusion as the objectives of policy and standard fiscal, monetary, industrial and trade policies as the instruments of policy, although the wastage of 'human resources' (HR) to the economy is sometimes noted and lamented.

Generally, the neoliberal prescription for growth, development and universal inclusion is best captured by the idea of the trickle-down effect which is effectively a reiteration of the welfare effects of free markets and the minimal state. From this perspective, growing income inequality may not only be seen as innocuous but actually as the stimulant to the engine of private enterprise

which drives economic growth. In the case of South Africa, this approach was manifested in the implicit acceptance of the race (liberal) side of the race/class debate on the nature of apartheid with the implementation of the Growth, Employment and Redistribution (GEAR) macroeconomic plan (Republic of South Africa [RSA] 1996a) at the start of the democratic era (Scerri 2009). From the liberal perspective, apartheid was seen as an aberration that distorted market rationality, which would otherwise not have tolerated racial discrimination as inefficient. The main policy implication of this position was that the redistribution required after apartheid would be best, almost naturally, achieved with the liberalisation of markets. The class side of the debate argued that capitalism is malleable and can adapt itself to a wide diversity of environments. In the case of South Africa, it took the form of racial capitalism[3] (Maharajh 2016) and over time adapted to and eventually entrenched the exclusion of the majority of the population. Proceeding from this class analysis of apartheid, the obvious policy imperative would have been redistribution before growth, specifically the extension of access to the various constituents of the formation of human capabilities to the population at large (see MERG 1993). There is little doubt that endemic poverty, unemployment, and the exclusion of a substantial portion of the South African population illustrate the relative policy relevance of the two sides of the debate, which set the macroeconomic framework for South Africa after apartheid.

In the 2019 South African *White Paper on Science, Technology and Innovation* (RSA 2019), this dichotomy is eroded within the context of STI policy. This is reflected in the linked policy nexuses specified in the chapter on the development of an inclusive NSI (RSA 2019, p. 26):

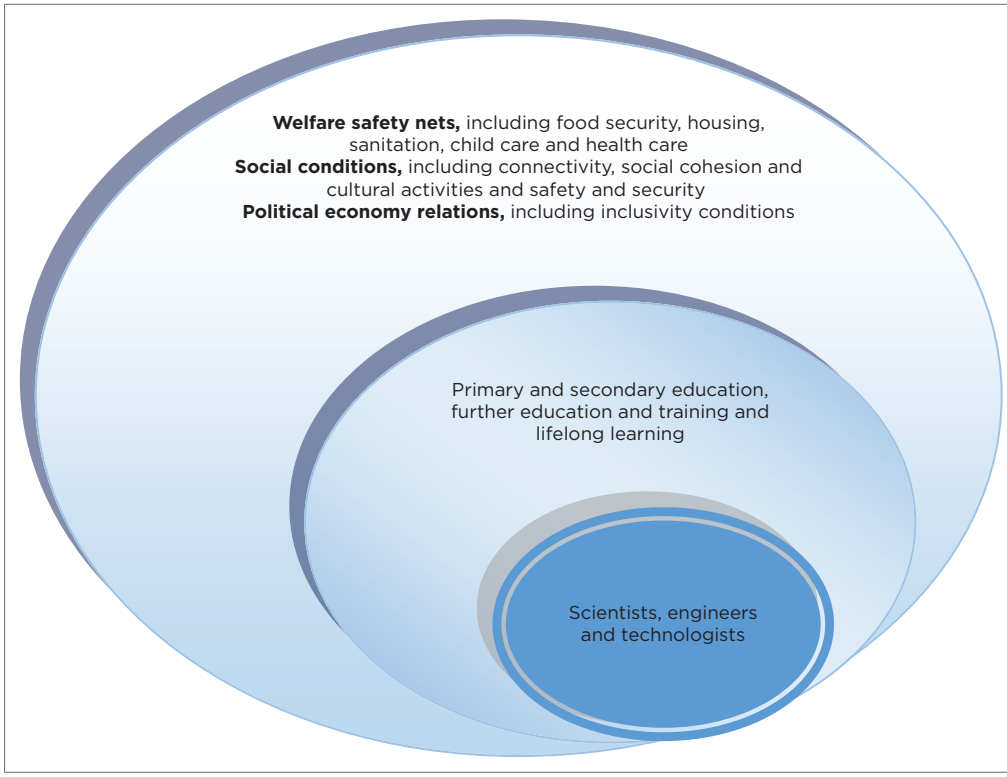
- **Education and skills development:** This nexus will focus on education and training involving the Department of Higher Education and Training (DHET), the Department of Science and Technology (DST) (now the Department of Science and Innovation [DSI]), the Department of Social Development, the Department of Basic Education (DBE) and the Department of Labour.
- **Economy:** This nexus will focus on business and enterprise development, involving at least the DST and the Departments of Trade and Industry, Economic Development and Public Enterprises.
- **Social:** The focus of this nexus will be on social development and IID, involving the DST and departments concerned with social and rural development and the social security-health-education nexus.

3. This refers to that variety of capitalism which emerged during the period of segregation in South Africa and evolved to adapt to the racial legislation under apartheid. This term stems from the class side of the race/class debate.

The main constraint on this policy direction towards an integrated conceptualisation of the NSI is the backdrop of national economic policy against which the STI planning framework is set. In the case of the 1996 *White Paper on Science and Technology* (Department of Arts, Culture, Science and Technology 1996), the policy direction of a document, which was at the forefront in the adoption of the system of innovation theory at the time, was severely handicapped by the GEAR macroeconomic plan (RSA 1996a). In the case of the *White Paper on Science, Technology and Innovation of 2019*, the national economic planning framework is provided by the NDP (RSA 2011), and the same handicap is still evident (Scerri & Maharajh 2016). In both cases, the NSI is explicitly seen as a sub-sector of the economy and the broad version of the system of innovation approach virtually excised from any meaningful policy formulation. The main issue that is obviously relevant for the formulation of policy on IID is the way in which the NSI is conceived. Most of the literature is implicitly anchored in a narrow version of the system of innovation, and policy interventions are mostly linked to science and technology policy aimed at developing appropriate and affordable technology for the poor and enabling the development of frugal technology for the excluded. This trait is quite evident in the case of South Africa.

In the case of evolutionary economics and the broad version of the system of innovation approach, which places human capabilities at the core of the growth and development process, poverty alleviation would be seen as a primary instrument of policy. Conventional economic policies would, from an evolutionary perspective, be considered as the facilitators of the process of shifting the capabilities base of the economy up the value chain within a rapidly mutating global system of innovation. With the expansion of the broad category of the excluded to take into consideration large sections of the population, both in and out of employment, the relocation of inclusive development and IID policies towards the core of economic policy becomes inevitable. Given the central role that human capabilities play in the evolution of systems of innovation and the fact that this role is becoming increasingly critical in the face of the current industrial revolution, it is crucial that we expand the focus on skills development and reconceptualise it in terms of human capabilities. From this perspective, we can think of the various layers in the development of human capabilities as shown in Figure 2.2.

The development of human capabilities is only partially dependent on formal education, although high-quality, universally accessible education is essential in the process. The foundation of this long-term development process, spanning childhood development to higher end skills formation, is essentially anchored in the guarantee of the integrity of the family unit, in the various forms that it may take (Scerri 2019a). However, sufficient consideration of the long-run nature and the complexities of human capabilities formation is generally absent in South African STI policy. The ‘human capital pipeline’,



Source: Adapted from the Institute for Economic Research on Innovation (IERI) (2014).
FIGURE 2.2: The layers of human capabilities provision.

which is one of the strategic pillars of South Africa's 10-year Innovation Plan (RSA 2007)' refers to the flow of students from their entry into university to their exit with a doctoral degree. The *White Paper on Science, Technology and Innovation of 2019* (RSA 2019) devotes a whole section to the development of human capabilities but the conceptualisation of human capabilities in the *White Paper on Science, Technology and Innovation of 2019* is virtually equivalent to human capital. Almost all of the section is devoted to the development of the tertiary education sector, using standard R&D metrics as the guidelines for achievement. The only brief section on primary and secondary education is the 'human resource development pipeline' (RSA 2019, pp. 49–50), echoing the 'human capital pipeline' in the 10-year Innovation Plan. Throughout the chapter on human capabilities, no mention is made of any of the elements that enter into the formation of human capabilities apart from education and training.

The other area that is of critical concern is the degree and extent of participation in the drafting of policy on IID. As argued by Scerri (2019b), STI planning is often structured on the triple helix model between the state,

universities and the private business sector. This model flows from adherence to the narrow version of the NSI. The implicit assumption in this model is that inclusivity is in the application of policy rather than in its formulation. In a number of countries, the helix has been expanded to include civil society advocacy organisations. Here, the possibility for a more participatory planning process representing disenfranchised sections of the population grows and has been seen to be effective. However, apart from a few countries such as the Nordic countries and Germany, organised labour is normally absent, even from the extended helix. The unstated assumption in this exclusion of labour representation, apart from ministries of labour, is that the relationship between labour and private enterprises and labour and the state as employer is essentially conflictual. This assumption is not inevitable, as can be seen in the case of the 'flexicurity' system pioneered in Denmark where national economic planning is seen as a collaborative process between the state, organised labour, universities and the private sector.[4] Boyer (2006) explores the applicability of the flexicurity model to developing economies and, while accepting the specificity of the political economies where this model originated, argues that this model is also suitable for the development agendas of developing economies, especially in the post-Washington Consensus era where the trade-off between economic efficiency and improving labour conditions is no longer as universally assumed.[5] He also points to the fact that small countries with strong welfare systems tend to show rapid growth rates at the time of rapid innovation.

In the case of South Africa, the 2019 White Paper on STI makes only a fleeting casual reference to the participation of labour in a consultative capacity alongside a rota of all possible participants (RSA 2019, p. 12, 41). This omission is curious in the case of South Africa where a structure, the National Economic Development and Labour Council (NEDLAC), was established at the very start of the democratic era (*National Economic, Development and Labour Council Act 35 of 1994*) to ensure that the country's economic future was to be determined by the triumvirate of state, labour and capital, echoing the founding premise of the flexicurity model. The failure of NEDLAC to fulfil its mission is evident in the consistently high incidence of strike action (Scerri 2019b, p. 13), and the significance of the role of organised labour in the formal economy of South Africa is evident in the unionisation rate which is significantly

4. Burroni and Keune (2011) are strongly critical of the ability of the flexicurity model to deliver on its promise of a collaborative and mutually beneficial relationship between capital and labour, arguing that it should either be abandoned or significantly transformed. This does not, however, deny the possibility of notion of complementarity (Streeck et al. 2005), which offers an alternative to the prevalent implicit assumption of a necessarily conflictual relationship between labour and capital.

5. We should be careful not to assume easily that there is a fundamental difference in the implicit theoretical foundations of the *Washington Consensus* and the post-*Washington Consensus* (see, among others, Fine & Saad-Filho 2014).

higher than the OECD average (Scerri 2019b, p. 7). It is this failure of NEDLAC to achieve its explicit goal of a collaborative relationship between the three main sectors of the economy that explains the neglect of organised labour in the determination of innovation policy. The implications of this neglect of IID are dire in a country where, apart from endemic high rates of unemployment, the increased precarity of work among the employed has effectively spread exclusion across all aspects of the South African economy. There are signs, although too early to assess, of initiatives to restore the functionality of NEDLAC as originally conceived in light of the persistent and rapidly growing unemployment rate in South Africa.

Conclusion

The main argument developed in this chapter has two linked components. The first is that the study of IID lies at the periphery of mainstream economic theory and hence of orthodox economic policy. This is primarily because of the global hegemony of the neoclassical/neoliberal paradigm across universities and governments and the failure of innovation studies to challenge this hegemony effectively (Scerri 2020). The other side of this argument is that the consideration of the excluded sections of the population is unnecessarily restricted and that its extension to allow for the effects of precarious life would spread its scope considerably across economies, both developing and developed. This expansion in the definition of the excluded could be instrumental in bringing policies relating to IID closer to the core of national economic policy. This shift would also help to question the dominant paradigm in economics and lead the way to an evolutionary approach to the understanding of the economy. The chapter finally looks at the current state of policy in this area in South Africa in the area of STI and finds that the current definition of the excluded constrains policy design and implementation in the case of IID. This is where inclusive development and the associated policy on innovation may move to the core of economic policy as widespread exclusion becomes the general feature of most economies. This will hopefully stimulate a reappraisal of policies such as IID at the national and transnational levels.

Chapter 3

Gender dimensions of science, technology and innovation in Africa: Legal and policy barriers to inclusive innovation

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Introduction

Science, technology and innovation are key drivers of development. The Internet and related digital technologies have led to a blurring of the boundaries between the physical and virtual systems and interfaces between

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them as described by Schwab in his elucidation of the Fourth Industrial Revolution (4IR) (Schwab 2017). The ubiquity of STI has propelled them to the top space as enablers of different things including R&D. Technology interfaces with both science and innovation even as each has its own distinct province. In the past decade, the African Union (AU) has steered several legislative and policy efforts geared towards transforming the continent through STI. The AU Agenda 2063 and the AU Science, Technology and Innovation Strategy for Africa 2024 (STISA-2024) place STI at the centre of Africa's socio-economic development and growth (African Academy of Sciences 2020). In Agenda 2063, STI is recognised as a major development driver and enabler, critical for achieving the goals of the AU and its member states. It, therefore, calls for investment in STI across different fields such as agriculture, energy, education and health care to ensure growth, competitiveness and economic transformation. The 2030 Agenda positioned STI as integral to the implementation of the SDGs and launched the UN Technology Facilitation Mechanism. Sustainable development goals are global goals to end global poverty and inequality, protect the planet and ensure all human beings enjoy health care, justice and prosperity. Both Agenda 2063 and the 2030 Agenda consider gender equality critical for development. This is also supported by the International Telecommunications Union Resolution 70 on *mainstreaming a gender perspective in ITU and promotion of gender equality and the empowerment of females through telecommunications/information and communication technologies*, which recognises that information and communication technologies are tools through which gender equality and female empowerment can be advanced, and are integral to the creation of societies in which both females and males can substantively contribute and participate (Irion 2009).

Despite the AU's commitment to the promotion of gender equality (AU 2018), these efforts have not paid substantive attention to the place of gender in bringing about Africa's socio-economic development and growth. For the most part, gender is integrated into Africa's STI blueprint through 'adding and stirring' females, and as such the path to gender equity is not clearly defined. Engendering STI in Africa can lead to innovation and transformation by steering Africa's socio-economic growth.

Engendering entails problematising substantively concepts such as science and innovation. This chapter is divided into four main parts. The first part problematises science as an exclusively 'male' domain. The second part identifies gender gaps in the key legislative and policy efforts that are in place to steer STI on the continent. The third part documents barriers and enablers to innovation. The chapter concludes with some reflections on what engendering STI would entail.

Female exclusion from science, technology and innovation as a creature of gendered science

Sciences have historically isolated females resulting in their under-representation in the profession (National Academies of Sciences, Engineering and Medicine 2020). Feminists have struggled to ensure that their perspective is incorporated in scientific methodology, epistemology, and scientific approaches and inquiries in general (Crasnow 2020). Earlier on, the perpetuated notion was that males thrived best in public places and females thrived best in private spheres. Therefore, females were encouraged to professions related to nurturing and homemaking, which included professions such as nursing, teaching, or baking, and sewing, which were considered feminine professions (Oketch 2014).

Males were considered critical and rational thinkers with the power to solve complex concepts such as algebraic equations (Kusumaningsih & Herman 2018). Consequently, sciences were thought to be masculine subjects (Central European Centre for Women and Youth in Science [CEC-WYS] 2009). This is similarly experienced while assessing the gender disparities in the analysis of the concept of law (Kameri-Mbote 2002). Science has not been too keen to study matters pertaining to females, their lives and their experiences in totality (Crasnow 2020). Therefore, research questions have not been relevant to females, and the production of scientific knowledge has been largely pro-male. The feminist quest is to encourage and promote the awareness of the social contexts within which this scientific knowledge is produced, disseminated and received (Crasnow 2020). As more females from the mid-20th century got involved in scientific research, the more the subject of female's lifestyles as a scientific aspect became evident (Crasnow 2020). This chapter argues that despite the fact that African institutions and governments have enacted numerous laws, policies and international agreements meant to ensure and encourage inclusivity and equality, so little has been seen to have been achieved in protecting the interests of females by way of encouraging their contribution towards spurring growth through STI because of the gendered nature of science. The section that follows connects females' historical exclusion from STI to what Naffine Ngaire calls the 'man of law'.

The man of law

Naffine Ngaire's theory of the man of law is the idea that humanity is infused with certain social and physical characteristics and moral qualities that are

considered ideal by those that interpret and administer the law (Naffine 1990). The use of the man of law by feminists resonates with Smart's criticism of law that either ignores or discounts females' contributions and rights (Smart 1989). The reconstruction of laws and legal processes to serve the goals of justice and equality is proposed as a solution. Comparatively, there exists a man of science whose description resembles that of the man of law.

Theorists such as Franzway and colleagues argued that the man of law is a creation of the imagination of few legal males at 'patriarch headquarters' (Franzway et al. 2009). This is in an attempt to tackle the question of whether the abstract individual is merely a prototype or he is an 'idea type'. Others have regarded this individual to be a consequence of a highly sophisticated interaction between groups and structures in the wake of a free market society as opposed to the efforts of certain important key persons conspiring together for selfish motives and gains.

Key characteristics can be drawn that arguably point to a male (not a females) from the middle-class (Naffine 1990). It suffices to say that this male of law is a myth of masculinity that fails to reflect actual complexities and diversities in male/female relations (Naffine 1990). This abstract individual is seen to inform the legal system, which seems to work more for them than the females.

To identify the sex of this person, we have to consider the ageless public versus private spheres debate. The social contract was only provided for females as the subordinates of their male counterparts, who ceased to exist upon marriage according to the social order. In fact, as Susan Moller Okin (1979, p. 199) criticises the Hobbeian and Lockean view of the social contract that alluded that everyone is equal in the society but implicitly opined that males, in their equality with females, acted in good faith on behalf of their families and females consequently.

The rule of law has generally tried to portray itself as blind to class through the universal legal subject. However, the rule of law is not class neutral, and the two are quite related (Naffine 1990). This is reflected by rights to property, for instance. Legal work is mostly done by the middle to upper-middle-class for those with some level of commercial interests and is concerned over their maintenance.

Law has thus embodied middle-class masculinity, and this has been a subject of criticism by most feminists from the second wave of feminism. They argued that the competitive and aggressive nature of law coupled with its obsession with individual rights 'reflected male tendency to pursue one's rights at the expense of others' (Naffine 1990, p. 117). In the next section, we will connect the 'man of law' to the 'man of science' and show how gendered science creates barriers to innovation.

Gendered science

Having provided the theoretical and conceptual framework in the previous section, we will now connect the man of science to the exclusions and barriers in science. We will begin by defining what science is and what it constitutes.

Defining science

The most basic definition of science as captured by Ester (2012) is a systematic enterprise that builds and organises knowledge in the form of testable explanations and predictions about the universe. This suggests that science breaks down mysteries existing in the universe into comprehensive information through logical approaches. As deduced from the aforementioned, science can also be termed as a systematic and structured study that, through observation and experiments, provides an explanation of the world's physical and natural phenomena. The Science Council defines science as 'the pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence' (The Science Council n.d.). Systematic methodology includes objective observation, induction, verification and testing.

In an attempt to define science within the context that it has developed, the journal 'why gendered science matters' records that given the fact that science is a human activity, it is, therefore, influenced greatly by social and cultural factors. The argument here is that science is in itself a social institution, with a set of historically, socially and culturally situated practices (Central European Centre for Women and Youth in Science [CEC-WYS] 2009). This means that much as science can be viewed as an ultimate practice that seeks to provide answers to both physical and natural phenomena, there is no particular point of departure from its very own context of development. As captured, it is, therefore, an enabler to development that underpins all other social and cultural dimensions that prevail in specific societies at different times. This includes how different communities perceive gender equality.

In his book, *What is this thing called science*, Alan Chalmers argues that the recent past has seen science gain popularity, not in the milestones of achievements it has rendered to human race, but to the impact it has added to authenticate believes and assertions. He notes, for instance, that some product advertisers may assert that a certain product has been scientifically proven to be more effective than a rival product. This statement on its own adds a substantial level of impact on many consumers because the notion created is that the claims made about the product are well-founded and beyond dispute. He further notes that besides the common knowledge that science has brought about a large share of problems like hydrogen bombs and contributed immensely to pollution, science still is held with high esteem.

Agassi (2013) fragments science and attempts to break it down at different levels: firstly, science as intellectualism whereby it rides on rational foundations. Second, the dominant view is empirical whereby science avoids traditions and other sets of beliefs and only relies on facts to ensure the correctness of theories it begets. In the view of instrumentalism, the argument here is that in the event that scientific ventures are deprived of information, then the instrumentalists will have no data to create theories. As such, therefore, this process can be more or less seen to be an endorsement of some arbitrary views of the world. Looking at them together, however, depicts science as a process of explaining speculations as well as being a continuous process of error elimination. Iaccarino (2003) avers that science is a process that aims at defining occurrences based on the course and effect approach. He suggests that culture and science are inseparable and are indeed dependent variables. Transcendental values are known to form the basis of human belief systems and are intrinsic in guiding the social and ethical rules around nature. To satisfactorily define the outside world, there is an automatic dependency on culture.

In a nutshell as mentioned, in almost all accounts, science and culture are inseparable and while that stands, what can be coined out of the interdependency of science with a culture that is engendered hindering inclusive innovation.

Inclusive innovation

Heeks et al. (2013) define inclusive innovation as the means through which individuals who have been excluded from the development of mainstream process develop goods and services. Inclusive innovation means the inclusion of individuals who have been marginalised or excluded from the mainstream process of development into the innovation process. The dominant group that inclusive innovation focuses on is the poor.

Exclusions in science

Feminist critiques of scientific research have expressed dissatisfaction with how sexist and gendered biases have manifested towards the science subject and the methods of research thereof (Crasnow 2020). It is, therefore, safe to assume that science is a gendered discipline. Some of the key phrases that arise from this discourse are gender dimensions, gender mainstreaming, gender equality and gender bias.

'Gendered dimensions' simply means the inclusion of sex and gender analysis into research. On the contrary, 'gender mainstreaming' implies the efforts taken to ensure gender equality (Central European Centre for Women and Youth in Science [CEC-WYS] 2009). For years, female participation in the

field of science has also not been recognised (Central European Centre for Women and Youth in Science [CEC-WYS] 2009). It is only recently that their participation and contribution have been encouraged by developments, such as structural changes, policy formulation, creation of academic programmes and provision of scholarships for females in the scientific arena (Bíziková, Sedová & Szapuová 2007; Kastens & Okhoya 2007). There are three approaches/dimensions to ensure gender equality (Central European Centre for Women and Youth in Science [CEC-WYS] 2009):

- The knowledge body/content of the subject science. Some refer to this as 'fixing the knowledge' or 'gendered innovations'. This aims at promoting sex and gender analysis in research geared towards scientific content such as methodologies, theories and paradigms. This is to ensure that STI is accelerated.
- Gender structure, popularly known as 'fixing the numbers of females'. The main aim is to increase females' participation in research.
- 'Fixing the institutions' aims at achieving structural changes towards ensuring female participation by this very conduit that has been used to exclude females.

The approaches outlined promote inclusive innovation by removing barriers. Gender biases take different forms, which are highlighted with respect to the 'man of law'. Science, just like the rule of the law, has apportioned traits considered masculine, such as objectivity, emotionality and disinterestedness, among others. Consequently, it propagates the very assumptions used to marginalise females (Central European Centre for Women and Youth in Science [CEC-WYS] 2009). Science was already male-dominated, and females were extremely under-represented, where there were any (National Academies of Sciences, Engineering and Medicine 2020). Therefore, males determined and managed matters of scientific knowledge.

Another bias relates to invisibilising females in the creation and formulation of knowledge. Many research subjects have been predominantly male. Sadly, conclusions about an entire population including females are drawn based on the information gathered from male research subjects, which is usually not objective. Such information excludes females' views and contexts. Science has also been considered biased because it has sometimes adopted and perpetuated the archaic notions that have traditionally negated female traits.

Legislative framework on science, technology and innovation internationally, regionally and locally

Science, technology and innovation are known to contribute immensely in fostering growth in different ways, for instance, in ensuring national security

and social stability, improving the quality of life, improving the sustainable growth of the national economy and its efficiency, creating adaptable cultures suitable for the new society and preparing for a smooth transition to an information society.

With respect to this realisation, therefore, there have been multiple attempts to harness the gains that come with embracing STI internationally, regionally and locally through passing laws within nations or ratifying conventions and agreements forged through international conventions.

International

The patent cooperation treaty

This international treaty was concluded in 1970 and provides for a standardised procedure for filling patent applications to protect inventions in its member states. The main objective is to protect new innovations from being duplicated as a sure way of encouraging the rise of more inventions among member states (Lapenne 2010).

Agreement on trade-related aspects of intellectual property rights

The trade-related aspects of the *Intellectual Property Rights from Publicly Financed Research and Development Act 51 of 2008* were agreed upon and signed in Morocco in 1994 (Malbon, Lawson & Davison 2014). The agreement is of minimum standard nature and allows its members to provide more extensive protection of intellectual property (IP) if they wish. Member states are left free to determine the appropriate method of implementing the provisions of the agreement within their own legal system and frameworks.

Its main objective is to foster protection and push for enforcement of intellectual property rights (IPR), which in effect should encourage technological innovation; the agreement thereby provides for the mutual advantage of both producers and users of innovative and technological know-how in a way that speaks to the balance of rights and, as such, citizen obligations.

Swakopmund protocol on the protection of traditional knowledge and expressions of folklore – 2010

This protocol was developed by the African Regional Intellectual Property Organization under the conviction that traditional knowledge systems, cultures and folklore offer a framework for diversification, innovation and creativity, which besides having a host of benefits offer distinctive creative life benefits to the local communities and to the entire human race (African

Regional Intellectual Property Organization 2015). The protocol recognised the local and traditional communities as the rightful owners of the rights in the expression of folklore.

Noting the pivotal role that the World Intellectual Property Organization (WIPO) played in the protection of traditional knowledge and as such encouraging more innovations within communities, WIPO member states affirmed their support in 2005 to enable the initiatives to continue (World Intellectual Property Organization 2005). WIPO is a global forum for IP services, polices and information corporation.

Malta declaration on networking the commonwealth for development

The Malta declaration was arrived at after member states agreed upon the notable contribution by information and communication technology (ICT), especially on spurring economic growth and development. Further to this declaration, the member states assented to the Digital Solidarity Fund that sought to pool together resources in an attempt to reduce the global digital divide. This offered great opportunities through access to information and the provision of infrastructure, which would expose potential innovators to more ventures with ease.

To further this agenda, international organisations have continued to partner in a bid to achieve the goal of bridging the existing digital divide. For instance, the 'EQUALS global partnership' was founded in 2016 with its partners originally being the International Telecommunication Union, UN Women, the International Trade Centre, Global System for Mobile Communications and United Nations University (Bogdan-Martin 2018). The partnership that has attracted the participation of more players including governments seeks to leverage available resources and knowledge, harness partner capacities and support action towards realisation of beneficial ICT projects.

Regional

Inter-African convention establishing an African technical cooperation programme of 1975

The ordinary session held in Kampala, Uganda agreed on key objectives of the convention, namely (AU 1975):

- to offer platforms and avenues to African experts to develop and grow their skills by innovatively tackling their challenges in their host nations

- to provide a facilitative environment for sharing expertise and skilled personnel among African countries
- to create an enabling ground for comparison of scientific and technological knowledge related to the development of African countries.

Local

The *Constitution of Kenya 2010* recognises and provides protection for IP. It seeks to bring excluded groups to the fore by making specific provision for the protection and enhancement of IP in, and indigenous knowledge (IK) of, biodiversity and the genetic resources of the communities (AU 1975: Article 69[1][c]). Different laws have been reviewed to align with the constitutional imperatives.

The Kenyan *Science, Technology and Innovation Act 28 of 2013*

An Act of Parliament was passed to facilitate the promotion, coordination and regulation of the progress of STI in the country to assign priority to the development of STI, to entrench STI into the national protection system and for connected purposes.

The Kenyan *Industrial Property Act 3 of 2001*

An Act of Parliament was passed to provide for the promotion of inventive and innovative activities; to facilitate the acquisition of technology through the grant and regulation of patents, utility models, technovations and industrial designs; to provide for the establishment, powers and functions of the Kenya Industrial Property Institute and for purposes incidental thereto and connected therewith. Passed in 1989 to provide a framework that did not require rights' validation in England, it was reviewed in 2001 and lastly in 2012 to reflect the 2010 constitutional imperatives. It does not explicitly address gender inclusion in science.

The Kenyan *Copyright Act 12 of 2001*

The Kenyan *Copyright Act 12 of 2001* was developed with the sole aim of protecting the rights of the creators and artists. Copyright is the automatic right that protects the owner of an original piece of literary, artistic, musical or other forms of art. Persons with talent within this industry are entitled to the protection of the board created under the act. This is in a bid to offer a conducive environment for even much more innovative approaches in the creative sector. An amendment to the Act in 2020, does not expressly address gender inclusion in science.

Policy framework on science, technology and innovation in Africa

The policy framework on STI in Africa is robust. This section outlines some of the policies and identifies some of the key gender gaps in these policies.

Policies supporting science, technology and innovation in Africa, internationally and in Kenya

Science, technology and innovation are evidently the key drivers of not just local but regional socio-economic development. They provide the way for a country to meaningfully engage with the ever-dynamic world of today that highly rewards scientific knowledge, progress and innovations. Therefore, countries including Kenya are in a rush to develop STI systems relevant and current for the times or risk to be phased out because of lethargy. To ensure functional and relevant STI systems are in place, countries in collaboration with other partners and stakeholders such as UN have come up with legislation and policies to facilitate the implementation of these STI systems. Some of these local, regional and international policy frameworks are highlighted.

African Science, Technology and Innovation Policy Initiative (ASTIPI) of 2007

This is a United Nations Educational, Scientific and Cultural Organization (UNESCO) initiative aimed at supporting and promoting the Africa Union's *Consolidated Science and Technology Plan of Action of 2005*. The aim of ASTIPI is to develop national STI policies for all those African countries still without one (Wambeti 2016). As in the past, UNESCO is working with African countries to reform their science systems, assist them in policy formulation, facilitate the adoption of national policies and accompany them in elaborating and implementing strategies and programmes.

Consolidated Science and Technology Plan of Action (2005)[6]

The *Consolidated Science and Technology Plan of Action* (CPA) (2005) states that (*Consolidated Science and Technology Plan of Action* 2005):

> This 'Consolidated Science and Technology Plan of Action' articulates Africa's common objectives and commitment to collective actions to develop and use

6. See Africa's *Consolidated Science and Technology Plan of Action* (2005:5).

> science and technology for the socio-economic transformation of the continent and its integration into the world economy (Kahn 2008). It is erected on three interrelated conceptual pillars. These are: (a) capacity building (b) knowledge production, and (c) technological innovation. Capacity building in this context refers to the creation, improvement and mobilisation of human skills, physical infrastructures, financial resources and the necessary policies for science and technology to be produced and used to solve specific African problems. Knowledge production is really about the conduct of science – the generation of scientific and technical knowledge about Africa's problems and identification of specific ways to solve the problems. This is what is often referred to as R&D. Technological innovation entails the generation of specific products, processes and services. The *Consolidated Science and Technology Plan of Action* puts emphasis on developing an African system of research and technological innovation by establishing networks of centres of excellence dedicated to specific R&D and capacity building programmes. It complements a series of other AU and New Partnership for Africa's Development (NEPAD) programmes for such areas as Africa's *Consolidated Science and Technology Plan of Action* Goal 6 [*agriculture*, *environment*, *infrastructure*, *industrialisation* and *education*]. (p. 5)

Science, Technology and Innovation Strategy for Africa (2024–2014)

The AU Science, Technology and Innovation Strategy for Africa 2024 (STISA-2024) (STISA-2014):

> [*P*]laces science, technology and innovation at the epicenter of Africa's socio-economic development and growth (African Union [AU] 2014).The STISA-2024 has been developed during an important period when the AU was formulating a broader and long-term AU Agenda 2063. The STISA-2024 is the first of the ten-year incremental phasing strategies to respond to the demand for science, technology and innovation to impact across critical sectors such as agriculture, energy, environment, health care, infrastructure development, mining, security and water among others. The strategy is firmly anchored on six distinct priority areas that contribute to the achievement of the AU Vision. These priority areas are eradication of hunger and achieving food security; prevention and control of diseases; communication (physical and intellectual mobility); protection of our space; live together; build the society; and wealth creation. The strategy further defines four mutually reinforcing pillars which are prerequisite conditions for its success. These pillars are building and/or upgrading research infrastructures; enhancing professional and technical competencies; promoting entrepreneurship and innovation; and providing an enabling environment for STI development in the African continent (Science, Technology and Innovation Strategy for Africa 2024). (p. 10)

The East African regional science, technology and innovation policy

The Member States of the East African Community (EAC) identify (United Nations Educational, Scientific and Cultural Organization 2019):

> [*T*]he role that STI can play in transforming key sectors of their economies drive strategic actions towards sustainable development.

> The East African Regional STI Policy is anchored on the following pillars: i) Capacity building for skills and STI infrastructure; ii) research, innovation and entrepreneurship; iii) resource mobilization, partnerships and collaborations; and iv) enabling environment. On the other hand, the priority (sector) areas for the East African Regional Policy for STI are: (1) Agriculture and food; (2) health and life sciences; (3) human resource development/education; (4) infrastructure; (5) energy; (6) ICT and big data (7) industrialization and trade; (8) environment and natural resources management; (9) climate change; (10) traditional and indigenous knowledge; and (11) space science and technology. (n.p.)

Barriers and enablers to innovation

Barriers to and enablers of innovation affect males and females but are nuanced by the gender division of roles that assigns females in the private realm and males in the public realm. Females are, therefore, likely to encounter more barriers and unable to make use of the enablers compared with males.

Barriers to innovation

Innovation is the ability to come up with a new approach or idea towards solving a challenge or increasing efficiency in delivering the expected outcome (Kahn 2018; Kline & Rosenberg 2009; Kogabayev & Maziliauskas 2017). Over time innovation has become handy, especially in the wake of technological advancement and at a time when the need for new methods of increasing productivity at lower costs cannot be overemphasised. The new world has posed a challenge for all to pick up the pace and catch up with the growth that has been spurred by the digital era. However, in the quest to achieve the same, there are challenges that hinder the eventual realisation of such intended innovations. Innovation must promote sex and gender analysis in research to ensure that females participate in research and gender equality is fostered.

Inadequate resources/capacity

Coming up with new innovations requires facilitation to actualise the theoretical ideas into tangible results or to convert the innovation to measurable results (Bradley et al. 2012). Measuring the impact of innovation and allocating a budget without overstretching available resources can be challenging because the benefits of incorporating new technologies into the dynamic of market demands are not obvious.

Financial support is not readily available, and the existing sources have strict conditions that may not even accommodate ideas as a guarantee. Research indicates that females are more likely to be poor compared with males; this, therefore, leaves females more vulnerable to such factors than males (Chant 2015).

Political factors

All over the globe, politics have played major roles in frustrating innovation. Being the sole policy formulators, legislators fail to create frameworks for new innovations, and as, such frustrate the birth of innovations being incubated. As democracies grow, internal politics become more complex, and the results become delayed actualisation of ideas (Foxon & Pearson 2008, pp. 148–61).

These hierarchies make decisions based on different factors including which entity is more powerful, and here gender inequalities play a bigger role. Implementing new innovation often involves internal politics, which results in both positive and negative reactions from those involved. Politics are largely marred by conflict of interest, and the disadvantaged gender remains on the receiving end.

Socio-cultural factors

Issues regarding cultural concerns and value systems are difficult to solve and promoting active discussions about possible innovations and changes can encounter resistance. Without a formal platform for such discussions to address issues of inclusion and equal opportunities, there can never be a level playing field for innovativeness.

While we appreciate the existing diversity, some cultural orientations continue to be impediments to growth by way of being rigid to cultural ideologies (Hadjimanolis 1999, pp. 561–570). For instance, male-dominated setups will discourage female innovators from achieving goals that would have probably contributed to development within and without their locality. Some distinct cultures have roles divided with respect to gender. This automatically means individuals are limited to the scope of activities that their gender status allows.

Lack of incentives or reward systems

Success of an innovation is ignited by incentives, the ability and willingness of people and teams to work together towards creative breakthroughs. The worth of an idea based on the source, instead of its merits discourages innovation. Most democracies have not yet embraced systems of rewarding and recognising outstanding innovation as a sure way of encouraging others to pick up and be creative and innovative (Bradley et al. 2012).

Fear: Belief that innovation is inherently risky

The stigma associated with failure cripples creativity and innovation. Every innovation has no guaranteed success; hence, the fear of consequences for

missteps affects the ability to make informed decisions. The ability to begin and register an invention from the ideation point is in itself a step ahead. Whether or not the trial reaches the desired level as foreseen should not create disruption as not to pick up an idea. As seen earlier, science has been engendered, which further increases the chances of certain gender quotas shying away from innovations that they think might flop before fruition (Zanello et al. 2016).

Lack of creative thinking training

Simplistic and familiar tools of learning and thinking are often preferable, but they hinder creativity and adaptation of new technology and innovation. This can result in reluctant participation and questioning the value of the same. Lack of sufficiently trained personnel hinders the ability to update skills required to adapt new technology or even to think beyond the basics. Even worse, research shows that people hardly have faith in investing in females by way of training (Jackson 2009).

Inadequate understanding of existing challenges

Inability to recognise the need for a change is a major challenge to innovation (McAdam, McConvery & Armstrong 2004). Most people focus on optimising existing processes, without a holistic evaluation of which aspects need to be improved or wholesomely scrapped for betterment. As seen earlier in most setups, information is controlled by certain individuals in a society, and as such alluding to the notion that information is power, those without information end up without power. In this case, females lose opportunities by virtue of being locked out of accessing vital information that may be important in informing their ability to innovate.

Enablers of innovation

Increased research and knowledge management

Research is a critical enabler for advancing technology and innovatively tackling challenges in Africa (National Research Council 1987). Today's problems require up-to-date solutions that can only come by rigorous research. Closely relating to research is the use of wealthy knowledge resources in our access so as to find creative ways to promote innovation. This knowledge can be indigenous and can be shared and disseminated for purposes such as capacity building and training. It is the way for Africa to be part of the global community.

Incubation hubs

Science, technology and innovation are necessary for Africa's socio-economic development. As part of building STI systems in Kenya and in the other regions, there have emerged new ways to facilitate this. This is the creation of innovation incubators. This has mostly been through the use of technical colleges and universities. These are nurturing spaces for the production of scientific knowledge and products. These spaces require heavy infrastructural and financial investments.

Formulation of science, technology and innovation policies and plans

To create an enabling environment for innovation, governments must be dedicated and keen on developing policies, legislations and plans that are innovation-oriented (Wamae 2008). We have witnessed policies such as AU's *Consolidated Science and Technology Plan of Action*. Innovation systems and policy formulation processes are highly interconnected. This is because policies guide research and innovation systems (Flores et al. 2008).

Increased innovative infrastructure

Innovative infrastructure is basically the ability or capacity of a nation to be competitive in an evolving environment. The availability of this capacity assumes that having good Internet connectivity, access to laboratories, resource centres, innovation hubs and dedicated platforms can contribute immensely to facilitating innovative activities (Flores et al. 2008).

As can be deduced from its definition, innovative infrastructure ensures that facilities in place are up-to-date with emerging trends, especially with respect to efficiency, and with technological advancements. Arguably, this is the most essential enabler of innovation as it prominently forms the foundation of the process, from ideation to the fruition of the inventions and innovative projects.

Socio-political and cultural factors

Innovation is a diverse discipline, as are its socio-cultural and political dimensions. In order to constructively innovate, there has to be a need for it. Our daily challenges are what spark the need to be innovative in the bid to offer solutions to these challenges.

Furthermore, through political activism informed by socio-cultural influences such as the need for inclusivity, inclusive innovation is progressively being made possible and the pace is promising.

Conclusion

The resultant inclusion of females in scientific projects and in innovation fronts, especially in the wake of technological advancements, can be attributed to the spirited push and advocacy for inclusive innovation and transformation. Progressive gains have been made with the progressive adoption of equality measures within systems of governance and decision-making platforms. However, as more positive results continue to be witnessed in female discovered inventions, the policies and laws need to be strengthened to ensure proper implementation and thus lead to inclusive innovation and transformation. Additionally, while gendered science evolves to take a more inclusive image, there is a need to bridge the gap that informs barriers to innovation discussed in this chapter.

Inclusive innovation and transformation demand concerted efforts to identify and correct systemic failures as well as root out cultural hindrances that reduce the pace of development by introducing stale traditions and beliefs that cripple the systems. Better frameworks by local and international bodies and governments must be put in place to inform operations with regard to inclusion and equality with regard to utilisation of existing resources.

Chapter 4

Engendering innovation for female empowerment in post-apartheid South Africa

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Introduction

There is now an extensive and growing body of research advocating for the mainstreaming of innovation to address multiple challenges associated with exclusion across social, economic, political and many other dimensions. In the development field, innovation has been praised as a solution to multiple challenges such as poverty, inequality and empowerment of previously excluded groups (Figuères & Eugelink 2014; Organisation for Economic Co-operation and Development [OECD] 2015). From mobile financial services in

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Kenya and gender, social and economic inequalities and exclusion in South Africa, to energy-saving technologies in the Global North, innovation has been promised to help meet the sustainable development goals (SDGs). Other authors have argued that innovation will help countries to transition into the sustainable, less-carbon world (Richter 2013; Wainstein & Bumpus 2013).

However, the review of the previous research suggests that researchers, practitioners and policy-makers who are working in the multidisciplinary sub-field of inclusive innovation have not mainstreamed gender approaches in this discourse. For others, when gender is mentioned, it is often treated as just an add-on (independent) variable. A large body of scholarship indicates that shortcomings of the mainstream development approach are because of their ideological beliefs in the trickle-down effects (Stiglitz 2016). Moreover, research has also shown that new development policies, projects and innovations that do not incorporate gender realities are likely to result in unequal benefits for males and females. However, many existing inclusive innovation approaches have not shown commitments to mainstream gender for transformative change.

Against this background, this chapter discusses ways in which STI could be gender-inclusive for it to have socio-economic benefits for the wider population. Existing studies suggest that females are often disadvantaged in labour markets and the economy at large; it is thus essential for innovation to incorporate gender dynamics in its design and implementation. Using South Africa as a case study and drawing from the emerging scholarly work on transformative innovation policies (TIP), the chapter argues that gender-inclusive innovation will be required to be mainstreamed to reduce the existing gender inequalities.

This chapter will firstly engage with a broader conceptual debate on gender, development and innovation. Secondly, it reviews the debates, data and indicators on the intersection of gender, race and class in South Africa and makes a case on why innovation policies must mainstream gender if the aim is to be inclusive. Thirdly, we argue that gender approaches can be integrated into the existing innovation systems by using TIP. This chapter concludes that innovative approaches that claim to be inclusive and pro-poor, but do not centre gender in their design and implementation, are anti-poor.

Gender and development

Gender has a long history within development studies, and its evolution can be tracked alongside the changing post-Second World War (WWII) development approaches and theories. From critiquing the grand ideas of modernisation to offering alternatives rooted in empowerment and participation, gender approaches have been advocating for female roles

in development. The starting point of the earliest feminist ideas in development was the critique of the grand theories, which did not seriously consider female roles and voices within development models. In particular, modernisation perspectives, which became the dominant approach from the 1950s, were based on the idea that economic growth, technological progress and industrialisation will solve most of the world's development challenges. This approach is usually linked to Rostow's linear stages of growth, from the traditional to the industrial society or Arthur Lewis's dual model in the underdeveloped economies.

The feminist critique of the modernisation perspective argues that female voices were excluded in all the grand development models. Ester Boserup was one of the first feminist writers to provide a critique and was followed by other feminist writers like Caroline Moser. Boserup's argument relied on the fact that, because females were predominantly found in non-productive sectors of the economy, doing unpaid household labour such as cooking and taking care of children, such benefits claimed by the modernisation proponents excluded females (Willis 2005).

Although there were other alternative development models critiquing modernisation's assumptions, these did not directly question the existing unequal gender relations. The more radical dependency theory is a case in point here. Drawing on the ideas of Andre Gunder Frank, Raúl Prebisch, Walter Rodney and others, the dependency theory argued that the unequal trade relation between the poor countries (periphery) and rich (core) within the international capitalist system is the cause of underdevelopment in poor countries. Such ideas challenged modernisation theorists and neoclassical economists' assumptions that economic growth will lift the developing world out of poverty. However, the main feminist critique can also be applied here: neither of these approaches considered the marginal, yet important, role of females in society and the economy.

With the diffusion of the neoliberal hegemony across various spatial scales, feminist perspectives also critiqued its negative impacts. Since the 1980s, neoliberal strategies of development have been adopted in many nations. The International Monetary Funds' structural adjustment packages (SAPs) rolled out the neoliberal policies to Global South. In particular, the impacts of the SAPs were felt in many Global South countries. Among others, SAPs encouraged trade liberalisation, privatisation of the key government sectors and other austerity measures. Evidence suggests that poverty increased during the implementation of SAPs (Willis 2011). The feminist perspective argued that, because females are the primary caregivers of society, the impacts of the SAPs were more severe for females in the developing world (Sharmer 1994). Overall, the evolution of gender and development thoughts is indicated in Table 4.1.

TABLE 4.1: Evolution of gender and development approaches.

Approach	Date	Description
Welfare	1950s onwards	Targeted females in their domestic role; females viewed as passive; projects addressing female practical gender needs, such as food aid, health care and nutrition advice
Equity	1970s	Prompted by the UN Decade for Females; aimed to address strategic gender needs by eradicating obstacles to females advancement in the public sphere; a strong focus on legislative changes
Anti-poverty	1970s	Low females status perceived from income poverty; focus on projects to create income-generating opportunities for females; no consideration of patriarchal structures of oppression
Efficiency	1980s	Focus on females as channels for development; during SAPs females' paid work and domestic work intensified
Empowerment	1990s	Aims to lead to significant shifts in gender relations; original focus on projects devised and run by groups of females from the South; approach increasingly adopted by Northern organisations; increased focus on incorporating males into gender and development projects
Intersectionality	2000 onwards	Intersectionality of various aspects of identities, including gender, race, sexual identity, disability and class, affects their position/power in society and impacts their ability to influence development decisions

Source: Adapted from Willis (2011).
Key: UN, United Nations; SAPs, structural adjustment packages.

Through reviewing recent work, we argue that gender perspectives in development are dominated by *intersectionality*. This perspective argues that gender intersects with other aspects such as race, class, disability and others to create various forms of marginalisation. Crenshaw (cited in Hopkins 2019, p. 938) first introduced the concept of intersectionality to argue that 'simply adding racism and sexism together does not address how black women are marginalised'. In this context, it was argued that black females experience multiple forms of marginalisation such as sexism, racism and socio-economic status.

According to Hopkins (2019), intersectionality can be categorised into three, namely, structural, political and representational intersectionalities. Structural intersectionality means that black females experience other forms of marginalisation in the labour market or exclusions in areas such as housing markets. Political intersectionality 'focuses on the ways in which black females belong to at least two marginalised groups and so often have to engage with different political agendas' (Hopkins 2019, p. 938). Finally, representational intersectionality can refer to how 'images of women of colour – and debates about these – tend to overlook the intersectional interests of such women' (Hopkins 2019, p. 938). The intersectionality perspective applies not only to the marginalisation of females, but also to other forms of discrimination, such as sexual identity/orientation, disability, ethnicity and nationality.

Innovation, inclusive development and gender

The growing literature on innovation and inclusive development (or inclusive innovation) opens a space for incorporating gender issues. In recent years, concepts such as inclusive, pro-poor and grassroots innovation have become buzzwords within the broader literature of innovation and development (Foster & Heeks 2013; OECD 2015). Such literature has focused on how innovation can be meaningful for the excluded and marginalised groups, especially in developing countries, in terms of poverty reduction and economic development (Chataway, Hanlin & Kaplinsky 2004). We have also increasingly seen 'innovative' programmes in agriculture, microfinance, sanitation and others being rolled out in developing countries in the name of 'development' (Guma 2020; Sutherland et al. 2021).

There are two fundamental issues when it comes to innovation and gender. Firstly, there is an under-representation of females when it comes to the actors in the innovation system (Andersson et al. 2012; Nählinder, Tillmar & Wigren 2015). Whether in terms of research outputs, patents and new businesses, the innovation in many sectors is still dominated by males (Andersson et al. 2012). The second issue relates to the fact that females still experience multiple forms of marginalisation and exclusions, especially in developing countries, as indicated by SDG 5 (UN 2018). From this perspective, it is argued that inclusive innovation would reduce gender inequalities.

Following the earliest feminist critique of 'grand' development approaches that have dominated developing countries, we argue that there is a need to critically consider gender relations within the inclusive innovation programmes and research. In this sense, inclusive innovation research must be multidisciplinary, engaging development economics, political economy, geography, political science and sociology/anthropology. This implies that technology diffusion and the increasing mainstreaming of innovation in development do not occur within a social, cultural and political vacuum. This would ensure that gender relation and unequal positions of power are considered when rolling out innovation.

Just as the critique of mainstream development approaches has been that they failed to consider the local context when applying development models in developing countries, the same could be said about inclusive innovation (Blake & Hanson 2005). In this context, innovation or innovation programmes, policies and products must not be seen as being politically neutral but must be theorised, as Blake and Hanson (2005) argue that:

> [/]nnovative products and those who create them are without a theoretical identity. Instead, reflecting the specific regime of accumulation within which this concept of innovation emerged, the focus has been on the process of innovating as the key to a region's capacity for economic growth. (p. 685)

The argument relates to researchers, policy-makers and large international organisations' growing tendency to regard global challenges as free of politics. We see similar trends, for example, in the ongoing debates about solutions to climate change and environmental problems. There is a tendency to *de-politicise* these problems and regard technological fixes as the solution to global problems. Similarly, IID will not address issues such as females marginalisation if it is applied through this limited lens of *de-politicisation*. The gender issue is a political issue but also a social, development and innovation issue. Against this background, inclusive innovation must go beyond regarding the excluded and the marginalised as just receivers of innovative development. Instead, the everyday life and understanding of the local contexts would be a key to have innovative products that result in transformative change.

Existing research indicates that studies have not engaged with gender and innovation in the transformative way as articulated. Alsos, Ljunggren and Hytti (2013) state that research in innovation and gender is dominated by empirical studies that view sex/gender merely as a (independent) variable and innovation as the outcome (see also Alsos, Hytti & Ljunggren 2016). Such research usually studies 'innovation in men-and women-owned businesses, as well as in the literature on gender differences on patenting, commercialisation, etc. in the university context' (Alsos et al. 2013, p. 243).

A note on the methodology

This chapter is based on a review of the literature and the analysis of secondary data, both quantitative and qualitative. To analyse empirical data on the evidence of females marginalisation in the economy, we used the 2018 General Household Survey (GHS) and 2020 Q2 Quarterly Labour Force Survey (LFS) data sets, both accessed from Statistics South Africa. The GHS is a nationally representative sample of South African households. For this analysis of the average household income per capita, we divided the total monthly household income by the number of household members (household size), including children and adults. These results are presented by gender and sex of the head of the household. Furthermore, statistical tests such as independent *t*-test, chi-squared test and regression model were used to test the relationship between gender and income.

Secondly, household poverty estimates were also calculated using the GHS. Three poverty lines are used in South Africa, namely, food, lower and upper-bound poverty lines. Statistics South Africa (2020, p. 3) defines these poverty lines as follows:

- **Food poverty line:** ZAR547 (in April 2018 prices) per person per month. This refers to the amount of money that an individual will need to afford the minimum required daily energy intake. This is also commonly referred to as the 'extreme' poverty line.

- **Lower-bound poverty line:** ZAR785 (in April 2018 prices) per person per month. This refers to the food poverty line plus the average amount derived from non-food items of households whose total expenditure is equal to the food poverty line.
- **Upper-bound poverty line:** ZAR1 183 (in April 2018 prices) per person per month. This refers to the food poverty line plus the average amount derived from non-food items of households whose food expenditure is equal to the food poverty line.

To calculate the number of households falling under these poverty categories, household income was divided by the size of the household, and then, the percentage of households living in poverty was calculated. The unemployment statistics were estimated from 2018 Q2 LFS and presented by gender and race.

The second part of the analysis sought to establish to what extent innovation systems and innovation policies have been committed to females empowerment at the policy level. We used government policy documents and budget speeches to answer this question.

Five policy documents were used, namely, *White Paper on Science and Technology of 1996* (Department of Arts, Culture, Science and Technology 1996); *National Research and Development Strategy of 2002* (Department of Science and Technology [DST]); 2007 National Systems of Innovation Review (OECD 2007); *White Paper on Science, Technology and Innovation of 2019* (DST 2019); and The NDP (NPC 2012).

These documents were selected because they have shaped innovation policy and strategies in the past 20 years. We have included the NDP because it has been adopted as government's policy and development strategy until 2030. In addition to these documents, budget speeches from the last five years (2015–2020) by DST (later became Department of Science and Innovation [DSI]), were also analysed. The budget speeches were obtained from the DSI website. These documents were analysed using NVivo to assess how gender and females have been included. The aim of discussing these inequalities is to build a case on why inclusive innovation approaches, especially in the context of developing countries, must mainstream gender in their design.

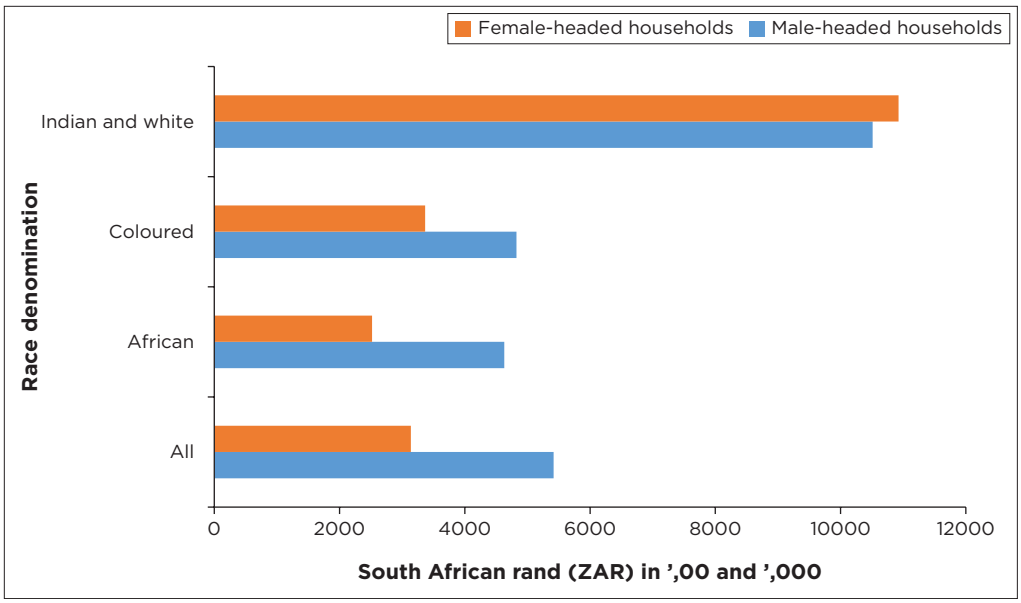
Gender inequalities in South Africa: Evidence from recent data

Similar to other developing countries, South African females are still affected by marginalisation and exclusion in various socio-economic sectors. Although the country has one of the most progressive constitutions and has policy programmes aiming to reduce gender inequalities, historical and structural inequalities persist. This section presents evidence from the GHS (2018) and the Quarterly Labour Force Survey (2020: Q2). The aim of this section is to

build from the previous argument made in the literature review that past development approaches/strategies have bypassed females. Therefore, this section attempts to show that although South Africa has made progress in terms of poverty reduction, some groups are still excluded from the economy and labour markets. The aim of discussing these inequalities is to build a case on why inclusive innovation approaches, especially in the context of developing countries, must mainstream gender in their design.

Figure 4.1 indicates the average monthly household income per capita, calculated by dividing the household income by the household size (total household members). On average, female-headed households have significantly lower monthly compared with male-headed households (female-headed household); the average income per capita is ZAR3 138 compared with ZAR5 417 in male-headed households. The independent *t*-test indicated statistically significant results ($t = -21.67$, $p < 0.01$), thus indicating significantly lower household income per capita in female-headed households.

Further analysis reveals that black females are most marginalised. Figure 4.1 indicates average household income per capita, but this time by sex and race of the household head. As the results indicate, black female-headed households have significantly lower household income per capita (mean = ZAR2 518) compared with others. To put this into context, a white



Source: Authors' calculation from General Household Survey Dataset (2018). Data are weighted to be representative of the South African households.

FIGURE 4.1: Average household income per capita by gender and race of the household head.

or Indian male-headed household's income is four times higher than that of the black female-headed households. When conducting regressions and controlling for other socio-economic statuses, black female-headed households had significantly lower income compared with other groups.

Next, we examine household poverty. Table 4.2 shows the poverty estimates in South African households by race and gender of the household head. Consistent with the findings, the prevalence of poverty is significantly higher in black female-headed households compared with others. For example, 23% of black female-headed households live in poverty, significantly higher compared with white/Indian male-headed households (1.3%). This pattern is similar across all other (lower and upper-bound) poverty lines.

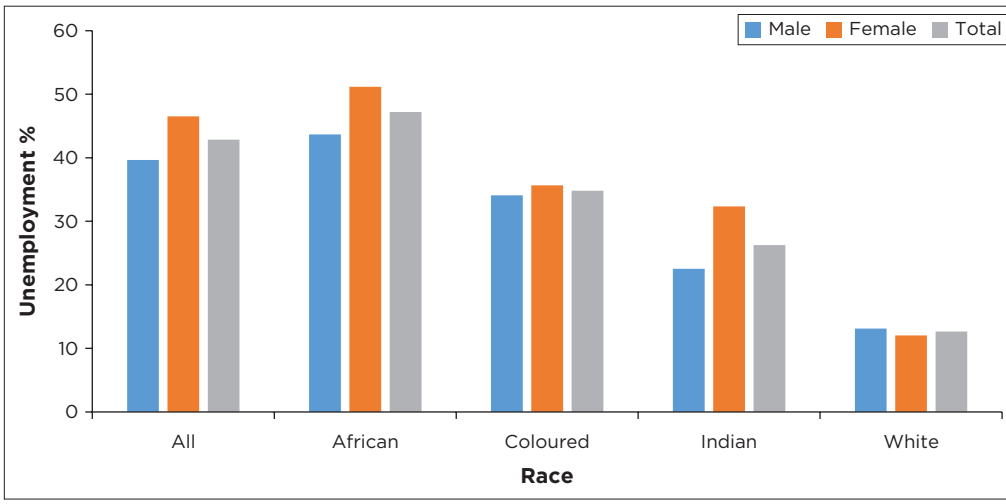
Figure 4.2 indicates that the percentage unemployment among females is higher compared to males. Chi-squared analysis indicated a statistically significant relationship ($chi^2 = 90.02$, $p < 0.01$). When focusing on race and gender, black females were more likely to be unemployed compared with other groups.

Empirical evidence provided supports the argument by researchers on the intersection of race, class and gender, as discussed in the 'Literature review' section (Willis 2011). Generally, black females are at the bottom of the chain compared with other groups. We can also argue that further marginalisation is taking place in the context of unequal poverty distribution between provinces and between rural and urban areas. Indeed, researchers have argued that the concentration of poverty is higher in rural compared with urban households. These statistics have several implications for innovation and development. Firstly, they show that if any development strategy aims to be inclusive and pro-poor, they cannot leave out gender in their design and implementation. Secondly, inclusive innovation cannot leave issues of gender inequality if it aims to benefit the excluded and marginalised group.

Table 4.2: Household poverty estimates by race and gender of the head of the household (breadwinner)

Criteria	Sub-criteria	Food poverty line (%)	Lower-bound poverty (%)	Upper-bound poverty (%)
African households	Male	10.7	15.2	24.0
	Female	29.6	38.1	50.3
	Subtotal	18.9	25.1	35.4
Mixed-race and coloured households	Male	7.3	10.1	19.0
	Female	17.1	21.2	30.7
	Subtotal	11.5	14.8	24.0
White and Indian households	Male	1.3	1.5	4.1
	Female	1.5	2.4	6.3
	Subtotal	1.4	1.8	4.7

Source: Authors' calculation from General Household Survey Dataset (2018).
Note: Data are weighted to be representative of the South African households.



Source: Authors' calculation from Quarterly Labour Force Survey Data Q3 (2020).
Note: Data are weighted to be representative of the South African adult population.

FIGURE 4.2: Unemployment by race and gender.

The status of innovation in South Africa and the role of females

In 2019, the then DST released a White Paper on STI. This document aimed to 'set a long-term policy direction for the South African government to ensure a growing role for science, technology' (DST 2019, p. 1). From this document, it can be argued that the government proposes systems of innovation that aimed for inclusive development and economic growth. This is in light of many talks of the 'Fourth Industrial Revolution' (4IR) circulating in the policy discourse. In fact, since coming in power as a President in 2018, Cyril Ramaphosa has made an emphasis on the 'digital revolution' or 'Fourth Industrial Revolution' in his State of the Nation Addresses. In 2018, the President stated that (State of the Nation Address 2018):

> We will soon establish a Digital Industrial Revolution Commission, which will include the private sector and civil society, to ensure that our country is in a position to seize the opportunities and manage the challenges of rapid advances in information and communications technology. (n.p.)

In 2019, similar statements were made (State of the Nation Address 2019):

> To ensure that we effectively and with greater urgency harness technological change in pursuit of inclusive growth and social development, I have appointed a Presidential Commission on the Fourth Industrial Revolution. Comprised of eminent persons drawn from different sectors of society, the commission will serve as a national overarching advisory mechanism on digital transformation. It will identify and recommend policies, strategies and plans that will position South Africa as a globally competitive player within the digital revolution space. (n.p.)

Although the Presidential Commission on the 4IR was established and made recommendations to the government, it is yet to be seen whether these are implemented. Regardless of whether this has been political rhetoric or not, we can establish that the talks of IID in policy instruments are not new in South Africa. In this section, we review various important documents relating to innovation that has been produced in South Africa.

White Paper on Science and Technology of 1996

In its framing, the *White Paper on Science and Technology of 1996* was based on the new democratic ideals at that time. Unsurprisingly, South African democracy was quite new at that time. It stated that its vision was based on the view that everyone (Department of Arts, Culture, Science and Technology 1996):

> enjoy an improved and sustainable quality of life,
>
> participate in a competitive economy using satisfying employment and
>
> share in a democratic culture. (n.p.)

It is also essential to put the *White Paper on Science and Technology of 1996* with the development agenda context of that time. In 1994, South Africa adopted the Reconstruction of Development Programme (RDP). Ambitious in its goals, the RDP aimed to address the social, spatial and economic inequalities of the past and build core inclusive and democratic South Africa. Within this background, many political and economic commentators regarded RDP as a strategy based on the ideals of social justice and inclusive development. Similarly, such ideals of inclusive development and social justice are circulated in the *White Paper on Science and Technology of 1996*. In more specific terms, the document mentions five underlying goals of innovation, discussed in Table 4.3.

The *White Paper on Science, Technology and Innovation of 2019* is more precise and more progressive than the previous white paper. The document notes the socio-economic issues (unemployment, poverty, inequality, health care and education challenges) in South Africa faces. In its policy framing, the *White Paper on Science, Technology and Innovation of 2019* aims to work towards achieving the goals of the NDP. Adopted in 2012, the NDP aims to reduce poverty and inequality by 2030 by growing the economy, building the infrastructure and improving social services such as health care, education and social protection (National Planning Commission 2012).

The NDP also makes a strong emphasis on STI (National Planning Commission 2012):

> Science and technology continue to revolutionise the way goods and services are produced and traded. As a middle-income country, South Africa needs to use its knowledge and innovative products to compete. On its own, a more competitive

TABLE 4.3: Goals of the *White Paper on Science, Technology and Innovation of 1996*.

Goal	Description
Promoting competitiveness and employment creation	• Innovation for growing micro-enterprises • Incentives and support for the business sector • Encourage R&D for business growth • Promote efficient use of technology in businesses • Increase the participation of historically excluded groups through innovation
Enhancing quality of life	• Environmental sustainability • Health care provision • Meet basic needs at the community level • Reduce the total cost of infrastructure provision • Provide safety and security to all who live and work in South Africa • Encourage the use of social innovation in communities
Developing human resources	• Promote science and technology education and training among the workforce • Develop new approaches to education and training • Innovation training for socio-economic problem-solving
Working towards environmental sustainability	• Adopt waste-minimising technologies • Innovation to address the problems of climate change, biodiversity loss and desertification
Promoting an information society	• Trickle-down benefits of informational revolution to communities • IT to address past imbalances and exclusion • Innovation for empowerment

Source: Adapted from Department of Arts, Culture, Science and Technology (1996).
Key: R&D, research and development; IT, information technology.

> cost of production will not be sufficient to expand the global presence of South African industry. This applies to both new industries and traditional sectors, such as mining. Innovation is necessary for a middle-income country to develop. (p. 33)

It further states that it aims to use technology for education and health care improvement and increase South Africa's competitive edge through innovation. It is within this context that the *White Paper on Science, Technology and Innovation of 2019* positions itself with the goals and vision of the NDP. More specifically, the objectives of the White Paper are to (RSA 2019):

- Improve coherence and coordination.
- Increase NSI partnering between business, academia, government and civil society.
- Strengthen and transform NSI institutions.
- Increase human capabilities.
- Expand research enterprise.
- Enhance enabling environments for innovation.
- Improve funding across the NSI.

The White Paper states that these objectives will be achieved by implementing the decadal plans, which will be reviewed every five years:

> The decadal plans will detail technology focus areas, programmes to be initiated, institutional arrangements and funding required for these programmes, and ways to evaluate their performance. They will be reviewed and updated every five years, or as deemed appropriate by the DST. (DST 2019)

To what extent do South African innovation systems and policies target and include females?

Analysing documents using methods explained in the 'Methodology' section showed that, at the policy level, the government had made emphasis regarding gender mainstreaming. Almost all the documents acknowledge the existing gender inequalities and that science and innovation must address these inequalities. The *White Paper on Science and Technology of 1996* states that racial and gender inequalities in science and technology in human resources (HR) and skills are very high. The 2002 R&D strategy report echoes this and state that there is:

> [*E*]vidence that women and people from previously disadvantaged communities have not benefited sufficiently in terms of access to, and participation in, science, engineering and technology in South Africa as yet. (DST 2002, p. 23)

The recent *White Paper on Science, Technology and Innovation of 2019* noted that although progress has been made in terms of reducing gender inequalities, there is still a lot of work that needs to be done (DST 2019):

> The participation of black people and women in the R&D workforce has increased considerably [...] The NSI is significantly underfunded, and the participation of black people and women at the highest levels (e.g. as professors) remains too low – to name but a few of the remaining challenges. (p. I, III)

In all these documents analysed, the emphasis is on including the previously disadvantaged population and especially black females, and the commitment to using innovation for inclusive, sustainable development is clear, as the 2002 R&D report notes (DST 2002):

> Science and technology for poverty reduction in South Africa and the region face the considerable challenges of poverty. In addition, it is women in the rural areas that shoulder the major part of the burden [...] In order for sustainable development to take place, rural and urban communities should have access to innovations that accelerate development and provide new and more effective solutions than those utilised previously. It is important that women play a key role in these processes. (p. 42)

What was clear from the analysis was that these policies recognise the intersection of race, gender and other aspects of exclusion and the need to consider these factors when designing policies. The *White Paper on Science, Technology and Innovation of 2019* is even more clear in this case as it specifically diagnoses the

socio-economic challenges and the most affected groups (Mpungose & Myeni 2021):

> South Africa has among the highest inequality rates in the world. In 2014, 21.5 per cent of South Africans lived below the poverty line. Black South Africans, particularly black women, continue to bear the brunt of poverty. Unemployment remains racially skewed. Youth unemployment is also of concern given that it increased from 30 per cent in 1994 to 40 per cent in 2013, leaving many young people, most of them black, on the margins of society (DST 2019, p. 2) Indeed, statistical indicators for the last ten years have shown that South Africa faces the issues of youth unemployment and those who are not in any form of employment, education or training. (n.p.)

With all these challenges cited, we have analysed strategies suggested by the government to reduce gender inequalities in STI and also to create innovative solutions to address females unemployment and poverty. The *White Paper on Science, Technology and Innovation of 2019* is clearer and more specific on the recommendations and plans as it states that one of its core goals will be developing a *National Systems of Innovation Gender Framework*. The *White Paper on Science, Technology and Innovation of 2019* states that its decadal plan will reduce gender inequalities and empower females in consultation with civil society and other government departments. Specific plans include:

- improving gender representation in NSI institutions
- ensuring gender-sensitive research agendas
- providing targeted support to female researchers and techno-entrepreneurs
- developing gender-sensitive monitoring and evaluation mechanisms
- putting in place mechanisms to unearth bias against females in the NSI and to develop appropriate responses – for instance, to address the risk of gender biases being perpetuated through incorporation into artificial intelligence (AI) applications (DST 2019, p. 25).

The *White Paper on Science, Technology and Innovation of 2019* further states that it will transform and broaden the base of the small firms and enterprises as one of the inclusive innovation strategies (DST 2019):

> In pursuit of an inclusive innovation system, particular attention will be given to supporting SMEs in informal settlements, rural areas and cooperatives. Furthermore, to support the transformation of the demographic ownership profile of technology-based firms (and in particular SMEs) in South Africa, the DST will develop guidelines, in cooperation with relevant NSI partners, to use intellectual property from publicly funded R&D under appropriate conditions to support women and black entrepreneurs when such intellectual property is commercialised. (p. 35)

If evidence shows that the economy tends to exclude females more than males, we argue that innovation programmes and policies and the national systems of innovation in South Africa must target and include females. Furthermore, we argue that females must not be seen as passive recipients of the benefits provided by innovation programmes but must be active players within the national systems

of innovation (transformative change). The following section shows how gender mainstreaming can happen using the TIP as a long-term framework.

Mainstreaming gender in the national systems of innovation: The potential role of transformative innovation policy

In this section, we propose that the TIP could be used to integrate gender as one of the important components within the country's innovative policies and systems. The TIP is an emerging framework that seeks to use STI for transformative transitions. It aims to address both local issues and those transboundary global challenges. In today's interconnected world, development approaches need to go beyond their boundaries to address issues such as climate change and sustainability.

Schot and Steinmueller (2018) traced the origins and development of TIP by outlining three innovations frame in a historical context: innovation for growth, national systems of innovation and transformative change. According to Schot and Steinmueller (2018), the first frame was popular from the 1950s to the 1980s. Influenced by the modernisation perspective, which was dominant at that time, the use of science and innovation here was for business growth, profit maximisation and the nation's economic growth. Little consideration was given to the negative environmental impacts. The first frame aligns well with the dominant development models at that time, the belief that economic growth will solve most of the world's problems. Negative environmental impacts and other externalities could be managed using technology. In the second frame, according to Schot and Steinmueller (2018), national systems of innovation are developed to complement the competitive advantage of the country. This frame became popular in the 1980s, and it is still dominant even today.

The third frame, which is the emerging TIP, recognises the global socio-economic and environmental challenges and that STI will have to play an important role to mitigate these impacts. The starting point for TIP is that STI has led to serious negative environmental challenges and inequalities between and within countries. For this reason, STI needs a new framing. TIP thus focuses on innovation that can bring transformative change and encourage sustainable socio-technical transitions (Schot & Steinmueller 2018):

> The development and implementation of transformative innovation policy requires a new knowledge base. Not one dominated by economics and innovation studies, but a more interdisciplinary one in which sustainability transitions studies, STI and more broadly governance studies, history of technology, and other fields contribute. Since transformation is a global process, it also requires a deep involvement of development studies. (p. 1564)

In this sense, the TIP recognises the global challenges and the need for innovation working towards achieving SDGs.

There are both theoretical and policy justification for why the South African national systems of innovation can mainstream gender through TIP. The literature in Science Technology and Innovation studies recognises that there is a need for socio-technical and environmental transitions to achieve SDG targets and mitigate climate change (Schäpke et al. 2017). Thus, this perspective recognises that innovation itself is embedded within the socio-technical systems. In this sense, the mainstreaming of gender within the TIP will further recognise that technology and innovation are not politically neutral; they can have different unequal outcomes for males and females. Depending on the state of gender equality in the country, new innovative solutions can either entrench and reproduce existing gender inequalities or mitigate them. In the context of South Africa, where there is evidence of female exclusion and disadvantage, gender perspectives need to take priority.

We now know that innovation and technology seldom benefit females and males equally. This gender gap constrains efforts to achieve gender equality and female empowerment and prevents females from becoming developers and consumers of technology that addresses their needs. Therefore, an innovation that is required is that it would help to address environmental, social, inclusion and sustainability challenges. It is argued that, from a transformative innovation lens, it is essential that policy-makers consider the use of policy instruments that target inclusion and sustainability that can help in challenging gender inequalities as that can also help in dealing with SDG challenges in existing and future policy mixes.

We know that the co-creation of knowledge, innovation and policy agenda, priority setting and community-driven learning are essential to transformative innovation. Individuals, including females and communities, are essential local agents for change, transformation and achieving the SDGs governing transformative innovation policies; policy-makers (likewise funders and researchers) must place a strong emphasis on the inclusion of broad base participation of actors who are often excluded in policy processes. Actors such as females and youth are very crucial even though they are excluded, lack resources or lack access, they are vital to the success of innovation activities. There will be no miracle for addressing and mainstreaming gender inequalities rather than capacity building directed to researchers and policy-makers involved in STI policies. It can be argued that the success of the mainstreaming of gender and empowerment of females depends on strengthening the capabilities of researchers, and policy-makers in TIP will help to ensure that STI policies in post-apartheid South Africa are refocused on addressing the gender inequalities, drawing on the TIP approach.

Conclusion

This chapter engaged the broader conceptual debate on gender, development and innovation. The idea was to show that the earlier work of feminist in development was the critique of the grand theories, which did not seriously consider female roles and their voices within development models. Moreover, the chapter reviewed the debates, data and indicators on the intersection of gender, race and class in South Africa to justify why innovation must be studied to understand the challenges for innovation for female empowerment and gender equality. In this chapter, we presented empirical evidence on gender inequalities in South Africa. The aim of discussing these inequalities is to build a case on why inclusive innovation approaches, especially in the context of developing countries, must mainstream gender in their design. Thirdly, we argue that gender approaches can be integrated into the existing innovation systems using TIP.

The argument presented and findings reported in this chapter have several implications for IID and for policymaking. Firstly, we have shown that innovation can be regarded as a linear process and thus, cannot be measured through linear models. Innovation must take into account the existing local realities. Secondly, we cannot separate politics from innovation. When we do this, we are running in danger of regarding innovation as a 'technological fix'. This point is important as it relates to gender; innovation can be regarded as a gender-neutral intervention. When it does this, it also runs in danger of maintaining and reproducing existing gender inequalities. In fact, we may go as far as to argue that innovation approaches that claim to be inclusive and pro-poor, but do not centre gender in their design and implementation, are anti-poor.

Chapter 5

A transdisciplinarity approach to citizen science and grassroots innovation

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Introduction[9]

An effort to bring current social realities in line with new scientific findings, as well as newly designed technological systems and devices, requires a revisit of foundational discipline embedded paradigms. Such a revisit requires, as primary conditionality, a clear articulation of advocacies within our current complex systems to ensure a closer and interactive relationship between science and society. Nowotny, Scott and Gibbons (2002) in this regard developed an open and dynamic framework to support these requirements by means of four conceptual pillars based on the nature of Mode 2 society; the contextualisation of knowledge in a new public space called the agora; the development of conditions for the production of socially robust knowledge; and the emergence of socially distributed expertise. Although not mentioned

9. Sections of this chapter represent a substantial reworking of the following publication: Du Plessis (2020).

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explicitly, these four pillars pave the way for citizen science to officially enter the space of new knowledge production and position grassroots innovation within the context of useful and socially embedded localised innovation.

Cilliers (1998) investigated the deficits of current research processes within the context of complex social and technological systems. He identified the limitations of the analytic method and the failure of algorithmic and information-theoretical approaches against the necessity to '[...] facilitate meaningful and special understanding of the relationships within specific environments' (1989, p. 24). The ideal will be not only to initiate an understanding of the limitation of complex systems where knowledge is created but also to introduce a connectionist model of complexity that is more embedded in reality. This reality is where citizen science and grassroots innovation processes play a vital role in adding to the transdisciplinary (TD) generated knowledge base.

To bring citizen science and grassroots innovation to the attention of the sciences, we could repeat the poignant statement by Hountondji (1997):

> [*T*]here exist within our oral cultures corpuses of knowledge sometimes very elaborate. What becomes of such corpuses? What of their relations with assumedly modern science, that is, the progressive, conquering, heuristic activity now developing in our universities and other centres of intellectual production, the institutional research that depends structurally on the west? (p. 13)

An integral part of these 'corpuses of knowledge', I will argue, is the innovations that emerged from local traditional and informal knowledge systems over a very long period. This statement immediately indicates that innovations are not newly modern, or linked to modernism, but are integral in managing the way people live and resolve their social and geographically specific problems. When Nabudere (2012, p. 3) proposed the institution of a 'restorative justice movement' and a 'new epistemology' that will lead to the restoration of social relations in society that should bring about a new sense of security and restore dignity and harmony within communities, we identify an echo of the neglect of assimilating indigenous knowledge (IK) into modern sciences. We only recently began to acknowledge that, without some blending between informal and formal knowledge, a holistic understanding of society within nature creates misconceptions and that eco-social problems are often little understood, acknowledged or recognised by formal academic sectors.

Background to citizen science and grassroots innovation

Knowledge about the eco-social need, technical process and product application of grassroots innovations could evolve as valuable epistemological additions to our corpus of knowledge. To do so, a better understanding must be developed to support little understood factors influencing the success and

failure of innovative practices, whether within old traditions or within new technologically driven challenges. It is important to realise that the external environment, government-level service for the public good and the expression of socially and economically valued products all form part of an extensive network. There is an eagerness emerging to identify, understand, acknowledge and absorb such innovations. But, at the same time, we need to concede that the kind of innovation that is of benefit to the poor and the excluded sections of society remains a neglected field of study because it does not formally rely on academically driven science and technology input. Against a background of recognition that innovations and new institutional arrangements for reducing poverty depend on supportive national policies, it is now urgent that we recognise and amplify this need to fast-track and balance our understanding of useful innovations and creative innovative thinking to ensure rapid economic growth.

Grassroots innovation takes place outside of deliberate academic interventions and is often happening in tandem with the interests of citizen scientists and their involvement with a community problem or a natural (locally as well as globally geographic specific) phenomenon that influences and affects society. In this regard, we are, therefore, obliged to acknowledge the advantages of a holistic, all-embracing TD approach and its epistemological imperative when doing research on grassroots innovation and citizen science practices.

On a much more global scale, the changes in climate brought about by the Anthropocene (Smith 2018) should be seen as accelerating inequality and poverty. Such inequality is often prominent within racial, as well as gender, positions. Innovation, which is ultimately embedded in a combination of the social sciences, humanities and science and technology, might ignore these neglected social imperatives at its own peril. It is not possible for science to tackle scientific issues, relevant to different societies that are situated in specific geographical localities, on an equal basis. Nor is it possible for scientists to coldly indicate their findings that humanity is genetically all the same and should be treated as such, without taking socio-political and economic issues into account.

A return to the local and immediate needs of people and to address inequality and poverty indicates that grassroots innovation and citizen science are capable to support, in an open and fair manner, some solution to this dichotomy. Applying a TD approach within a fast-evolving complex world enables the introduction of additional, value-adding aspects, embedded in the soft sciences, such as attention to the importance of care, self-care, care for others and living carefully. These are important elements in the innovation process and will enhance and advance response to social challenges (Laugier 2013).

Innovation per definition

To capture the true essence of what innovation means is not always possible. The South African government's (Department of Science and Technology [DST] 2012) approach is that:

> [*I*]nnovation is the capacity to generate, acquire and apply knowledge to advance economic and social purposes. It includes both the search for frontier technologies driven by R&D, as well as the forms of learning and adaptation that might be market led or socially driven. Innovation is fundamentally uncertain, highly contextual and path dependent, but it is the heart of moving the country from its present mix of resource- and efficiency-driven economic activity to one that is driven by the generation and application of knowledge. It is about doing new things in new ways. (p. 15)

Complexity consists within our natural and artificial worlds, and societies are no longer static or situated within specific geological domains. As stated by Ferguson (2017, p. 15), the natural world is made up of 'optimised, space-filling, branching networks,' in addition to humanities' formation of social networks built upon the structures humans beings naturally form, beginning with knowledge itself and the various forms of representation we use to communicate. Human patterns of settlement, migration and all manners of social arrangements act upon our innate, ancient urge to network and in modern times, new technologies have become the facilitators and activators to network and communicate instantly across the globe. Traditionally, in order for knowledge to proliferate, we formed social geographically bound networks (cultures), and this is reflected in the current interest and purpose of those striving to maintain and protect the IK systems of indigenous peoples who adapted their lifestyles to suit their ecological and geographical surroundings.

Whereas innovation is *per se* closely linked to the development of products, its application in the area of new systems and social practices is intimately entangled within the way we live, migrate and communicate. It will, therefore, be foolish to ignore the necessity of recognising the forms of social innovation as part of the process of innovation. One example might be in looking at proposals based on the argument that we are facing a new social structuring of society (Parsons 2010). Hardt and Negri (2000) considered the rise of a new form of society (the Multitude), which represents a technologically linked society. This introduces a new era of social relations, brought about by the rise in industrial and managerial technology in a world dominated by transnational corporations, and is based on a new global hegemony of 'systemic totality'. This multitude consists of an ensemble of individuals whose life tool is the brain and whose productive force exists through cooperation. In the current fast-evolving societies, Munro (2002) proposed that new social formations are brought about by:

> [*T*]he massive migrations from the country to the metropolitan centres, the flows of legal and illegal migrant workers upon which transnational corporations depend, and the millions of disposed who have had to flee famine and war. (p. 176)

The social impact of technologies, as well as innovations, could bring about some positive changes in society. Extending this impact to low-income communities in the Global South requires successful implementation and use of technologies on a large scale. Therefore, technological innovation must be developed in line with the objectives of a circular economy and be adequately recyclable. Through new products, services, models and practices that involve new social collaboration, we notice an emerging 'new normal' that exists relative to social innovation (Hart et al. 2014; Mayer-Schönberger & Cukier 2013).

It must be considered then that, in this fast-paced globally linked society, the need to develop, understand and acknowledge grassroots innovation, as well as the contributions made by citizen scientists, entered a space of new urgency. To facilitate this process, we need to apply a TD approach to the research required to do so.

The transdisciplinary approach

It has been accepted within academic circles that the TD approach to research has become an important asset in all fields of human interaction with natural systems, including those where humans depend on natural resources to survive and where economic exploitation serves as a driver (Gibbons & Gummett 1984; Gibbons et al. 1994; Klein 2014; Nowotny et al. 2002; Valiani 2012). These interactions are, as a rule, facilitated by technologies or give rise to the development of new technologies. In addition, to ensure public acceptance, TD plays an important role in areas of communication of scientific findings as well as when introducing new technologies (Jantsch 1972; Klein 1996). Areas of research where social values and cultures are affected by technical and economic development (such as in, for example, nuclear and biotechnology) have already become dependent on TD to ensure not only effectiveness but also social acceptance (Klein et al. 2001; Klein 2014).

As an example, we witnessed how TD became an integral part of the archaeology of health care diagnostics through extensive epistemological questioning about the nature of medical diagnostics (Levine 2012). To prevent the challenges posed by migrant work and the export of labour in a position of absolute unequal labour exchange, as argued by Valiani (2012), the undervaluation of, for example, health care and nursing has a detrimental effect on society. It is not always possible to globally address '[…] the causes and consequences of the inability to forge collectively oriented social and economic development' (Valiani 2012, p. 148). This paves the way for the innovation of more efficient services, based on local

systems of knowledge. It will also affect the manner in which knowledge systems are functioning and managed, and this process is central to the way TD developed.

As argued, TD is an accepted and widely recognised part of the integrated process of Mode 2 of knowledge production (Gibbons et al. 1994). Klein et al. (2001, p. 11) refer to the forward as well as reverse processes of knowledge production:

> [*W*]hen the primary goal is to profit first from existing, but widespread and often controversial knowledge, and where computer-aided information will be increasingly useful, to where existing general knowledge must be applied to very specific but inherently complex cases, as when localized environmental standards for soil reclamation have to be set or the decline of fish population in whole river systems has to be understood.

Transdisciplinary is successful when there is, from the outset, a very specific goal, based on a specific socially identified or agreed-upon problem. In his attempt to demonstrate that there is more to knowledge than the research generated in academic institutions, Gibbons and Gummett (1984) identified two models or modes. He started off by calling the conventional, discipline-bound way of research 'Mode 1', where knowledge '[…] is validated by the sanction of a clearly defined community of specialists' (Gibbons et al. 1994, p. 22). These discipline-bound areas are characterised by academia viewing the scientist/researcher as an independent (and isolated) agent of knowledge, often having no need to consult outside the field of their specialised interest.

When one shifts outside the parameters established by accepted research paradigms and academically constructed disciplines, one starts to work in 'Mode 2' or in a TD mode. This then brings together actors from different academic disciplines, in accordance with the principles of Mode 2 of knowledge production, as Mode 2 of knowledge production introduced the notion of multiple participants in research as well as proposing academic and social diffusion of sites of knowledge production. Gibbons and Gummett (1984), in their support for an alternative way of looking at the production of knowledge, as in Mode 2, inadvertently proposed this alternative route for research methods that could, as an example, successfully capture the IK embedded within geographically specific and traditional communities as well as the new knowledge coming from migrants and geographically displaced people. Utilising Mode 2, Gibbons strived to supplement the shortcomings and inadequacies within the established discipline-bound areas of specialisation. In Mode 2, Gibbons et al. (1994, p. 4) proposed a methodology that would integrate the different skills across various social and cultural traditions into a 'framework of action'. The purpose of the establishment of a framework of

action is to investigate the possibility of consensus across and between disciplines.[10]

The possibility opened up by Mode 2 of knowledge production is capable of facilitating communication around shared interests of research. This adds new impetus and meaning to the research process as a whole. Gibbons et al. (1994) further identified the heterogeneity and organisational diversity of the TD process by recognising authentic and potential sites of knowledge outside of the academic and institutional domain. This paves the way for collaboration with grassroots innovators as well as citizen scientists through its acceptance that universities and colleges could fruitfully work with non-university institutes, research centres, government agencies, industrial laboratories, think-tanks, consultancies and individuals. By establishing communication links between the various sites of knowledge, it becomes possible to join functioning networks of electronic, digital, organisational, social and even informal channels of communication. It also becomes possible to recombine and re-figure the dominant paradigms found in various fields and sub-fields of knowledge production to form the basis for new forms of knowledge. From this perspective knowledge, production must move increasingly away from traditional disciplinary activity into new societal contexts (Gibbons et al. 1994, p. 6).

Applying this process of shifting paradigms, establishing new criteria and new constituencies of knowledge creation is possible as previously argued by Nowotny et al. (2002). The most important factor, however, is that people's knowledge is recognised within the process of knowledge creation (Hart et al. 2014). This 'privilege' comes with its own challenges and might even create a sense of disparity in an unreal world, mostly characterised by complexity and complicatedness. In addition, the expansion of the role of social actors as knowledge creators raises questions of academic capability, ability and objectivity. At the same time, it is necessary to recognise that social relationships are not fixed or stable, creating their own opportunity for transgression. It also implies that deep reflectivity is not always possible. The social input varies between amateur observations, the so-called precariat's

10. In the Mode 2 of knowledge production in a transdisciplinary methodological process Gibbons et al. (1994) identified four main advantages: (1) Transdisciplinarity '[…] develops a distinct but evolving framework to guide problem solving efforts' (Gibbons et al. 1994:5). (2) Transdisciplinarity engages with both empirical and theoretical aspects of knowledge that originates from within 'a particular context of application' (Gibbons et al. 1994:5). Although this combination adds to the growth of knowledge, the accumulative effort does not necessarily fall within a discipline and can therefore shift into any direction even after a particular problem has been solved. (3) Transdisciplinarity transcends the limitations of communication, and is capable of breaking down the barriers to communicate by establishing a relationship of dialogue between the researcher and the community. This may lead to an endless re-configuration and re-application of research findings. It will also break down the stereotype of associating and restricting the production of knowledge to the domain of the university (Gibbons et al. 1994:5). (4) Transdisciplinarity is a dynamic process and capable of establishing a closer interaction of '[…] knowledge production within a succession of "problem contexts"' (Gibbons et al. 1994:5).

non-institutional affiliations, common people expressing deep knowledge within the geological context and new knowledge shared by migrants who relocate to new geographical spaces.

Citizen science[11]

The most important characteristic of citizen scientists is that they are people who are driven and motivated by curiosity. Their interests are numerous and historically included actions such as counting species or reporting sightings of birds, butterflies and mammals and even collecting debris on the coast. Citizen science may be performed by individuals, teams or networks of volunteers. Citizen science (crowdsourcing, volunteer monitoring or networked science) is also scientific research conducted, in whole or in part, by amateur (or nonprofessional) scientists.

Citizen science is sometimes described as 'public participation in scientific research', because it requires participatory monitoring and participatory action research. I will argue that there are two different activities that involve citizen scientists in research. The first is the independent, curiosity-driven individual, and the second is the deliberate involvement of citizens in the academic research process that adds additional information to the main research question being investigated by scientists. With a few exceptions, the case of the first kind of citizen scientist often led to a few individuals receiving recognition for their contribution to science by institutions such as the British Royal Academy of Science. These individuals were, as Albert Einstein famously claimed, driven by curiosity and obsession (and not inheritance or upbringing) (Smith 2003).

Joining the ranks of scientists like Einstein we also have the so-called amateur explorers, botanical illustrators, fauna and flora collectors, and intrepid explorers. Their notes on travel experiences and observations of different cultures, botanical specimen collections and field notes still fill the archives of Science Museums across the world. Motivated by the interest or sometimes honour received through the Royal Academy of Science, their passions and obsessions saw the light in thinking out of the box mostly established by their contemporary academic scholars (Maddox 2017). Some citizen scientists can be both. In publications such as George Scrope's *Geology and extinct volcanoes of central France* (Scrope 1827), for example, we find the profitable exchange of notes between what can be considered a personal interest and its shift towards being valued and even absorbed by academia. In the first journal papers of the Philosophical Transactions of the Royal Society

11. For further information regarding sources, please see the notes in this chapter. This section of this chapter is based on the following publication: Du Plessis (2020).

(initiated in 1665), meticulous evidence of all kinds of new discoveries and a change in scientific research culture was presented by many scholars who were formally employed, privately sponsored or driven by pure curiosity (Fortey 2008).

A further appropriate example of citizen science in the past is the evidence of astronomical as well as botanical observations we find in the ancient manuscripts of Timbuktu. Recognition of the value of past science citizens, Jeppie and Diagne (2008) aptly prosed in *The meanings of Timbuktu* that:

> [*A*]n ongoing scholarly investigation across disciplines, and a broadening of the present narrow base of specialists concerned with this rather neglected aspect of the history of Africa, remains imperative. (p. vii)

Against this somewhat prophetic observation, it is becoming clear that the importance of citizen science has changed over the years. As Fortey (2008) predicted:

> [*I*]f the early phase of systematic learning was mostly powered by privilege, the middle phase by support from government for professionals, maybe the third phase will be immensely democratic, and driven by the freedom of information exchange thrown up by the web. (p. 310)

Shifting away from the crucial contributions coming from adventurers, travel writers and specimen collectors, what we more recently find then is that a citizen scientist is considered a member of the general public who collects and analyses data relating to the natural world: typically, as part of a collaborative project with professional scientists. In addition, the phrase 'citizen science' was only coined in the mid-1990s by Alan Irwin, a sociologist, who defined it as both '[…] science which assists the needs and concerns of citizens' and as 'a form of science developed and enacted by the citizens themselves' (Irwin 2018, n.p.).

The understanding of what citizen science is was expanded further upon after a 'Green Paper on Citizen Science' was published in 2013 by the European Commission's Digital Science Unit and Society. This included the definition (Lewenstein 2016):

> [*T*]proposed that what citizen science offers is not so much new knowledge but more about citizenship since it links academia with non-scientists in the process of gathering data according to specific scientific protocols and in the process of using and interpreting data. Citizen science forms part of Science Engagement and allows for non-scientists to participate in true decision-making about policy issues that have technical or scientific components. Such engagement with research scientists in the policy domain adds tremendous value to government policies. (n.p.)

Formal acceptance of the term 'citizen science' by academia happened in January 2015 when the ETH Zürich and University of Zürich hosted an international meeting on the 'Challenges and Opportunities in citizen science'. The first citizen science conference hosted by the Citizen Science Association

was in San Jose, California, in February 2015 in partnership with the American Association for the Advancement of Science (AAAS) Conference. The Citizen Science Association Conference, CitSci 2017, was held in Saint Paul, Minnesota, USA, between 17 May and 20 May 2017. The conference had more than 600 attendees.[12]

Today, citizen science uses new technologies that are increasing the options for doing citizen science. Citizen scientists can build and operate their own instruments to gather data for their own experiments. Examples like amateur radio and amateur astronomy, open-source hardware (scientific equipment), Open Data Open Science and the Science Commons are networks used by citizen scientists (Cooper 2018).

Examples of technology-based platforms include Zooniverse as home to the Internet's largest, most popular and most successful citizen science projects. The Zooniverse and the suite of projects it contains are produced, maintained and developed by the Citizen Science Alliance (CSA). The member institutions of the CSA work with many academic and other partners around the world to produce projects that use the efforts and ability of volunteers to help scientists and researchers deal with the flood of data that confronts them. On 29 June 2015, the Zooniverse released a new software version with a project-building tool allowing any registered user to create a project. Project owners may optionally complete an approval process to have their projects listed on the Zooniverse site and promoted to the Zooniverse community.

12. During September 2015, the European Citizen Science Association (ECSA) published its Ten Principles of Citizen Science (Robinson et al. 2018). The European Citizen Science Association (ECSA) Ten Principles of Citizen Science (Robinson et al. 2018) are: (1) Citizen Science projects actively involve citizens in scientific endeavour that generates new knowledge or understanding. Citizens may act as contributors, collaborators, or as project leader and have a meaningful role in the project. (2) Citizen science projects have a genuine science outcome. For example, answering a research question or informing conservation action, management decisions or environmental policy. (3) Both the professional scientists and the citizen scientists benefit from taking part. Benefits may include the publication of research outputs, learning opportunities, personal enjoyment, social benefits, satisfaction through contributing to scientific evidence e.g. to address local, national and international issues, and through that, the potential to influence policy. (4) Citizen scientists may, if they wish, participate in multiple stages of the scientific process. This may include developing the research question, designing the method, gathering and analysing of data, and communicating the results. (5) Citizen scientists receive feedback from the project. For example, how their data are being used and what the research, policy or societal outcomes are. (6) Citizen science is considered a research approach like any other, with limitations and biases that should be considered and controlled for. However unlike traditional research approaches, citizen science provides opportunity for greater public engagement and democratisation of science. (7) Citizen science project data and meta-data are made publicly available and where possible, results are published in an open access format. Data sharing may occur during or after the project, unless there are security or privacy concerns that prevent this. (8) Citizen scientists are acknowledged in project results and publications. (9) Citizen science programmes are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact. (10) The leaders of citizen science projects take into consideration legal and ethical issues surrounding copyright, intellectual property, data sharing agreements, confidentiality, attribution, and the environmental impact of any activities.

A NASA/JPL picture to the right gives an example from one of Zooniverse's projects named 'The Milky Way Project'.[13]

CrowdCrafting enables its participants to create and run projects where volunteers help with image classification, transcription, geocoding and more. The platform is powered by PyBossa software, a free and open-source framework for crowdsourcing.[14]

Project Soothe is a citizen science research project based at the University of Edinburgh. The aim of this research is to create a bank of soothing images, submitted by members of the public, which can be used to help others through psychotherapy and research in the future. Since 2015, Project Soothe has received over 600 soothing photographs from people in 23 countries. Anyone aged twelve years or over is eligible to participate in this research in two ways: (1) by submitting soothing photographs that they have taken with a description of why the images make them feel soothed and (2) by rating the photographs that have been submitted by people worldwide for their soothability.[15]

There are also smartphone apps available for monitoring birds, marine wildlife and other organisms, through themes such as the 'Loss of the Night'. The Android app Sapelli, for example, is a mobile data-collection and data-sharing platform designed with a particular focus on non-literate and illiterate users with little or no prior information and communication technology (ICT) experience.

'The Crowd and the Cloud' citizen homepage consists of a four-part series broadcast during April 2017, which examines citizen science. It shows how smartphones, computers and mobile technology enable regular citizens to become part of a 21st-century way of doing science. The programmes also demonstrate how CSs help professional scientists to advance knowledge, which helps speed up new discoveries and innovations. The Crowd and The Cloud is based on work supported by the National Science Foundation.[16]

We have numerous examples from South African projects that involve citizen science projects.[17] This is good news for our profile in participation and

13. Viewed 13 November 2020, from https://www.zooniverse.org/.

14. Viewed 13 November 2020, from http://www.projectsoothe.com/.

15. Viewed 13 November 2020, from https://scifabric.com/crowdcrafting/.

16. Viewed 13 November 2020, from crowd and cloud.org.

17. South African projects include: The Stream Assessment Scoring System (miniSASS) which 'encourages enhanced catchment management for water security in a climate stressed society' (viewed 13 November 2020, from http://www.minisass.org/en/).

The citizen science project Snapshot Serengeti classifies animals at the Serengeti National Park in Tanzania (viewed 13 November 2020, from https://www.zooniverse.org/projects/zooniverse/snapshot-serengeti).

The Forestry and Agricultural Biotechnology Institute (FABI) at the University of Pretoria that makes use of members of the public, or 'citizen scientists' to identify *Phytophthora* species present in the fynbos flora (viewed 13 November 2020, from https://www.fabinet.up.ac.za/index.php/arp-projects/phytophthora-cinnamomi).

promoting citizen science. Expressing confidence in the active participation of citizen scientists in research, the European Commission (EC) under its European Research Area advertised in 2020 for interested parties to apply for funding according to the following: The active role of citizens and their direct involvement are essential to address climate change and other human actions harming the environment on land, air and sea. Changes in citizen's and consumer's behaviours towards more sustainable patterns can happen through education, awareness raising, citizen science, observation and monitoring of their environmental impacts, civic engagement and social innovation. It is essential to directly involve citizens and communities in contributing to climate action and protecting the environment, thereby encouraging them to change their personal behaviour and their mindsets, reducing their carbon and environmental footprint and taking action at the individual and collective level. This would lead to a more sustainable lifestyle and relationship to the environment.[18]

To conclude, it is important to note that citizen science, in general, helps improve literacy and understanding of science and nature among members of the public. In many cases, participants come away with a greater appreciation and understanding of the scientific process and deepened knowledge of the topic they are researching. Citizen science projects, however, are more than mere training to participate as a member of a well-executed project. Citizen Scientists develop the ability to collect meaningful data that require significant planning and ongoing communication with a network of professionals and volunteers and involve the substantial follow-up data analysis and communication of research findings.

Grassroots innovation

Citizen science is a twofold process driven by personal interest and personal commitment, based on a specific research task as well often involving active collaborative participation with academically driven research projects. Methods make use of field observations over a specific period. Grassroots innovation, on the contrary, requires a bit more of a complex environment to flourish. The reason for this is that innovation, on grassroots level, involves multiple TD interactions, between often very polarised conceptual domains. The activities related to grassroots innovation have the tendency to blur the boundaries between informal and formal knowledge, based on individual and professional actions versus organised corporate action. It sometimes even infringes upon local and global interests and is restricted by social and economic limitations (Iizuka 2013; Iizuka & SadreGhazi 2011).

18. See https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/lc-gd-10-3-2020

In a working paper for the Mapungubwe Institute for Strategic Reflection (Du Plessis 2020), I argued that grassroots innovation speaks to the way in which indigenous peoples live by an almost instinctive sense of the ecological integrity of their environment, in order to transform nature and create a habitable space. I considered this not only against a background where the changing climate and its ecological fall-out are affecting lives but also against the global penetration of the media, technology, industry and modern economics that is bringing about transformations to local cultures through the introduction of new systems and products of monocultures that ignore previous preconditions of biodiversity (Du Plessis, Sehume & Martin 2014). The challenge is that it has become imperative that humanity will have to adjust to a transformed natural environment and the socio-political dominance brought about by technology (Shrivastava & Kothari 2012).

Against these 'threats', the main aim of grassroots innovation is, therefore, to establish a locally sustainable livelihood and empowerment for communities. There are three challenges facing those embarking upon the grassroots innovation process: firstly, the ability to attend to local specificities while simultaneously seeking wide-scale diffusion; secondly, to identify suitable existing situations that one ultimately seeks to transform; and thirdly to work with project-based solutions within goals of social justice where root causes rest in structures of economic and political power. Each challenge effectively frames grassroots innovation differently, and responses generate valuable forms of knowledge production such as grassroots ingenuity, grassroots empowerment and structural critique.

Grassroots innovation is currently receiving specific attention from the South African Department of Science and Innovation (DSI), in collaboration with its entity, the Technology Innovation Agency (TIA). The government officially launched the Grassroots Innovation Programme in March 2019. Grassroots Innovation Programme is designed to identify and support innovators and inventors who do not have a formal education or access to formal innovation facilities. The DSI *White Paper on Science, Technology and Innovation of 2019* commits South Africa to an inclusive and responsive NSI that is able to support all kinds of innovation. It is within the Department of Trade and Industry (the DTI) where the function for grassroots innovation currently resides.

Many debates were introduced to get to some understanding of the functionality as well as implementation and legal protection of grassroots innovation. The Academy of Science of South Africa (ASSAf 2019) reported, as an example, on the Protection of Intellectual Property for Grassroots Innovation[19] where it was mentioned that many grassroots innovators do not have a formal education and lack an understanding of the law. In addition,

19. doi: 10.17159/assaf.2019/0053 – accessed 15/19/2020

both the NSI and the 2011 NDP highlight the centrality of STI in national development policies and processes that has a direct impact on the support available for grassroots innovation. The NDP notes, in addition, that development in STI could fundamentally alter the way people live, communicate and transact, with profound effects on economic growth and development. The NDP further indicates that countries that are able to tackle poverty effectively by growing their economies are characterised by strong STIs. This implies that STI is fundamental to the promotion of equitable economic growth that underpins economic advances and improvements in health care systems, education and infrastructure. Furthermore, the NDP acknowledges that STI and NSI have roles to play in improving South Africa's global competitiveness. This is significant as the trend to support innovation is a globally popular goal as we witness in Europe and countries such as China and Russia (Du Plessis 2020).

One of the best global examples of grassroots innovation is found in the Honey Bee Network (HBN)[20] The HBN, founded by Anil Gupta in 1988 in India, is a social justice initiative that has the aim of fixing failures of top-down development initiatives led by the government. The HBN is based on three main guiding principles that speak directly to a TD approach. Firstly, when new knowledge is collected, it must be shared back with the sources and the communities in their local languages. In the past, it was seen that academic researchers would obtain all the information from the grassroots level and distribute it in ways that were inaccessible to the knowledge producers. The second principle is that the source of the knowledge must be acknowledged. Finally, the knowledge holders must benefit from the success of their work and inventions in both fame and remuneration.[21]

Science literacy as pre-condition for grassroots innovation

While the NDP acknowledges that advances in technological innovation and the production of new knowledge are critical to growth and development, I will, in addition to this, argue that no economic viable grassroots innovation

20. See https://www.honeybee.org/

21. See https://socialinnovationexchange.org/insights/honey-bee-network. The HBN is an amalgamation of like-minded people, be it innovators, farmers, scholars, academicians, policy-makers and entrepreneurs, institutions and civil society. Based on a specific philosophy of discourse, the HBN functions on four fundamental principles: (1) The innovators should not become anonymous; their identity must be acknowledged and given due recognition, respect and reward. (2) Whatever is learned from people must be shared back with them with value addition in their language and in a manner that they can understand. (3) Following the principles of cross-pollination, engaging in people-to-people learning entails sharing ideas openly among the community. (4) If any income, wealth or monetary incentive is generated through diffusion of innovation or any other activity related to it, a fair part must be shared back with the innovator/knowledge holder and insight provider.

is possible without a measure of scientific literacy. Scientific literacy is considered to be an individual's ability to have a basic understanding of scientific concepts and processes required for personal decision-making. This will enable the individual to participate in social and cultural affairs and, in this case, support the innovation process. It is an indication of a person's level of understanding science and technology when such a person is able to function as an engaged citizen in a modern industrial society. Scientific literacy has the additional benefit of its capability of strengthening democracy.

For innovation to thrive in disparate and complex social and ecologically specific environments, it becomes crucial for governments to pay attention to the development of science literacy. A scientifically literate person will have the ability to describe, explain and predict natural phenomena; read with understanding articles about science in the popular press; and engage in social conversations about the validity of scientific inventions. A scientifically literate person will develop an understanding of the scientific method and an appreciation of the quality of scientific information shared by the media and science communicators (Du Plessis et al. 2014).

Within this context, science literacy may, therefore, be broadly conceptualised as having three dimensions: Practical scientific literacy, which indicates scientific knowledge that can be applied to help solve practical problems; civic scientific literacy, which enables a citizen to become more aware of science and science-related issues and thus participate more fully in the democratic processes of an increasingly technological society; and, finally, cultural scientific literacy, which is an appreciation of science as a major human achievement (Durant 1994; Miller 1983, 1998; Shen 1975; Shumba 1999). Miller (1983) emphasised that in a democratic society, the level of scientific literacy in the population has important implications for science policy decisions and will help improve the quality of both science and technology and political life.

Technology in support of actions involving citizen science and grassroots innovations

Innovation, specifically grassroots innovation, and the application of citizen science function better when seen in a context of mutuality of knowledge creation processes, supported by the formal knowledge brought in by science and technology. Understanding the complexities often witnessed in complicated situations, I argued, adds value and serves the purpose of framing the approach followed by citizen science and grassroots innovative actions and supports whatever science methods and mathematical equations are used in the innovation process.

We need to be very clear about what we mean by technology when shifting into citizen science and grassroots innovative areas of research. Dusek (2006)

provided us with a comprehensive definition of technology that will enable us to consider the full implication of technological innovation and a citizen scientist's contribution to society. Dusek (2006, p. 32) proposed that there are three definitive aspects of technology that must be taken into account when trying to understand the technological process as a process of knowledge.

We must first understand 'technology as hardware'. Here, Dusek (200, p. 31) stressed the importance of 'tools and machines' in the production process. But there are also instances where technology is possible without the use of tools and machines, as, for example, in the case when we manipulate the behaviour of human beings to accomplish certain tasks (for example, in the extensive use of people in the building of the ancient Egyptian pyramids). From this perspective, the enforced manipulation of human labour (in the form of slavery) reduces the human being to the level of the tool he uses. Contemporary examples of such forms of tools will be the so-called information technology (IT) sweatshops where people are employed by multinational companies to sell their products and services.

Secondly, we have 'technology as rules'. Technology as rules happens when 'patterns of means-end relationships' are involved (Dusek 2006, p. 32). This application of technology happens when we rationalise behaviour and certain social actions by fixing our behaviour into regulatory rules. The western dominance of rule-governed systems of law, science or bureaucracy is a good example of technology as rule. Colonialism is, therefore, a system of technological rule with its dominance over indigenous technology, replacing the local indigenous law, science and bureaucratic rules with that of the colonial administration.

Thirdly, Dusek (2006) emphasised 'technology as system'. Technology as system positions the function of technology as something that happens within the human context – something that needs to function as technology to constitute as, ironically enough, technology. As an example, we may reduce technological hardware to the level of 'non-functionality' when we exhibit 'primitive' artefacts in museums outside of their context of social function and use. Dusek (2006, p. 33) indicated that '[…] although the artefacts were simultaneously both technology and art for their original users, they were not technology, but solely art, for the curators and viewers of the museum exhibit.' According to Dusek (2006), we can only legitimately speak of a technological system when technology stands in relation to the social context while it performs its various tasks. Such tasks will include the manufacturing and social use of artefacts, music, mathematics and judicial laws. A technological system that maintains the traditional social organisation, and human skills may legitimately be considered to represent an IK system.

It would be historically and systematically misleading to define technology as 'applied science'. Furthermore, it will be just as misleading to consider technology to be constricted to the definitions. Many scientific discoveries of the creative-contingent-accidental process fall outside of these definitions. Dusek (2006) was correct when he defines technology as: '[...] the application of scientific or other knowledge to practical tasks by ordered systems that involves people and organisations, productive skills, living things and machines' (Dusek 2006, p. 35).

Ihde (1993), as a philosopher of technology, talks about a revised look at the narrow perception when considering any culture involved in the use of technology (the 'us and them' phenomena) and proposes a multicultural perspective. What we experience today is a universal, multiple awareness of high technology – coupled with a multicultural awareness of dominant current technological innovation. We are progressively able to recognise the multicultural nature of all technologies. If we accept that technologies are invariably culturally embedded, we must also acknowledge that the same technologies are being used differently in different cultures and mean different things to different societies. Different cultures may also infuse similar technologies in different ways. Different cultures may also use technology creatively (as may be seen, for example, in the application of different cooking methods and different culturally based cuisines).

Conclusion

Diversity in products, meanings and applications of technology is a characteristic of the modern complex world. The rapid expansion of communication technologies has opened up numerous new ways for developing, sharing and interpreting new knowledge. At the same time, we are facing a growing disparity between those with access to IT and those who live their lives in an intimate and close relation with their geographical locations. This is the cause of a growing awareness of the value of the knowledge inherent within local communities – knowledge that is not always captured on the Internet. Local communities, at the same time, are no longer stable societies but consist of migrants, as well as the so-called digital nomads referred to as the multitude (Hardt & Negri 2000). This creates opportunities for the expansion of new knowledge.

The idealism inherent in promoting grassroots innovation through a TD process does not come without serious challenges. In a scenario with multiple partners partnering in any research process, it is often government that fails in its support of marginalised communities. Policies are often inadequate or removed from realities on the ground, and the innovation process is often focused on developing commercialised products for the

global market or for local mass production industries instead of for specific communities. More often, innovations on grassroots level are one-of-a-kind or locally specific solutions to problems. The contributions coming from citizen scientists have the ability to greatly enhance the institutional understanding of local conditions and needs. When science, communication and education systems add further value through the growth of scientific literacy, one might begin to find ideal conditions for innovative processes to happen on the ground.

Chapter 6

Innovation and the public service: Facilitating inclusive industrial and social development

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Introduction

Public servants are concerned with innovation from two perspectives. Firstly, they are looking to promote innovation inside their own agencies or departments and to improve service delivery and reduce costs. This is usually termed 'public sector innovation' (PSI). Secondly, they aim to facilitate and support innovation in the economy and society broadly: by funding or incentivising R&D in industry, by providing training and market intelligence services and by building links between knowledge creators and users. This chapter focuses on the latter role and the associated routines, capacities and legitimacies that are needed to effectively support external innovation activity – while also recognising that there are significant dependencies between the two perspectives and associated capabilities.

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With renewed interest in the role of a developmental and now 'entrepreneurial' state in supporting innovation, there is a growing demand for public officials to adopt new ways of working in realising innovation goals: from defining and coordinating multi-sector innovation 'missions' to implementing open and experimental policy practices and creating digital platforms to facilitate knowledge exchange (Daniels et al. 2020; Kankanhalli, Zuiderwijk & Tayi 2017; Mazzucato 2013; Organisation for Economic Co-operation and Development [OECD] 2019; the Presidency 2019).

Research from South Africa has highlighted similar trends and associated changes to what is needed from public officials; it is now widely recognised that successful industrial and scientific innovation depends on a mix of local and global knowledge and resources, from different sectors (Reddy 2011). At the same time, there is more recognition of the importance of informal innovation activity taking place at the periphery of economies, which is central to people's survival and development strategies (Kraemer-Mbula et al. 2019). As a result, across all spheres of government, there is an expectation that public officials become innovation brokers (Jacobs et al. 2019, p. 896). This includes stimulating (Ndabeni, Rogerson & Booyens 2016):

> [*A*] multi-spatial and open innovation system which fosters strong linkages with national and international agencies, institutions and actors to access to knowledge, financial resources, and global markets to stimulate learning, collaboration and innovation. (p. 308)

However, these same studies acknowledge that there are fundamental challenges with how the public sector operates, which affects its ability to build linkages and stimulate learning across industries and society. This is not unique to South Africa. Much of the inability of the state to adopt emerging practices and engage with other sectors to facilitate innovation is put down to 'flaws' inherent to the state's bureaucratic machinery, such as opaqueness and rigid processes (OECD 2019). A popular response has been to establish relatively autonomous innovation agencies or programmes, which have some freedom to define their own culture, brand and (open and agile) processes (Breznitz, Ornston & Samford 2018). The peripheral status of these agencies is seen as key 'to reduce the likelihood of political interference and to allow space and to create organizational need for policy experimentation (and innovation)' (Karo & Kattel 2016a, p. 8).

However, in South Africa, the reality for autonomous agencies and hubs is often quite different from what was anticipated when they were established. Typically, these entities and instruments continue to be resourced via public servants located in traditional government structures. In addition, most public-financed agencies and hubs continue to operate within the same or similar legal frameworks as their government funders, reporting to the same political principals (Kaplan 2021; Masilela 2008). As a result, these entities are not able to operate with the freedom that many external stakeholders expect, and

emerging entrepreneurs regularly express their frustration when engaging with public officials involved in innovation and enterprise development (Reyneke 2020). All these are seen as typical of an 'ingrained parastatal bureaucracy' (Sibanda 2021, p. 266).

For a number of innovation policy researchers and commentators, getting out of this bureaucratic trap is seen to depend on a more wholesale change of mindset and culture across the public sector, highlighting the dependence on PSI mentioned earlier. There are many ongoing, internally oriented programmes that aim to mainstream innovation within public entities. Such inside-out reform is expected to improve service delivery effectiveness and efficiency, while enhancing public capacity for facilitating external industrial and social innovation (Petersen & Kruss 2020). It is hard to disagree with calls for increased creativity and innovation to address persistent service delivery and socio-economic challenges. However, to better understand how this capability can be developed, it is important to be conscious of the diverse organisations, individuals and values at play in the public sector environment (Hood 1991; Karo & Kattel 2016a).

Systems of innovation scholars have long highlighted the need to recognise organisational diversity and how this varies across contexts and time. A variety of public sector organisations support the practical realisation of various (formally and informally defined) institutional rules, norms and resourcing activities. Different enabling functions include, among others, networking, financing and incubation (Edquist & Hommen 2008; Edquist & Johnson 1997). As a practical tool, the OECD popularised the use of 'institutional mappings', including in South Africa (Kruss & Lorentzen 2011; OECD 2007), to identify key (mainly public sector) entities and functions involved in the formulation of policy, financing and funding of R&D and those that play a bridging role – such as for technology transfer. The OECD (1999, pp. 30–41) noted the complex, variable nature of this support system across countries.

So, rather than simply pushing for the uniform adoption of innovation practices and administrative values that have had success in certain organisations and regions – such as openness, participation (Drechsler & Karo 2017) or a business mindset (Chipkin & Lipietz 2012) – we need to develop a more nuanced perspective of the different roles public servants and public sector organisations may fulfil within the institutional milieu at this point in time. This includes understanding that public sector actors are and could be participating in innovation activities, especially from an inclusion perspective (Daniels, Ustyuzhantseva & Yao 2017, p. 523), and *what distinctive* capacities and legitimacy are required to do so effectively.

South African case study

At this point in time, South Africa presents an interesting opportunity to explore these issues, partly because a number of new public sector entities

are being encouraged to support innovation activity, such as municipalities through their local economic development plans, but also because the recent *White Paper on Science, Technology and Innovation of 2019* ('STI White Paper') (Department of Science and Innovation [DSI] 2019) has outlined a significant shift towards a more 'inclusive' approach to innovation, which draws on various open principles (Plantinga & Adams 2020, 2021).

While much has been written about formal, mostly national STI institutional arrangements, there has been more limited discussion about South Africa's distinctive organisational (and individual) morphology and diversity – with associated values, legitimacies and capacities – that enable or inhibit innovation and how these relate to the broader state priority of inclusive development. To address this gap, three questions will be addressed in the following sections.

Firstly, from empirical research and conceptual debate in other regions, how do public entities involved in innovation leverage their distinctive organisational routines, legitimacy and capacity to enable innovation activities, especially in relation to achieving inclusive development as a broader outcome? Secondly, what has been the policy and programme approach of public entities in South Africa in relation to supporting both firm-level and community-based innovations and in what way have they pursued inclusive development outcomes? Through a detailed description of the different approaches that public sector organisations, and relevant sub-units, have adopted (and modified or discarded), we are able to better understand why certain forms are in place. The description is based on a content analysis of information contained in policy and programme texts, as well as in relevant media and social media discourse. Finally, by drawing on the theoretical frame developed in the first section, the various South African entities are mapped according to their main organisation types, associated routines and capacities and inclusion approaches. This analysis is an initial attempt to describe the distinctive characteristics of public sector entities and provides a framework to start identifying possible adjustments to routines that could enhance an organisation or division's role as an innovation enabler.

Mapping organisational diversity

To develop a rich picture of the types of organisations and practices involved in innovation, the case study draws on a framework used by Karo and Kattel (2015, 2016a, 2016b) to explore the organisational routines of different public entities as they relate to innovation activities. In these papers, the authors adapt Mintzberg's organisational configurations (1989, p. 110) and Wu, Ramesh and Howlett's policy capacities (2015) as a lens to demonstrate how the interaction of a 'variety of organizations with different routines and capacities' (Wu et al. 2016, p. 2) is responsible for realising effective innovation policies in different regions.

For each country, the authors describe how innovation-enabling public sector entities typically fit with five core types, characterised by certain political, policy and administrative capacities, which are realised through the routinisation of certain management activities (see Appendix 1 for a table summarising the organisation types, routines and capacities). The key management routines are organisational (how core tasks are organised), strategic (how planning and management are performed), personnel (how staff recruitment, reward and learning take place), financial (how resources are allocated, used and audited), coordination (how internal and external interactions are organised) and research (how new ideas are identified and adopted).

As an example case study, Karo and Kattel describe how the Defense Advanced Research Projects Agency in the United States of America (USA) follows an entrepreneurial managerial approach, which is anchored by a human resources (HR) routine based on the recruitment of short-term experts-on-loan to work on projects. Programme managers are assessed through personal feedback and peer pressure, rather than formal performance management and incentives (Karo & Kattel 2016a).

Of course, these ideal types are mainly for analytical purposes, and we should expect that there will be mixtures of routines within organisations and variations in time and place. Given South Africa's increasing emphasis on inclusive development as an innovation outcome, this chapter seeks to be explicit about governance actions as they relate to inclusive growth and development (Foster & Heeks 2015; OECD 2017). In addition, the case study considers the growing role of technology in the 'evolution of innovation bureaucracies' (Karo & Kattel 2016a, p. 27), especially as public officials look to use digital technologies to facilitate inclusive innovation interactions.

Changing legitimacy and routines

In innovation policy, the public sector's legitimacy, access to resources and governance approach evolves in line with what countries and regions expect of it, which is tied to underlying rationales related to how innovation takes place in the economy and society (Laranja, Uyarra & Flanagan 2008). An influential rationale is that the public good characteristics of technology information, such as low excludability, disincentivise firm investment in innovation. Under this rationale, policies tend to focus on the protection of intellectual property rights (IPR). Public officials, therefore, are mainly expected to support the administration of those rights, which is typical of a traditional professional-bureaucratic function implemented by a government patent office. In recent decades, an innovation 'system' rationale has emphasised the importance of linkages between innovation actors for

knowledge accumulation. Under this rationale, public officials are expected to facilitate system-enabling activities such as forums and shared working spaces.

The public innovation agency has emerged as a key enabler of national and regional innovation systems. Innovation agencies are relatively independent entities with flexible organisational and personnel management routines, which allows them to mediate the diverse values and working cultures of government policy and firm-level practice. Breznitz et al. (2018) argue that the design of innovation agencies – including insulation from or embeddedness in political and industrial networks – depends on the type of innovation or mission it aims to pursue. For example, Denmark's government-approved Research and Technology Organisation derives close to 90% of their revenue by working with private sector clients to solve technological challenges and is therefore deeply embedded in local industrial and small and medium-sized enterprise (SME) networks, working on more incremental innovations. In contrast, larger, state-led agencies in Singapore and Chile have used significant public-funded budgets to support the technological upgrading of strategic industries.

Increasingly, systems thinking has taken a regional turn, providing subnational officials with more legitimacy and resources for driving innovation activity. Similarly, there has been a shift to smart specialisation as a more sector-focused approach to innovation activation. In this case, sub-sector agencies have narrowly defined capacities and legitimacy, often drawing on 'meso-level' policies, networks, and labour and industry associations (Cunningham 2012; Karo & Kattel 2015, p. 183).

As rationales and associated policy approaches change, public officials need to develop new capacities and routines. For example, if a region is looking to move towards using demand-side policies, such as procurement of innovation, there will be a need to develop new policy and administrative routines. This may be done through training and pilot exercises to 'build analytical competencies for understanding what types of instruments (procurement vs. standards) may work given the (research, development and innovation) characteristics in specific regions or economies' (Karo & Kattel 2015, p. 183).

Certain public entities and associated rationales have a particularly strong influence over external innovation activity. For example, universities and research councils or agencies have been central to the development of scientific skills and in contract research relationships with firms and state-owned enterprises (SOEs) (Kruss 2012). In recent years, there have been significant shifts in the public research-industry interface. As a result, entrepreneurship has become an influential agenda in many university and research council environments, encouraged by the passing of legislation such

as the Bayh-Dole Act in the USA. This has led to an expansion in licensing activity and an increased number, but also evolution in the role of technology transfer offices (TTOs), including working with or establishing business incubators (Rothaermel, Agung & Jiang 2007). These entities typically have more flexible financial routines than the host university, for establishing new ventures and equity investing. Similarly, while large industries and SOEs continue to be seen as critical to the development of new industries and fast-tracking industrialisation (Tonurist & Karo 2016, p. 630) – which establishes them politically and financially as a key enabler of innovation in certain sectors – start-ups and small business development have become integral to regional and national innovation strategies. These shifts in orientation have led to a proliferation of private and public incubators, co-working spaces and technology hubs, which provide core administrative support for a pipeline of emerging entrepreneurs. It has also led to the emergence of more demand-led programmes, such as the Small Business Innovation Research Initiative in the USA (OECD 2010), which have been relatively successful in helping government entities to articulate needs and develop innovation partnerships with small enterprises. These types of programmes require stronger professional, consulting capacities and coordinating routines to match innovation creators with users.

Inclusive development as priority

The shift into entrepreneurship is linked to a broader reorientation away from high-tech and large-firm innovation. This has been driven by a growing inequality and skills gap as natural-resource abundant countries struggle to transition into value-adding manufacturing activities or enable wider participation in the services sector (Bhorat et al. 2020) and concern about the potential harm to people and the environment that has and will be caused by emerging technologies (Schillo & Robinson 2017). At the same time, there is increasing recognition of the role that more informal, local, co-creation and user-oriented innovation plays in developing countries in particular (Hart, Booyens & Sinyolo 2020; Jacobs et al. 2019; Kraemer-Mbula et al. 2019; Ndabeni et al. 2016; Senyolo et al. 2018).

In response, a substantial field of practice and scholarly work has developed around, among others, social (Mulgan 2006), inclusive (OECD 2017), responsible (Schillo & Robinson 2017), sustainable or transformative (Daniels et al. 2020) and grassroots innovation (Gupta 2006). While this chapter focuses on IID, the conversations in other areas are critical for understanding policy linkages and opportunities that public sector actors are seeking to pursue. For example, for some universities, responsible research and innovation (RRI) is seen as a potential source of competitive advantage (Owen et al. 2020).

When looking at the state role in relation to IID, an OECD (2017, p. 162) report on innovation for inclusive growth emphasised the coupling of policies aimed at social, industrial and territorial inclusiveness, highlighting the need for public officials to have a systemic view on innovation activities as well as coordinating capacities (Petersen & Kruss 2019). The OECD report also identified a set of 'expertise' that needs to be built among public sector officials and consultants deploying the programmes, such as creating expert teams to assist regional government design programmes and proposals for funding by the national government, conducting more targeted recruitment processes that ensure candidates will be able to deal with expected challenges and enhancing the business skills of those involved in social entrepreneurship work (Petersen & Kruss 2017, pp. 198–199). Foster and Heeks (2015) suggest that the starting point for IID policy implementation is for policy actors to adopt a new worldview oriented to the inclusion of marginalised groups, from which specific policy governance actions may flow.

From previous research, it is evident that implementing IID policies requires a greater sensitivity to relational and spatial interactions, supported by officials with sufficient experience, credibility and technical ability to facilitate inclusive processes. For some public entities, such as dedicated incubators and innovation agencies, support for IID may be a core function. However, building these capacities and implementing these activities at scale requires time and substantial HR. Altenburg (2009, p. 46) goes as far as arguing that instead of extensive investment in various micro- and meso-level instruments, there is a need to 'design innovation policies in a way that reflects the ability of governments' – which could mean a stronger emphasis on basic market enablers, such as ensuring trustworthy and efficient business registration processes. At the same time, though, much of how state organs support IID is about how they are able to respond when activist grassroot movements or civil-society organisations (CSOs) engage them to address local or national development issues (Fressoli et al. 2014). Civil society organisations tend to be entrepreneurial in character, which leads to tensions with more administrative and process-oriented public servants. Nonetheless, there are cases where 'friendly' public entities and officials combine a mix of political creativity, public legitimacy and relentless consistency to see actions through (Franco 2008). Persistence is particularly important for winning legal challenges or effecting legislative changes. These entities and capacities are also relevant to growing concerns about the negative impact or harm that is resulting from emerging technologies (Schillo & Robinson 2017) for which there is likely a need for a mix of soft (e.g. codes of practice) and hard law instruments (Lee & Petts 2013). Independent oversight entities and human rights agencies are typically in a better position to do this kind of work. For public organisations innovating around oversight, audit, prosecution and human rights, important capacities include an ability to acquire necessary professional skills, secure

core funding, build leadership stability, retain institutional memory and ensure transparency.

The following section explores how public sector entities in South Africa are managing innovation, including how this relates to inclusive development outcomes. The section starts by providing context on the country's broader shift in STI policy thinking, focusing on the recent calls for a more demand-side orientation and an expansion of the NSI to enrol additional government actors.

South African policy and programmes

In the post-apartheid transition to new innovation structures, South Africa has seen significant institutional development and diversification (OECD 2007, pp. 200–209). Generally, the earlier policy approach focused on direct R&D investment and supply-side instruments, largely under the influence of neoliberal macroeconomic policies, which is seen to have led to a number of missed opportunities. For example, there were no significant initiatives to link large-scale housing development programmes with the development of indigenous technologies relevant to local contexts (Scerri & Lastres 2013, p. 256).

More recently, the *White Paper on Science, Technology and Innovation of 2019* suggests a shift in policy approach away from direct, supply-side-focused R&D funding, towards active partnering with industry, government departments and civil society through a stronger demand-side focus (DSI 2019, p. 33). This appears to come from a recognition that STI impact depends on buy-in from other parts of government (DSI 2019, p. 25), a desire to more directly improve economic competitiveness in target sectors (DSI 2019, p. 27), the need for transdisciplinary approaches to solve complex challenges (DSI 2019, p. 16) and an emphasis on achieving inclusive development outcomes by working more directly with civil society (DSI 2019, p. 24). Ultimately, this forms part of an 'expanded' NSI, which depends on the strengthening of 'government's role as an enabler for innovation' (DSI 2019, p. 41).

In the following sub-sections, selected categories of public entities are examined to understand how they relate to these high-level principles and policy directions that the DSI and national public service entities are espousing.

Universities and research councils

For the *White Paper on Science, Technology and Innovation of 2019*, in the expanded NSI, the role of universities in STI continues to be 'central', but as part of a more dispersed research and innovation environment (DSI 2019):

> Universities will continue to play a leading central role in research in South Africa. However, in line with global trends, other organisations such as science councils, non-governmental organisations, SOEs and other privately funded institutions are increasingly becoming sites of research and innovation activities. (p. 15)

It may be argued that, from a research perspective, research councils have been playing a similarly 'leading central' role, especially through their focus on what the Human Sciences Research Council (HSRC) calls 'engaged research', which is 'solution-oriented' and 'policy-linked, highly engaged' for government, private sector and civil society (HSRC 2020, p. 11). Competition for relevance from councils and universities has increased, with a number of vice-chancellors and CEOs applying rhetorical, conceptual and governance innovation to (re) position universities as relevant to emerging technological developments and their impact on pressing social and economic challenges (e.g. Marwala 2019).

The Council for Scientific and Industrial Research (CSIR) mainly pursues impact through the commercialisation of technologies for industrial development and knowledge transfer to enable a capable state (CSIR 2020a, p. 7). As the largest research council in the country, the CSIR supports a diversity of innovation activities, often in partnership with universities and SOEs, from basic research to technology localisation with SOEs and promoting alternative production methods (CSIR 2020a). Classified as a Schedule 3B SOE under the *Public Finance Management Act (PFMA) 1 of 1999*, the CSIR is different from other research councils in not being financed fully or substantially by Treasury (Bronstein & Olivier 2015). While largely self-sufficient, the CSIR is still required to establish a shareholder compact with the executive authority, which determines performance expectations (CSIR 2020b).

For both universities and science or research councils, 'impact' has traditionally been realised through senior research and management relationships with industry and the public sector, typically along sector lines. However, in an effort to formalise the use of public-funded research and modelled on Bayh-Dole and similar legislation globally, the *Intellectual Property Rights from Publicly Financed Research and Development Act 51 of 2008* (IPR Act) was promulgated in 2008. The IPR Act included the establishment of a National Intellectual Property Management Office and TTOs at institutions to oversee compliance and reporting on the disclosure and protection of intellectual property (IP) created by or with researchers.

To fulfil the compliance requirement, most TTOs depend on highly qualified individuals and legal expertise although often outsourced to legal firms (Mustapha et al. 2017, pp. 19–21), which means that a high proportion of operational costs (around 50%) are allocated to the evaluation and formal registration of IP (Mustapha et al. 2017, p. 26). Another key activity is that of 'marketing' and commercialisation of IP, with responsible individuals seeking out technology licensing partners in the private sector and in SOEs (Mustapha et al. 2017, pp. 19–21). As seen internationally, better-resourced universities have established incubators to support new venture creation as a growing licensee for research (e.g. LaunchLab n.d.; Tuksnovation n.d.). TTOs either incorporate or work with a diverse mix of professionals and administrators

involved in impact-related work across the wider university structure. These individuals coordinate researcher involvement in various external-facing activities, such as designing and running short courses for industry and government, research contracts and community engagement (Kruss 2012).

From an inclusive development perspective, community engagement has become an increasingly important vehicle for exploring and demonstrating university impact in a more direct form. Beyond the largely voluntary and *ad hoc* engagement work by individual staff and research groups (from national policy committees to community-based organisations), many universities are looking to position themselves more strategically as a development advisor and facilitator for communities or a region. This is especially relevant to historically disadvantaged universities located in marginalised and rural areas of the country, which see their local knowledge and credibility as an opportunity to attract public, private and non-governmental partners to work on development issues. As part of a strategic agenda, universities may adopt more structured models of engagement to guide researchers towards authentic and sustainable co-creation of solutions to local challenges. Embedding university cooperation in the local municipality and provincial government plans is a key feature of this approach (Jacobs et al. 2019). However, the way in which universities develop 'interaction capabilities' is likely to vary. From a comparative study of two research universities, Kruss found that both organisations promoted social engagement as a priority at all decision-making levels. Differences were evident in the way they facilitated the adoption of social engagement practices, with 'one relying on academic compliance with formal procedures and the other relying on a diffusion, brokerage and advocacy model' (Kruss 2010, p. 20).

The strategic opportunity related to inclusive development is also reflected in RRI discourse, as outlined in the *White Paper on Science, Technology and Innovation of 2019* (DSI 2019):

> A South African focus on RRI would help local researchers to collaborate and compete with their foreign counterparts in a world where ethical concerns (such as fair trade) and environmental concerns (such as emission standards) are increasingly influencing competitiveness. (p. 6)

Aside from being a competitive advantage, basing itself on the European Union RRI framework, the *White Paper on Science, Technology and Innovation of 2019* anticipates, among others, 'increasing open access to STI' and 'developing the required governance framework to drive the RRI agenda across the NSI' (DSI 2019, p. 19). These pillars connect with similar goals of mainstreaming IID (Petersen & Kruss 2019) and facilitating open research and innovation as enablers of a 'whole-of-society approach to innovation' (DSI 2019, p. 33).

Practically, this also means that research data and research infrastructure need to become more open (DSI 2019, p. 58). One example in the National

Integrated Cyberinfrastructure System (NICIS) is the South African National Research Network (SANReN). South African National Research Network provides low-cost, high-speed connectivity to research and education organisations, including, often quite remote, Technical and Vocational Education and Training colleges (Parliamentary Monitoring Group [PMG] 2018). South African National Research Network has significant competing demands in needing to ensure the inclusion of geographically dispersed organisations and having to manage the advanced science and innovation requirements of 'large-scale global research and science projects' (NICIS n.d.). Through both its broad reach and its association with globally prestigious projects such as the Square Kilometre Array, SANReN (and the wider NICIS and National Research Foundation-supported group of research infrastructure projects) appears to maintain strong political support (PMG 2018). This reflects a similar politically complex path that universities and research councils need to navigate in seeking to enhance their 'world-class' status while expanding inclusivity.

Innovation agencies and hubs

Public innovation agencies and hubs are a more recent addition to South Africa's NSI. One of the first, and largest, entities established was The Innovation Hub (TIH), a provincial government-funded science and technology park, which runs a variety of innovation support programmes and incubates over 200 start-up companies (TIH n.d.). Together with the national TIA and many other regional innovation intermediaries, TIH has elevated the profile of innovation in the country. Start-up incubation and enterprise development have become a central feature of innovation and IID support. Typically, this involves supply-side assistance, such as grant funding, vouchers for technical services and access to public-financed IP. Increasingly, attention is directed towards linking emerging entrepreneurs with customers in government and corporates.

These activities form part of what the *White Paper on Science, Technology and Innovation of 2019* sees as 'Specific support for SMEs', which includes incubation and mentoring focusing on SMEs in 'informal settlements, rural areas and cooperatives' and addressing 'regulatory hurdles, as well as burdensome administration and legal requirements' (DSI 2019, p. 35). In recent years, with the promulgation of the IPR Act, a stronger emphasis has been placed on providing 'access mechanisms' to the IPR registration system so that 'all innovations, regardless of source and nature, may find protection, where relevant and desirable' (DSI 2019, p. 33). Underlying this statement is an explicit attempt to assist marginalised innovators to derive commercial benefit from their works and to prevent unregulated harvesting and exploitation of indigenous IP by external actors.

For public agencies and hubs, there is a strong dependence on running fair, transparent and efficient administrative processes to facilitate the registration of new businesses and IP or in allocating funding. Normally, this involves standardised administrative tools and routines. To reduce risk and maintain an arms-length relationship, these processes tend to be inflexible and time-consuming (with extensive information and review requirements), leading to the perception and reality of 'red-tape' that is anathema to innovators and entrepreneurs (Abrahams 2020).

In addition to these administrative functions, agencies and hubs are expected to play a more hands-on mediating role. To expand the reach of incubators to underserved areas – as done by TIH with its eKasi Labs programme, the Small Enterprise Development Agency (SEDA) and TIA IID – there is a heavy dependence on accessing or building facilities and engaging local youth, females or business associations for the identification and enrolment of participants. This often requires partnering with local municipalities (Eyewitness News 2016; SAnews 2020). In this role, incubator staff need political, policy and administrative skills to navigate a somewhat complex inter-governmental relations environment and then deliver on outputs (Jacobs et al. 2019).

Given that most incubators and hubs focus on early-stage innovators and entrepreneurs, they are also expected to facilitate user, partner and funder interaction by arranging meetings with potential customers or co-sponsors. They may also draw on design thinking, lean start-up and community engagement tools to enable user engagement. Incubators often contract external mentors, who are typically associated with the wider enterprise and supplier development community, and which tend to provide generic business advice. However, for the mentoring of technology-oriented innovators (which can range from university research groups to social entrepreneurs in informal settlements), there is a critical need for the translation of prototype products and services into small- and medium-scale client or donor-funded pilots. For this support, project management, compliance, IP guidance, certification and technical business development mentoring are required (Abrahams 2020; Hart et al. 2020).

Among the government-linked business incubators and innovation enablers, there is substantial organisational and administrative variety. As an example, Innovate Durban has been established with funding from the eThekwini Municipality (2017), but by being established as a non-profit organisation, it has significant flexibility around financial management and HR routines. More broadly, Schedule 3A public entities as listed in the PFMA, such as TIA, TIH (as a subsidiary of the Gauteng Growth and Development Agency) and SEDA are subject to similar laws and, therefore, routines related to financial management. While these entities are largely 'dependent' on Treasury

funding and budget approval, they do have some independence similar to the 'major' Schedule 2 SOEs (Bronstein & Olivier 2015). These entities are able to generate their own revenue through rentals, in the case of TIH, and investment returns in the case of TIA (*Technology Innovation Agency Act 26 of 2008*) and have some flexibility in the remuneration of staff (Maloa 2020). As a result, there is a relatively strong emphasis on selling services, mobilising co-funding and bidding for contracts with the private sector, government departments and investees. All of these activities can create a tension in priorities when looking to serve more marginalised innovators and municipalities, which are less likely to provide a financial return. The same balancing of priorities is evident in specific programmes, such as TIH's OpenIX, which runs open innovation challenges on a web platform to 'provide solutions' for industry and government clients *while also* 'creating opportunities for solution providers and entrepreneurs from the region' (OpenIX n.d.).

Innovation funders

National Treasury – which sets the rules for government procurement through the PFMA, *Municipal Finance Management Act 56 of 2003* and related legislation – and a group of related public entities are critical to how state funds are allocated directly and indirectly (via SOEs and other state entities) to innovation activities. These entities include the Auditor-General, which reports on compliance with Treasury rules; the Department of Trade, Industry and Competition (DTIC), which designs and administers several large competitiveness and industry development incentives; the South African Revenue Service (SARS), which implemented tax-related instruments such as the recently discontinued section 12I manufacturing and section 12J venture capital incentives (National Treasury 2022; not official published act); and the Industrial Development Corporation (IDC) and Development Bank of South Africa as two large development finance institutions.

For innovation and inclusive development, the DTIC, working with these entities, is of particular importance through three key activities. Firstly, through investment and export promotion programmes and by facilitating participation in international trade fairs, the DTIC is exposing local enterprises to potential partners and ideas globally (DTIC n.d.a). Secondly, through the administration of special economic zones, the DTIC influences the spatial distribution of economic activity and the location of innovation-oriented competitiveness improvement activities (DTIC n.d.b). Thirdly, the DTIC oversees the *Broad-Based Black Economic Empowerment Amendment Act 53 of 2013 (Act 53 of 2003)* for which the fundamental objective is 'to advance economic transformation and enhance the economic participation of black people in the South African economy' (DTIC n.d.c). Broad-based black economic empowerment, together with the *Preferential Procurement Policy Framework Act 5 of 2000* (National

Treasury 2000), has sought to leverage procurement to accelerate localisation and transformation across a range of sectors. This legislation has been supported by supply and demand-side initiatives driven by other entities, such as the Department of Public Enterprise's (DPE) Competitive Supplier Development Programme, which aimed to 'leverage (SOE) expenditure to develop competitive national supplier industries, and where possible, to build export capabilities' (DPE 2007, p. 2). However, the intent of these policies and programmes has not been fully realised, largely because of weak enforcement of localisation requirements (Andreoni, Kaziboni & Roberts 2021). Enforcement issues aside, through procurement-related incentives, private sector companies have contributed to the rapid growth of enterprise and supplier development programmes and incubators, many of which have a technology or innovation orientation (Masutha & Rogerson 2014). In addition, following the alignment of B-BBEE and preferential procurement policies, government entities are empowered to direct spending towards black-owned enterprises (DTIC n.d.d). The ability of qualifying enterprises to benefit from these policies depends on government's ability to minimise abuse (such as 'fronting' by historically white-controlled enterprises) and ensure efficient administration (such as allocating B-BBEE certificates).

Although B-BBEE and procurement policies are intended to favour SMEs and there are smaller innovation funding instruments, such as the Support Programme for Industrial Innovation , also known as the SPII (DTIC n.d.e) and a Gro-E Youth Scheme (Industrial Development Corporation [IDC] n.d.), much of the attention of these national entities is directed towards larger-scale spending and projects implemented by relatively established firms using proven technologies. The dominant routine in these entities is financial management related to investment decisions, which seek a mix of development potential (e.g. job creation, exports) and return on investment. In addition, newer multi-sector instruments, such as the sovereign innovation fund (DSI 2019, p. 65), require significant political and policy capacities to build trust and enrol partners.

To address earlier-stage innovation funding needs, TIA was established as a consolidation of a number of innovation funding entities (Kahn 2013) and generally supports earlier stage financing of technology-oriented innovation. One instrument that has seen significant growth is the TIA Seed Fund, which has mainly targeted the commercialisation of university research by working with TTOs, but also supports innovation by small enterprises (TIA n.d.a). The Seed Fund has traditionally allocated funding via TTOs and certain business incubators such as TIH (TIH n.d.).

From a public sector and inclusive development perspective, there has been a substantial expansion in TIA's funding responsibilities: the Youth Technology Innovation Programme (YTIP) has existed for several years as a voucher-based funding mechanism, enabling youth-led enterprises to access various services within a network of providers. More recently, TIA has been

managing a ring-fenced pilot programme of DSI on IID specifically, which aims to 'establish community-based innovation centres that develop solutions through co-creation approaches, geared for local challenges,' to 'support grassroots innovators that have simple, social innovations' and to 'support the innovation for local economic development strategies of districts and municipalities' (TIA n.d.b). In addition, the same partners have (re)launched a Technology Acquisition and Deployment Fund (TADF) pilot programme to (TIA 2020):

> [*F*]acilitate the commercialization of locally developed technologies, promoting their uptake by government and its entities i.e. public sector, to improve their operations, enhance service delivery and address pressing socio-economic challenges. (n.p.)

This type of programme requires significant consulting-type expertise for engaging with government departments to identify and articulate their innovation requirements.

Participants in these early-stage programmes are generally seen as a pipeline for later-stage TIA, IDC and DTIC instruments (DTIC n.d.f). While the financial management routines of later-stage TIA instruments have similarities to those of the IDC, early-stage TIA and incubator funding are generally grant based, with no expectation of financial returns. As a result, the administration of these funds tends to be more flexible and often delivered in partnership with local incubator programmes, which aim to support engagement with and development of a user base – including 'promoting uptake' – which can hopefully be monetised. Technology Innovation Agency units leading the Seed Fund, YTIP, IID and TADF programmes are, therefore, more likely to engage collaboratively with intermediaries, such as TIH, to review candidates and identify pathways for adoption or commercialisation as with previous initiatives of a related kind (Hart et al. 2020; Jacobs et al. 2019; Senyolo et al. 2018).

Regulatory and oversight entities

The previous sub-sections have described an array of innovation-related instruments and intermediaries, as well as their relationship to inclusive development outcomes. Effective implementation of these instruments, as well as broader oversight as to the benefits and harms of innovation, depends on a number of other specialised public organisations with diverse capacities.

As a more established actor in the innovation space, the Companies and Intellectual Property Commission (CIPC) is responsible for, among others, the registration of companies, and of IP, such as trademarks and patents (CIPC n.d.). The process of registering a company and, the now-tightly coupled, registration with SARS, setup of company bank accounts and registration on the Treasury's Central Supplier Database (CSD), is critical for emerging

enterprises to be able to bid for and be awarded contracts, especially with government entities (National Treasury 2016). For innovators, the effectiveness of IP administration is similarly important. As a result, efficiency, reliability, transparency and accountability are all key for how CIPC (and SARS with the CSD) operate.

However, the CIPC in particular has had to navigate a difficult transition post-apartheid. As described by Chipkin and Lipietz (2012, p. 22), in seeking to undo the bureaucracy and establish the CIPC as a 'business' entity, along with leadership's efforts 'to be sincerely innovative' in developing and implementing a *business* case for the organisation, the CIPC management disrupted its core operations. In contrast, they highlight how with SARS (Chipkin and Lipietz 2012):

> While ostensibly a victory of the NPM model, in that [*SARS*] sits outside the public service and that skilled personnel are paid market related salaries, many of its major achievements have come from very careful attention to the core functions and processes of revenue collection. (p. 23)

While reliable operation is central to how CIPC and SARS enable innovation, various other entities are having a more strategic influence over emerging digital technologies and related innovation and inclusive development outcomes. South Africa's Competition Commission (CC) recently published a draft report on 'competition in the digital economy' under the rationale that 'the digital economy in developing countries already threatens a new era of global concentration and, with it, the further marginalisation of vulnerable countries and businesses' (CC 2020, p. 4). The intent of the CC is evident in its successful implementation of findings from an inquiry into data costs. This included a settlement with Vodacom on the reduction of retail pricing and an extension of zero-rating to additional 'pro-poor' websites (CC n.d.). Together with the Competition Tribunal, the CC has the authority to impose various sanctions on companies, including administrative penalties and 'ordering a party to supply or distribute goods or services to another party' (*Competition Act 89 of 1998*). These types of orders are important for enabling market access for and competition by emerging technology enterprises.

As highlighted by the CC, including in the digital economy report, data and related innovation have become a key concern for several regulatory entities. The Information Regulator (IR) entity, which has recently transitioned out of its temporary home in the South African Human Rights Council (SAHRC), has dual mandates: the promotion of access to information and the protection of personal information (IR 2020). Access to information and, more specifically, access to government and other 'big' data are regarded as a key enabler for technological innovation, not only for the expansion and improvement of e-government services but also for enabling social impact innovation by digital entrepreneurs (Department of Communications and Digital Technologies [DCDT] 2017; Open Government Partnership [OGP] 2019).

However, these policies and programmes also emphasise that the opening of information and data must be complemented by appropriate privacy and security controls.

As the IR notes, 'there is an unprecedented retention of personal information in the digital space' and as a result, for innovations such as artificial intelligence (AI), which are built on big data, 'such innovations should comply with [the *Protection of Personal Information Act (PoPIA) Act 4 of 2013*]' (IR 2020, p. 13). The IR will require a strengthening of administrative capacity as public and private entities seek to comply with the various regulations and will need to continue building its strategic and legal capacity for anticipation emerging issues, such as around AI. Through these activities, the IR has a critical role to play in building and sustaining trust in South African information systems, as a requirement for interconnection, data-sharing and e-commerce with other parts of the world (Blom & Nkado 2020). While the IR has substantial independence in only being accountable to the National Assembly, the Constitution and the law – and can enforce compliance with relevant regulations – it has been dependent on Department of Justice and Constitutional Development policies and systems and is funded out of Treasury allocations for which the 'unavailability of adequate budget remains a huge challenge' (IR 2020, p. 3). In addition, to support its strategic capacity, the IR may need to consider ways of responding to a fast-moving innovation environment, such as by hosting or participating in regulatory sandboxes as a way to explore and anticipate possible challenges while also educating innovators on PoPIA regulations (Mostert 2020).

More broadly, entities such as the SAHRC are seeking regular engagement with researchers and the public on topics related to data (information), AI and the 4IR so that human rights are respected and democratic governance is not threatened by the adoption of emerging technologies (SAHRC 2020). The SAHRC is empowered by its Constitutional and legal status and, through its provincial Legal Services Units (LSUs), provides legal advice and seeks redress through the courts for victims of human rights violations. Given the emerging nature of many technologies and associated issues, the SAHRC, courts and judges will need to be equipped to handle matters associated with these platforms and develop precedent that can extend the interpretation of existing laws. Again, this points to the need for a strategic and pre-emptive approach in the human rights and legal community, which could include benchmarking with international precedent among other actions (Razzano 2021).

In addition, the increasing concern with human rights and potential harm from innovation activities and the 4IR is echoed in various policy arenas and somewhat ironically in conspiracy theories propagating through social media. It is, therefore, a key area in which the DSI and innovation stakeholders will

need strong convening capacities to work with entities such as the SAHRC and facilitate meaningful awareness and discussion.

Discussion

More than a decade ago, the OECD noted that South Africa's innovation system was characterised by significant 'organizational creativity in building new structures to support new aims' (OECD 2007, p. 200). If anything, this creativity has expanded to new sectors and organisational forms, especially in the intermediary and policy sub-system (Cooke 2008). The case study is, therefore, a small sample of the myriad organisations and units involved in policy development and programme implementation and only those that have been established as public entities. In this sample, it is possible to start seeing the pressure that growing innovation, and now *inclusive* innovation, expectations are starting to exert within these public entities, from researchers to procurement officials.

In Table 6.1, drawing on the case study, the main routines, capacities and legitimacy related to innovation are summarised. The table also provides an indication of emerging and possible actions towards addressing inclusive development outcomes. The examples from the case study are mapped to the framework developed in the conceptual discussion and outlined in Karo and Kattel (2015, 2016a, 2016b). Where new attributes need to be added to the framework, these are highlighted with an asterisk (*) when first used. In each cell, while many routines, capacities and legitimisers may be relevant, only selected characteristics are highlighted. By doing this, the table seeks to provide an initial insight that can form the basis for more in-depth validation and research.

From the mapping in Table 6.1, five key themes emerge. Firstly, there is broad dependence on the effectiveness of administrative capacities and associated routines across incubators, funders and compliance entities. Long application and support timelines are consuming much of the motivation and limited runway of emerging entrepreneurs, as a particularly vulnerable group, so policy actors should be exploring opportunities for encouraging and rewarding improvements in core administrative functions performed by public officials (as much as other, more visible innovation practices).

Secondly, external legitimacy is established in different ways. For example, TTOs are enabled by the IPR Act that gives them stronger legal authority to search and 'claim' IP within the university organisation, and their technical attractiveness to industry and society is enhanced by the relatively ground-breaking IP and skills that are available on campus. A public innovation agency is able to establish technical legitimacy in private and civil society sectors by assembling teams of skilled professionals and consultants with experience outside government. This is possible because of relatively flexible personnel

TABLE 6.1: Case study examples mapped to routines, legitimacy and capacity, with inclusion actions.

Organisation or division	Organisation or division type	Key individual*	Innovation goals*	Key routine(s)	Legitimacy	Key capacities	Inclusive development actions*
Innovation agencies and hubs	Professional machine	CEO	Economic impact; political recognition for leading innovation	Strategic management: 'Corporate' portfolio strategy and divisions or programmes with individual strategies	Investor and customer relationships	Commercial; technical	Extend the reach of innovation programmes
Enterprise development/ incubation organisation or division (e.g. SEDA, TIH)	Professional machine Entrepreneurial	Division or programme head	New business creation; business investment; business revenue	Coordination: standardisation of work processes; mutual adjustment	Access to investors and customers; pipeline of emerging entrepreneurs for investors	Commercial; technical	Extend the reach of incubation and investment facilitation programmes to marginalised areas
Innovation facilitation organisation or division (e.g. TIH)	Entrepreneurial	Division or programme head	New provider-customer projects	Coordination: openness; financial management: process-oriented; flexible; personnel management: needs-based recruitment and development	Access to potential customers; access to researchers and innovators; innovation processes and IPR knowledge; 'independence' from government bureaucracy	Technical; policy	Identify opportunities for incremental/local innovation; facilitate public sector and social innovation involving CSOs
Innovation funders (e.g. TIA, IDC, DTIC)	Diversified machine	CEO	Economic impact; political recognition	Strategic management: 'corporate' portfolio strategy and divisions with individual strategies	Funding; co-investor relationships	Commercial; policy; political	Identify value chains for diversification; invest in public and social innovation

Table 6.1 continues on the next page →

TABLE 6.1 (cont.): Case study examples mapped to routines, legitimacy and capacity, with inclusion actions.

Organisation or division	Organisation or division type	Key individual*	Innovation goals*	Key routine(s)	Legitimacy	Key capacities	Inclusive development actions*
Sector investment/ incentives organisations and divisions (e.g. IDC, DTIC)	Diversified machine	Division head	Sustainable businesses	Financial management: process and output-oriented; coordination: standardisation of skills; openness	Funding; co-investor and customer relationships; market knowledge	Commercial; administrative	Earlier stage, hands-on (equity) investment relationships, working with incubators; facilitate investor and customer engagement
Early-stage investment organisations and divisions (e.g. TIA, DTIC SPII)	Professional machine	Division head	Increased pipeline and better quality innovators	Financial management: Process-oriented; professional autonomy	Funding; co-investor and customer relationships; IPR knowledge	Administrative; technical	Work with incubators to grow reach and improve quality; diversify types of support and candidates
Regulatory and oversight entities	Varies	-	-	-	-	-	-
Business and IP licensing organisations and divisions (e.g. CIPC)	Diversified machine	Commissioner/ CEO	Reduce time and cost to register businesses or IP	Coordination routines: standardisation of work processes and outputs; professional development (IP opinions)	Legal (and efficiency)	Administrative	Improve accessibility and usability of registration systems; expand education initiatives
Economic and labour regulation organisations and divisions (e.g. CC)	Professional	Commissioner/ CEO	Increase and diversify participation in markets; Reduce labour exploitation	Personnel management: variety and mix of skills, openness to learning; flexible recruitment; peer review	Legal and technical knowledge	Policy; technical	Open learning to identify emerging areas of market dominance or labour exploitation (e.g. data and gig economy)

Table 6.1 continues on the next page →

TABLE 6.1 (cont.): Case study examples mapped to routines, legitimacy and capacity, with inclusion actions.

Organisation or division	Organisation or division type	Key individual*	Innovation goals*	Key routine(s)	Legitimacy	Key capacities	Inclusive development actions*
Human rights organisations and divisions (e.g. IR, SAHRC)	Professional	Commissioner/ CEO	Prevent harm from emerging tech; use tech to empower marginalised	Financial management: process and output-oriented; coordination: standardisation of skills; openness	Funding; co-investor and customer relationships; market knowledge	Commercial; administrative	Community and CSO relationships to identify areas of harm; enable beneficial use of tech
Universities and research councils (e.g. HSRC, CSIR)	Professional	Deputy vice-chancellor of research	Social or industrial impact; research revenue	Strategic management: stable, many fragmented strategies by professional judgment and collective choice	Intellectual recognition; relevance to industry or society needs	Political (innovation narratives/ rhetoric); policy	Localise strategic management and production; diversify personnel management
Research division	Professional	Division or unit head	Research revenue; social or industrial impact	Research: open search and validation processes including design, field work, conferences, peer review	Intellectual academic reputation; relevance to industry or society needs; international partners	Technical; commercial; policy	Identify social or public funding sources; encourage community action research methods; mobilise multidisciplinary teams
Business development and contract management division	Professional machine	Bid officer/ manager	Process compliance (e.g. bids, database registrations); budget and audit compliance; research and consulting revenue	Financial management: efficiency and process-oriented	Knowledge of processes and compliance/ reporting; awareness and control of budgets	Administrative; technical	Identify alternative funding sources related to social and public sector needs; build skills on community-linked project management, including. inclusive reporting

Table 6.1 continues on the next page →

TABLE 6.1 (cont.): Case study examples mapped to routines, legitimacy and capacity, with inclusion actions.

Organisation or division	Organisation or division type	Key individual*	Innovation goals*	Key routine(s)	Legitimacy	Key capacities	Inclusive development actions*
TTO	Professional	TTO head/lawyer	IPR Act compliance; protection of IP	Coordination: standardisation of work processes and outputs	IP knowledge; access to university or council IP	Technical; administrative	Address emerging IP issues involving communities (e.g. related to IKS); increase awareness of formal IP options
	Entrepreneurial	Commercialisation officer	Licensing revenue; startup creation; social or industrial impact	Personnel management: flexible recruitment (often includes consultants), output-oriented	Access to potential customers and investors; knowledge of commercial and legal issues	Technical; commercial	Increase awareness of IP options, including opportunity costs of formal IP registration

Source: Karo and Kattel (2016a, 2016b).

Key: CEO, chief executive officer; SEDA, Small Enterprise Development Agency; TIH, The Innovation Hub; CSOs, civil-society organisations; TIA, Technology Innovation Agency; IDC, Industrial Development Corporation; DTIC, Department of Trade, Industry and Competition; IP, intellectual property; CIPC, Companies and Intellectual Property Commission; CC, Competition Commission; IPR, intellectual property rights; IR, Information Regulator; SAHRC, South African Human Rights Commission; HSRC, Human Sciences Research Council; CSIR, Council for Scientific and Industrial Research; TTO, technology transfer offices; IPR Act, *Intellectual Property Rights from Publicly Financed Research and Development Act 51 of 2008*; IKS, indigenous knowledge systems.

management (recruitment and retention) routines and perceived independence from government bureaucracy. At the same time, these innovation agencies are also able to establish legitimacy with government officials by being sufficiently embedded in and knowledgeable about key public policies and processes, especially financial management routines. In this way, they can potentially bridge between sectors, but both the consulting *and* public policy legitimacy and associated capacities need to be nurtured.

Thirdly, interactive capacity or 'ecological fitness' (Petersen & Kruss 2020, p. 58) is an increasingly critical capacity for most public entities, especially intermediaries. Organisations and divisions need to be open to information on social and industry needs by expanding their networks – including to grassroots civil society organisations. They also need to be able to assemble multidisciplinary teams that can respond more holistically or systemically to user requirements. Political and relational capacities are necessary for developing partnerships across sector, economic, race and language boundaries while managing significant power asymmetries that are typical in IID programmes.

Fourthly, enhancing trust and opening access to innovation programmes depends on strong enforcement of market rules and protection against harm. For this reason, Competition and Human Rights Commissions and the Auditor-General, which have significant legal and technical legitimacy, have an important role to play. This role can be supported by internal personnel management approaches that can assemble and nurture a mix of professional skills, as well as an openness to learning through open consultation and peer review on draft opinions. Going forward, this openness – including in coordination routines – is important for being able to identify rapidly developing areas of market dominance or labour and other exploitation, such as in control over data or in the gig economy.

Finally, developing the necessary capacities and routines in public sector organisations will require a sensitivity to the dominant culture within an entity, which may require a more compliance-driven or a more advocacy-oriented approach (Kruss 2010).

Conclusion

In describing the organisational and sub-organisational variety of public sector entities supporting innovation in South Africa, this chapter has identified routines and capacities that are not only enabling but also constraining innovation outcomes. The expectation that innovation can support inclusive development is creating additional pressure on public officials to adjust and add to the more traditional administrative and financial management practices. In response, this chapter has sought to demonstrate that the policy language

and resources allocated to innovation programmes can better reflect the need to improve or adapt specific routines, capacities and legitimacy in specific areas – whether administrative, technical, commercial or political – as a way to achieve desired outcomes.

TABLE 6–A1: Taxonomy of organisations and routines.

Organisation type	Entrepreneurial	Machine	Diversified	Professional	Innovative
Organisational routines	Simple; informal; flexible; little staff or middle-level hierarchy	Centralised bureaucracy; formalised; specialised work, division of labour	'Divisions' loosely coupled together under headquarters	Bureaucratic, decentralised; pigeonholes' for professional autonomy	Fluid, organic and selectively-decentralised 'adhocracy' (multidisciplinary task forces)
Strategic management routines	Visionary; flexible; leadership-based	Planning that is strategic programming	'Corporate' portfolio strategy and divisions with individual strategies	Stable and also many fragmented strategies by professional judgment and collective choice	Largely emergent, evolving through a variety of bottom-up processes
Personnel management routines	Limited personnel; no systemic routines; needs-based development	Standardised work and skills and recruitment processes	Divided between headquarter and autonomous divisions	Dependent on training to standardise the skills of its professionals	Variety and mix of skills; openness to learning and experimentation
Financial management routines	Flexible; emergent	Efficient and process-oriented	Autonomous divisions; output-oriented	Mixed; based on professional autonomy	Flexible; not efficiency-oriented
Coordination routines	Direct supervision	Standardisation of work processes	Standardisation of outputs	Standardisation of skills	Mutual adjustment
Capacities and values	Simple/initial developments and changes	Efficiency; transparency; accountability	Concentration of different focuses	Professional proficiency	Learning and complex innovations

Source: Adapted and reduced from Karo and Kattel (2015, 2016a, 2016b).

Chapter 7

The value of developing inclusive innovations for disaster risk communication and management in developing countries

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Introduction

Human interaction with nature, technology and other living entities results in disasters (Ashwini Roy 2018, p. 265). Disasters are unpredictable and sudden and can either be slow or lingering. The various types of disasters affect the way people live on a daily basis. The innovations by human beings have brought about new ways in which to curb the effects of disasters. Past and current years have seen most governments' actions during disaster events being reactive in nature. In most cases, communities being aware of the risks that they face would wait in anticipation of a disaster to happen and then activate plans and procedures. Disasters impede human development. Development gains are inextricably linked to the level of exposure to disaster risk within any given community. Every year, countries in African countries suffer disaster losses, which set back development and leave vulnerable communities living in an unending state of risk. The chapter introduces the field of disaster risk reduction (DRR) communication. The first part of the chapter focuses on the rationale for taking an inclusive approach. It firmly establishes the links between disasters, disaster risk communication and the need for action on innovation and inclusion. It introduces the terminology and frameworks that support later practical advice in section two. The different elements of disaster risk management enjoy attention and how the different elements contribute to our understanding of disaster risk communication risk.

Disaster risk reduction and disaster risk communication conceptualisation

Disaster risk reduction concept (also referred to as just disaster reduction) implies a practice of reducing disaster risks. This is done through systematic efforts to analyse and manage the causal factors of disasters (Cadag & Gaillard 2012). Disaster risk reduction focus on reducing exposure to hazards. It aims at lessening the vulnerability of people and property including prudent management of land and the environment as well as improved preparedness for antagonistic effects (Blackburn 2014; Cadag & Gaillard 2012). The strategies for DRR are primarily, vulnerability and risk assessment. It also has a number of institutional capacities and functioning abilities. Other assessments of the vulnerability go on to consider critical facilities, social and economic infrastructure, and early warning systems. Thus, consideration of different types of scientific, technical and other abilities is an essential feature of DRR (Cadag & Gaillard 2012). In reducing the risk of disasters, communication between scientists, engineers, government officials, disaster response officials, the media and the public is vital (United Nations Inter-Agency Secretariat of the International Strategy for Disaster Reduction [UNISDR] 2013). Thus, DRR communication aims to empower people to take actions that are practical to protect themselves from hazards and disaster events. Furthermore, DRR

communication needs to be implemented as a vehicle to demand that private, vulnerable communities and governmental organisations act in disaster prevention, mitigation and response.

Mehdi et al. (2019) state that the Roundtable on the Media, Scientific Information and Disasters summarised DRR communication as the situation where there are timely, accurate and sensitive communications in the face of natural hazards that are cost-effective means of saving lives, reducing property damage and increasing public understanding. Such communications can educate, warn, inform and empower people to take practical steps to protect themselves from natural hazards. Thus, for disaster risk communication to be effective, the convergence of science and technology is imperative to foster innovation that is essential to create and repeat accurate messages that can reach people through various media including other innovative alternative forms of communication in order to be inclusive (Henman 2018; Hu et al. 2018; Mehdi et al. 2019).

Communication in the DRR context involves various groups of people on different levels in society (Donovan et al. 2018; Donovan, Eiser & Sparks 2015). The implication, therefore, is that the essence of communication efforts should result in various relationship forms being established. Until now, communication is mainly focused on the aftermath of a disaster. There is a lack of a proactive approach for civil society and non-profit organisations to focus more of their public information efforts, and the media focuses more of its coverage on disaster prevention and reduction, rather than loss of life and damage to property. Communication for DRR that is happening currently fails to tackle issues that ensure effective communication to reduce the risk of disaster and improve preparedness in communities and show impatience and crisis fatigue (Donovan et al. 2018; Huesca 2003). Some forms of communication trends favour humanitarians, the growing prominence of climate change, technical advances in video news gathering, the rise of Africa as a geopolitical issue, posited links between poverty and terrorism and growth of peer-to-peer media (Blackburn & Pelling 2018; Haughton & White 2017). The Internet and 24-h news have also extremely increased the market for humanitarian testimony. The scenario, however, does not mean that we should be limited by the view that coverage via established news media is the only way for communicating with the public (Klein 2008). Although it is important to formulate and spread specific disaster preparedness and prevention messages in cooperation with television and radio, there are also alternative ways of communication that are innovative and inclusive. Disaster risk reduction messages communicated through the print and electronic media could be printed on sport items like soccer balls, posters and indigenous methods in order to impact communities that may be beyond reach. As communication is vital to establish an attitude and behaviour of preparedness for disaster within communities, it is important that an approach should also

be followed that empowers the members of communities to take action (Allen 2006; Lauer 2012). The following section describes, explains and illustrates the framework of disaster risk communication, the different contexts to consider when communicating for DRR and the different tools, methods and channels of communication that could be implemented for DRR.

Disaster risk communication

Abarquez and Murshed (2004, p. 96) indicate that researchers and practitioners apply risk communication for disaster reduction and management. Risk communication is conceptualised (Skinner & Rampersad 2014):

> [*A*]s an interactive process that exchanges information and opinion among individuals, groups, and institutions. It [*frequently*] involves multiple messages [*about*] the nature of the risk and expresses concerns, opinions, reactions to risk messages or to legal and institutional arrangements for risk management. (n.p.)

The actors in risk communication include government, local authorities, the private sector, scientific organisations, employers, employees, news media, civil society organisations, environmentalists, at-risk groups, researchers and individual citizens (Benessia & De Marchi 2017).

It is important to note that risk communication is different from other communication (Skinner & Rampersad 2014):

> It is a political process [*with several*] ethical problems. [*Additionally*], risk communication [*is different*] from public awareness [*for*] it aims to educate the public on [*disaster*] risks but is also a reciprocal process. [*This implies*] that different stakeholders listen to each other and form a common understanding about risks, their acceptability, and actions to reduce those risks. Also, the aim of risk communication is to ensure agreement between stakeholders on different risk management measures and to improve transparency of decisions and increase the potential acceptance of the outcome (Abarquez & Murshed 2004; Reynolds 2002). (n.p.)

The often-cited challenges for risk communication are the diversity of approaches towards it. Disaster risk communication focuses on risk perception, enabling us to understand the diverse ways in which people make sense of risk. However, there is evidence that this has been inadequate in motivating people to take action (Wachinger et al. 2013). For risk communication to be successful, it should engage dialogue. The sources of information should be trustworthy, credible, honest, transparent and accountable (Benessia & De Marchi 2017). This calls for four types of trust to be determined before disaster risk communication is implemented, namely, trust between individuals, between institutions of civil society and formal institutions, between individuals and households, and between groups of people and non-governmental and non-profit organisations. It is also important to build relationships between these groups in order to establish trust.

Then, risk communication for disaster preparedness and reduction is a long-term process as it comprises the hearing, confirming, understanding, believing and personalisation of messages (Haynes et al. 2007; Mileti & O'Brien 1992; Sagala 2007, p. 7). It should be implemented over a period, long in advance of actual disasters and repeated in order to establish a proactive perception and attitude towards disaster risk. Also, the exchange of information and knowledge among the groups should lead to the empowerment of communities to act in order to be prepared for and to reduce the risk of disasters. Researchers have found that when attempting to produce real innovations that are inclusive and bring about behavioural change, especially within marginalised communities, community participation is key (Srampickal 2006; Wilson 2007). Any disaster risk communication innovation should be shaped by the mindset that aggressively encourages stakeholders to take part in shaping communication, which is more or less geared in community needs (Blanche, Durrheim & Painter 2006). There are a number of innovations that tend to be inclusive and have been applied in different contexts. Forming community collaborations or coalitions often proves helpful and can lead to negotiation, compromise and collaboration among stakeholder groups in order to obtain innovative solutions of realistic and achievable goals for a coalition, where early success can motivate later action.

Examples of inclusive disaster risk reduction innovations[22]

In disaster DRR, innovation includes the implementation of creative ideas, processes and appropriate ideas that combine knowledge with new ideas in a creative way (Lee, Park & Kang 2018). It has been noted that innovations are not always products. Innovations may take several forms, processes, approaches, frameworks, concepts and other types. Disaster risk reduction innovations exist in many groups: interdisciplinary innovation concepts such as resilience and technological innovations that include maintaining and strengthening geospatial information technologies. Other innovations may increase the uptake of scientific knowledge in policy making and integrate local knowledge into DRR decisions and innovations through inclusive and participatory approaches. The *Sendai Framework on Disaster Risk Reduction (2015–2030)* encourages investment in developing innovations and technology that are informed by research to address gaps, social changes and disaster risk.

Several technological innovations advanced in recent years have emerged in areas where they were least expected. The technological innovations

22. This section of this chapter is based on Izumi et al. (2019) and shows a reworking of more than 50%.

have also made behavioural changes considerably and systematically in governments including various stakeholders. Examples include the following:

1. The social network service/system (SNS) also known as 'social media'.
2. Disaster prevention radio and the telemetry system.
3. Disaster resilient materials.

The SNS, an online space, has improved the making of connections with others. Users of SNS create a profile and connect with others using file-sharing, emails, messages or comments. In the past, disaster information has been utilising radio and television to pass messages (Veil, Buehner & Palenchar 2011). The first SNS, called SixDegrees.com, was started in 1997. This was later followed by Facebook, Friendster, Instagram, MySpace, YouTube, Google Plus, Reddit, Twitter, LinkedIn, Snapchat, Tumblr, Pinterest and Vine. The advent of tablets, computers and smart phones has brought in the proliferation of SNS use. Social network service/system in recent years has become an important tool for DRR. It can make communities and societies to be more resilient to disasters and other challenges that bring about crises. More opportunities have been offered by SNS to educate people, among them the youth, on hazards knowledge, data-collection of hazards and giving a voice to people, especially during an emergency. Social network service/system has also provided information on logistic and humanitarian needs. However, there are some negative effects of SNS that have been observed in relation to disaster information. The innovation lies in the fact that for most disasters, the public are the first responders who gather social capital directly or through SNS, in the form of the mobilisation of skills, networks, leadership and support systems. The 2010 Haiti earthquake saw people posting texts, photographs and personal experiences via SNSs. This resulted in the pouring in of resources within a very short time and a cost-effective way for donations. Mass participation seemed to have provided correct information that got used prominently in the aftermath of the Great East Japan earthquake and tsunami of March 2011. Social network service/system is being viewed as an innovation that helps create social cohesion and promote therapeutic initiatives using media by people to inform their family and friends that they are safe. Researchers for education may use data obtained through social media for decision-making purposes.

Other innovations, such as a telemetry system, are being used to monitor various disaster situations such as floods as well as to operate DRR facilities on a real-time basis. A disaster prevention radio system is used to sharing disaster information with residents. Vulnerable communities and organisations concerned can collect real-time information on disasters and DRR facilities through telemetry systems. Real-time data are essential in issuing early warning and evacuation orders. Disadvantaged groups and other people can also access information on the weather and other hazards on the World Wide Web including the use of smartphones to prepare for disasters.

The communities and organisations worried can get to understand disaster situations more clearly by collecting image data because of developing technology, such as optical fibres, closed-circuit digitalisation and climate radars. Before the advent of wireless systems had been installed in the 1960s, observers monitored water and rain gages directly. They then reported the findings to the organisations concerned through telephones.

In the current period, DRR facilities of pumps and gates are operated remotely by staff using the telemetry systems without having to stay on-site. Such scenarios enable operators to avoid facing risks of disasters from floods and other hazards. Local governments can issue disaster information, warnings and evacuation orders through community telemetry systems that comprise central stations at government offices responsible for sending information in towns or to individual receivers and households through loudspeakers.

There are several materials that have been developed to mitigate damages caused by disasters. These range from waterproof materials used for temporal measures to protect assets from inundation while embankments, floodgates and other structural measures. Fires are being managed in the most vulnerable communities within the Southern Africa Development Community countries effectively by interior decoration of walls and ceilings of buildings with materials that are fireproof. Fireproof materials are hardly ignited with an ordinary fire source. Other innovations being implemented are the use of temporary and demountable flood protection materials. Such practices can reduce flood damage by closing pathways for floodwater and restricting its spread. In some instances, piling sandbags are widely used as temporary measures to secure additional heights of flood barriers over a long time. In urban areas, water bags are used instead of sandbags to place on the embankment in towns to protect against flooding. The bags can be easily moved and installed on-site.

Other examples of DRR innovations are rainwater harvesting (P), safe schools and hospitals (P), crowdsourcing, terminologies of resilience and vulnerability, resilience index (A), traditional practices and evacuation behaviours (A) and indigenous DRR technologies among others. Products (P) and approaches (A) bring multiplier effects to DRR capacity.

Most innovations that are inclusive have their origins from community-based disaster risk reduction/risk management, hazard mapping, national platforms for DRR, safe schools and hospitals, post-disaster assessments, crowdsourcing, traditional practices and evacuation behaviours and indigenous DRR technology (Borie & Hulme 2015; Mei & Lavigne 2013). The discussion (Donovan, Borie & Blackburn 2019):

> [*D*]emonstrates the complexity and breadth of [*disaster*] risk communication [...] [*I*]t is not merely the last part of a process, but occurs throughout risk assessment, management and dissemination [...] The fact that the knowledge travels, and is

> read differently across diverse audiences, strongly suggests that robust risk communication that can withstand social questioning must be built on protocols that are derived with the knowledge itself [...] Ultimately, reducing the risk from disasters requires the effective communication of warnings that are useful and useable for populations, and that meet them in their context. If people receive a warning but have no power to act on it. (pp. 16–17)

Thus involving citizens and social scientists in planning and in knowledge production, genuine co-production can facilitate to achieve inclusive innovation in disaster risk communications (Lane et al. 2011). The following section discusses some of the practical guidelines to follow.

Practical guidelines on designing inclusive disaster risk communication

Some practical guidance on how to design inclusive disaster risk communication strategies that will influence changed practices and behaviours has been proposed based on theories, strategies and some best practices in developing countries.

Several theories and strategies have been designed in communication for disaster risk communication 'from within the modernisation paradigm, traditional public information and communication campaigns along the perspective of Everett Rogers' "diffusion of innovations" theory' (Chagutah 2014):

> The theory suggests that by transmitting information using the mass media from a sender to a receiver through a linear, unidirectional process, modern values can be instilled and ideas changed. (n.p.)

Such ways of information dissemination may result in changed behaviour in individuals (Waisbord 2005). Other pundits in the innovation and dissemination space have adopted a 'two-step flow' approach. There is combining of mass media and interpersonal communication channels (Waisbord 2005) (Chagutah 2014):

> The approach [*safeguards*] that the media [*does*] not operate in a social vacuum for the dissemination of ideas from the media to individuals is mediated through other persons – opinion leaders. (n.p.)

In the current era of climate change-related disasters, it is suggested that diffusion theory alone is inadequate (Melkote, cited in Mody 2003, p. 135). The shortfalls of the diffusion model are the absence of feedback from message recipients.

Other strategies and innovations prevalent include education entertainment, which uses 'media such as radio, television, video and folk theatre/[*drama*] to carry out behavioural change at individual and community levels' (Chagutah 2014). Dissemination of educational information has been embedded in

entertainment programmes. These strategies are moulded by Bandura's social learning theory whose strategy is premised on the idea that individuals learn behaviour by observing role models. Countries experiencing seismic activity have developed and staged a theatrical performance 'Terra non-Firma'. The theatrical performance saw children learn the basics of seismic behaviour and protection techniques through collaborative education-play (Blackburn 2014). 'Entertainment-education programmes [*have facilitated*] social changes at the individual level [*for they influence*] awareness, attention and behaviour' (Chagutah 2014). 'At the community level [*they have served*] as an agenda setter or by influencing public and policy initiatives in a socially desirable direction' (Chagutah 2014, see also Melkote & Steeves 2001, p. 140). The UNISDR (2004, p. 282) advocated for DRR public awareness activities programmes to implement innovation, which are inclusive and use different types of messages, locations and delivery systems to reach their various target audiences. Waisbord (2005, p. 81) reveals criteria for successful disaster risk support communication campaigns, which should observe the following (see also Chagutah 2014):

- **Mass media role:** Mass media is of importance in the creation of awareness and knowledge. Mass media assists also the stimulation of others to participate in the communication campaign process. Successful campaigns in the mass media messages should be complemented by interpersonal and group communication, as well as small/alternative media channels.
- **Interpersonal communication role:** Interpersonal communication, particularly through peer groups and social networks, has always been instrumental in attitude and behaviour changes.
- **The message:** Messages need to be simple as possible, sustained, consistent and continuously reviewed and improved. There is a need for the message to be delivered at different locations in different communication environments and through the different channels that are necessary to reach various levels of stakeholders living in at-risk communities.
- **Medium characteristics:** Mass media channels are supposed to be complemented by small, alternative media, like video clips, film strips, posters, fliers and audio recordings. Other media sources, like folk or traditional media, theatre, song and dance, storytelling and puppeteers should involve the participation of the community in the planning and implementation of the message dissemination. Some requirements are that they should be believable, culturally sensitive and recognition of local knowledge in crafting the message.
- **Social context:** Most communication activities happen within given social contexts. They cannot be abstracted out of their contexts, for it is the context that mediates the process of meaning creation by the community.
- **Formative evaluation:** The communication campaign objectives and messages should be evaluated to ensure that they fit media habits, audience predispositions and the availability of resources.

There are, however, some structural characteristics of communities and specific aspects of community structure, which should be considered for inclusivity to be achieved. These include an aiding 'environment and community resources for exercising individual and communal action' (Chagutah 2014):

> Structural characteristics of individuals for [*example*] some people turning knowledge into behaviour is impossible [*for*] they lack the personal resources, such as finances or time, to undertake any recommended practices. (n.p.)

Governance issues, especially the roles and responsibilities of governmental bodies before and after the disaster, have an influence on disaster risk communication. The sociological context includes the level of activism within a community. When a community is well organised to take social action, it may act quicker in addressing the effects of the disaster. Demographic factors like class, religion, gender, race or status will determine how messages should be created. In a patriarchal society, males may keep their wives from participating in projects that strongly promote gender equality. The perception of rights of disabled people also determines whether disaster risk communication is structured to establish an attitude towards respecting the rights of this group. All these issues have a lot of bearing on innovation for inclusivity, which calls for communication to be adapted in order to address and reach people with disabilities (i.e. special communication methods to reach the blind, deaf or people with other disabilities).

Cultural practices and values directly influence the implementation of communication efforts for these issues related to language barriers that need to be considered, especially the dialect and the literacy level of community members. Communication innovations for inclusivity should be designed according to the target audience's ability to receive the messages as they were intended.

Thus, effective disaster risk communication requires the alignment of complex factors that include the communicator and the audience(s), audience involvement and emotional responses to risk (Cutter et al. 2015; Gaillard & Mercer 2013). Disaster risk communication is especially challenging for there are changes in the landscape for both communicators. Addressing stakeholders is also a key element in the development disaster risk communication that is inclusive (Wilson 2007). When partnering with stakeholders, the government has to work with business, industry, civil society, academia, vulnerable communities and students (Melkote 2003, cited in Chagutah 2014):

> The most powerful discourses to emerge after World War II, [*that posed*] enormous social, cultural, and economic consequences, was the discourse on development predicated on the modernist hallmarks of reasoning and rationality. (p. 130)

The modernisation paradigm assumed that the roots of underdevelopment were inherent in the societies of developing countries. There was, therefore, a need (Chagutah 2014):

> [*F*]or them to 'catch up' and become like the developed countries. The [*direction*] of modernisation was to transform people and implant new values and beliefs'. The transfer of values, information and knowledge [*had*] to be achieved through 'communication' (Melkote 2003, p. 135). The role of communication [*aimed at transmitting*] pro-development innovations and skills to an unsuspecting and passive audience. (n.p.)

Tools that were to be used included the mass media and extension workers, particularly agricultural and health care field workers. The exercise was meant to win over followers to the new concept of development (Melkote & Kandath 2001, p. 190). Mass media sources, like radio, were roped in to spread the message of extension even further than change agents could manage. Mass media was to act as a 'magic multiplier' of the pro-innovation and top-down messages. Extensive interrogation and criticism of the top-down and paternalistic development and development communication ensued among scholars and practitioners in the 1970s (Huesca 2003, p. 209). Thus, the involvement of communication, media and other innovations became inevitable for DRR.

Disaster risk communication (Donovan et al. 2019):

> [*H*]as been shown to be affected by format of information, by demographics of the 'readership', by the assumptions of the originators and many other factors (Slovic 2000, 2016; Slovic et al. 2004; Eiser et al. 2012) [...] [*Other challenges include*] the [*neglect*] of risk communication [*role in in the*] production of risk as well as being a solution to risk [...] This is because while poverty is known to be the most fundamental driver of risk (Wisner et al. 2004), it is also linked to poor communication. Exclusion from formal risk communication channels is common where investment in communications infrastructure has not been forthcoming, and/or the upkeep of these is lacking – common for example in informal settlements or isolated agricultural communities. Poverty also undermines access to risk information where communications rely on private television, radio or mobile phone ownership. Intersecting with these issues, socio-political structures can serve to disproportionately preclude socially, economically or otherwise marginalised households from access to (or ability to act upon) risk information, depending on their status and agency within society. In sum, poor communication typically impacts the more remote, vulnerable and isolated individuals and communities the most, and thereby exacerbates their vulnerability. Poor access to risk communication infrastructure (e.g. early warning systems) may equally be the result of poor governance, of active discrimination against certain groups, or of poor or unequal investment in infrastructure. (pp. 4, 9–10)

Thus, DRR communication process is not as easy as we would want it to be in everyday life; communities experience relationships that end as a result of a lack of or breakdown in communication. Nyondo (2006) explains that when a disaster strikes, it remains to not only respond with accurate, understandable and complete information as quickly as possible but also to communicate in a proactive way that involves all members of communities to reduce the potential risk of disaster. There is an acceptance that disaster risk practitioners listen to the people and that problems and solutions must be collectively

identified (Twigg 2004, p. 166). Inclusivity and 'participation is held as being necessary in order to share information, knowledge, trust, commitment, and a right attitude in development planning and implementation' (Servaes 2004; cf. Wisner et al. 2004 in Chagutah 2014):

> Communities should not be passive recipients of information; and [*disaster risk reduction*] efforts must be based on faith in the people's capacity to contribute [*innovative ways*] and participate actively in the task of transforming society. (p. 61)

According to Donovan et al. (2019):

> It is clear from the evidence here and elsewhere that the production of risk information is not a linear one, nor is it straightforward: there is no one key approach that serves all circumstances. (p. 27)

Furthermore (Donovan et al. 2019):

> The most important [*is the*] need for listening [in order to] communicate – and this includes scientists understanding government decision-makers, as well as both of these groups having insights into the publics that they serve. (pp. 27–28)

Regarding disaster risk communication (Abarquez & Murshed 2004):

> [*I*]s a dynamic process with a twofold purpose that can foster learning, positive change, and empowerment. It is a continuous process of coding, decoding and interpretation and a way of sharing objectives, attitudes, knowledge, information and opinions. It takes place in a social context and people take the roles of both source and recipient. (pp. 96–99)

When considering communication for DRR, there is a need to point out that context plays a key role, For instance, the socio-cultural context of the society and scale of the community (is it rural, small or mega) will determine how communication will be implemented (Kruger et al. 2015). Also (Skinner & Rampersad 2014):

> [*C*]ommunication planning occurs in an organisational context and is embedded in institutional cultures with specific agendas. Moreover, communication takes place in a context of risk assessment, risk intervention and risk evaluation, making it a strategy that is executed within disaster risk management. [*Then*] also, social vulnerability is key to determining the methods of communication and [...] people, complex social systems and non-structural solutions should be analysed (Sagala 2007, p. 2, 8; Wisner 2003; Glik 2007, pp. 35–36; Abarquez & Murshed 2004, p. 96). (n.p.)

The DRR calls for decisions that influence community members' lives, for example, the relocation of a village or group of people, the establishment of opportunities for social change or the empowerment of marginalised groups; hence, a participatory and development approach for communication should be followed in communication for disaster reduction and preparedness (Alexander 2014; Benessia & De Marchi 2017; Donovan & Oppenheimer 2015; Scolobig et al. 2015). 'Lane et al. (2011), [...] provide an innovative approach to risk management, involving the consultation of local people in the development of plans for flood risk mitigation' (Donovan et al. 2019, p. 28). The 'involvement

of local people significantly [*enhance*] the [*knowledge*] that [*are*] involved in risk assessment as well as allowing the inclusion of local values in the mitigation measures proposed' (Donovan et al. 2019, p. 28).

Communities as a whole participate in resolving the potential risk they may face in their specific circumstances. Participatory communication is about people coming together to identify problems, create solutions and empower the marginalised people (Cutter et al. 2015; Gaillard & Mercer 2013; Pidgeon & Fischoff 2011). The process helps co-creation and the sharing of knowledge between all stakeholders. In the African tradition, participatory communication exists in various forms that include theatre, song and dance. However, social media also established participatory ways of communication, including (but not limited to) community media, blogs, wikis, social bookmarking, music-photo-video sharing, podcasts, participatory video projects and videoblogs, tags or links to and from people interacting. The availability of social media results in the active participation of many people in programmes and community relationships (Jasanoff 2003, 2005; Stirling 2006, 2008, 2010, cited in Donovan et al. 2019):

> Risk communication cannot be viewed as a bolt-on to risk assessment and decision-making: it is formulated within the risk assessment process, and that process must itself be reflexive – as emphasized in other fields. (p. 30)

It may be considered that (Donovan et al. 2019):

> The Sendai Framework for DRR requires countries to reduce the risk from disasters at multiple scales, taking a multi-hazard approach and increasing public awareness of risk. Communication is a substantial part of this process – not only in public education, but also in scientific assessment and government planning. Understanding disaster risk holistically requires engagement with populations from the start of the process – and also requires some acknowledgement of the risk perceptions and heuristics of physical and social scientists (e.g. Donovan et al. 2014). [*Disaster*] risk is dynamic both objectively and subjectively. Understanding risk and enhancing preparedness involve significant interdisciplinary thinking – beyond and between the social and physical sciences, and involving engagement with communities and institutions. (p. 30)

Conclusion

The need for use of innovation and new technologies in DRR is greater in the face of an increase in the occurrence of disasters. There are, however, many gaps in the interface of science, technology and policymaking. To increase innovations, it is important to simply work with all people including those that are well-off and the vulnerable and share innovations. There is also a need to understand that innovations go beyond high technological products to include approaches as excellent innovations for adoption.

Chapter 8

Potable water and improved sanitation in South Africa: Extending access by innovation for inclusive development

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Introduction

More than 1 : 10 human beings (844 million people) are living without access to safe drinking water. Even more (2.3 billion) lack access to improved sanitation (Water.org 2019). In South Africa, the scale of the challenge is smaller but no less serious, with 5% reliance on deliveries by water tanks or collection of their own daily water supply directly from rivers or pools. A further 20% do have access to potable water, but not within their own homes. In respect of sanitation, the 'gold standard' flush toilet was invented 200 years ago but serves a small fraction of the global population and does not even destroy pathogens. At least one-third of the global population does not have

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access to an adequate sanitation system (Human Sciences Research Council [HSRC] 2017), most of these living without an on-site sanitation system or not having a toilet at all. In South Africa, more than a fifth (21%) of residents do not have a flush toilet or other forms of improved sanitation facility. There is a high reliance on unventilated pit latrines (HSRC 2016a). The need for cost-effective and innovative methods to mitigate these gaps in access to such basic resources is therefore critical. Governments and private funders have invested continually in the provision of additional water and sanitation, both by conventional means in accessible urban environments and by less conventional, more innovative means, especially in inaccessible rural localities. This volume seeks to elucidate the role of technical and social innovation as means of supplementing the overstretched conventional methods of providing services. This chapter focuses specifically on solutions to the water and sanitation needs of disadvantaged and remote communities.

Globally, the concept of IID in all sectors (Juma 2015; Kruss & Gastrow 2015; Lorentzen 2010) is being propagated and promoted as a means of supplementing the existing provision of services in the developing regions of our planet. To a limited extent, South Africa's commitment to IID has encouraged and facilitated research into enhancing access to potable water and improved sanitation. In its series of IID seminars, the HSRC, a statutory research institution, has profiled and interrogated a range of approaches to, and implementation and measurement of such innovations. Two of these seminars focused on sanitation (in 2016) and potable water (in 2017), respectively. This chapter looks into examples of each of these technologies, including the *EarthAuger* (HSRC 2016b), the *Pour-Flush* (Water Research Commission [WRC] 2018a) and the *LaDePa* (WRC 2018b) sanitation systems and the *Vulamanz Point of Use Water Filtration Device* (HSRC 2017). Some aspects of the inclusivity, quality, cost and scalability of such technologies are examined in the light of the existing backlog in the provision of water and sanitation to the country's hitherto excluded, unserviced localities.

Global limitations in access to potable water and improved sanitation

Piped-potable water and improved sanitation are likely to be the everyday experience of most readers of this book. Switching on a tap in one's home to take a shower or to fill the kettle to make tea or to top-up the cooking pot to boil potatoes are regular actions that are probably never given a second thought. Disruption to the municipal supply of water is arguably a breach of human rights, and in the case of South Africa, a contravention of the intent of the Constitution (South Africa 1996). Likewise, regular visits to a toilet with a waterborne flushing facility are taken for granted by many. Any prolonged

lack of access to such a facility in a home or work environment is an unpopular discomfort to be avoided. Yet, millions of our fellow human beings live in circumstances where easy access to potable water and flush toilets are considered aspirational luxuries. National budgets in the developing world are simply inadequate to provide these services to all. Alternative methodologies of supply need to be found.

The scale of the problem with respect to accessing safe drinking water in South Africa is shown in Table 8.1. Just over half (56%) of the population has direct access to piped water (connected to a municipal meter) within the comfort of their dwellings. A further 16% of the population has access to piped water outside but on the site of their dwelling. Almost a fifth (18%) of the population needs to collect water from an off-site public or communal standpipe or from an obliging neighbour. The most extreme level of need is among the 5% who rely on a flowing river or stream (2.7%), a dam or pool (0.2%), an on-site rainwater tank (0.3%), a delivery by a water carrier or tanker (1.7%) or bottled water (0.1%) (HSRC 2016a).

Access to flush toilets that are linked to a municipal sewage system stands at only 60% (Table 8.2). A further 5% has chemical toilets or toilets connected to septic tanks. The rest are reliant on pit latrines either with ventilation pipes (15%) or without ventilation pipes (16%), a bucket system (2%), other facilities (1%) or none at all (2%).

TABLE 8.1: Sources of drinking water in South Africa, 2016.

Source	%
Piped tap water in dwelling (metered)	45.0
Public/communal tap (free)	14.8
Piped tap water in dwelling (pre-paid meter)	11.2
Piped tap water on-site/yard (no meter)	7.4
Piped tap water on-site/yard (metered)	6.7
Flowing river/stream	2.7
Piped tap water on-site/yard (pre-paid meter)	2.3
Neighbour (free)	1.6
Neighbour (paid for)	1.6
Borehole on-site	1.5
Borehole off-site/communal	1.4
Water carrier/tanker on-site/communal	1.4
Public/communal tap (paid)	1.3
Water carrier/tanker	0.3
Rainwater tank on-site	0.3
Dam/pool	0.2
Bottled water	0.1
Well	0.0
Other	0.2
Total	**100.0**

Source: HSRC (2016a).

TABLE 8.2: Types of sanitation facilities used in South Africa, 2016.

Type	%
Flush toilet connected to a municipal sewage system	59.5
Pit latrine without ventilation pipe (long drop)	16.0
Pit latrine with ventilation pipe (long drop)	14.5
Flush toilet connected to a septic tank	2.6
Bucket toilet	2.2
Chemical toilet	2.1
Other, specify	1.1
None	2.0
Total	**100.0**

Source: HSRC (2016a).

Global efforts to increase access to water and sanitation

Sustainable development goal 6 (SDG 6) is to ensure the availability and sustainable management of water and sanitation for all and specifically by 2030 (World Health Organization [WHO] & United Nations Children's Fund [UNICEF] 2016). The source of water is defined as 'improved' and located on the premises of the user; 'available when needed' and free of faecal and priority chemical (e.g. fluoride and arsenic) contamination (WHO & UNICEF 2016, p. 12). Although more than a billion people gained access to piped water sources between 2000 and 2015 (WHO & UNICEF 2017), there remained 663 million inhabitants of the planet (79% rural and predominantly in sub-Saharan Africa and Asia) who did not have access to improved drinking water sources. About 30% of countries were not currently on track to achieve this goal. Other sources that are regarded as 'improved' are packaged water (in bottles or sachets), which is usually in countries where piped water is also common, and water that is delivered by tanker trucks, predominantly in regions of sub-Saharan Africa and Asia.

A variety of methods are utilised to improve water quality. These include boiling, filtration (microfiltration or ultrafiltration), ultraviolet (UV) light and reverse osmosis or the careful addition of chemicals such as chlorine or iodine, all of which entail specific risks, advantages and disadvantages that need to be evaluated within the context of the particular need being addressed (Global Hydration 2019; Zularisam, Ismail & Salim 2006). An international NGO Water.org (2013) founded by Matt Damon and Gary White, specifically leverages funding to improve access to potable water. It has implemented its WaterCredit product in five countries in Africa, five in Asia and three in Latin America.

Recent research on water purification technologies (Kiger 2019) details several innovative methods that are being implemented within the imperatives of the IID framework internationally:

- **Direct contact membrane desalination (DCMD):** Developed by Professor Kamalesh Sirkar (New Jersey Institute of Technology), entails the flow of heated seawater over a plastic membrane comprising hollow tubes that are filled with cold distilled water. The tubes have small pores that can be penetrated by the water vapour that condenses on them. Salt, however, is not able to penetrate. This vapour can then be extracted and condensed into water. The system produces 80 L of drinking water from 100 L of seawater, about twice the volume that existing desalination technology can produce. One potential downside of DCMD is that it requires a steady, inexpensive source of heat in order to prevent the water temperature on either side of the membrane from equalising. However, the potential exists for DCMD systems to recycle waste heat from shore-based factories and offshore oil drilling operations (Greenemeier 2012).
- **Super sand:** Entails the coating of sand grains with graphite oxide (GO) that can potentially filter substances and elements such as, mercury (Hg) from water up to five times more effectively than untreated sand (*Science Daily* 2011a).
- **Sunlight treatment:** Using thin sheets of a photocatalyst (graphitic carbon nitrite [g-C3 N 4]), extracts *Escherichia coli* (*E. coli*) and other disease-causing bacteria. The sheets attract electrons that form compounds with oxygen (e.g. hydrogen peroxide [H^2O^2]) to rid the water of harmful bacteria.
- **Removing arsenic with plastic bottles:** Developed by Professor Tsanangurayi Tongesayi (Monmouth University), entails the coating of pieces of plastic with cysteine, an amino acid. The cysteine binds to the arsenic, thereby yielding potable water, converted from levels as high as 20 parts per billion to only 0.2 parts per billion (*Science Daily* 2011b).
- **Flocculation:** Entails the addition of salt to water extracted from a clay environment (Dawney & Pearce 2012), which clears the clay content and facilitates the elimination of diarrhoea in the clear water, by means of exposure to sunlight, that is, UV radiation.
- **The SteriPEN water purifier kit:** A small device weighing 184 g, uses UV light to eradicate microorganisms. Insertion of the device into 1 L of water for 90 s renders the water potable (Stone 2010).
- **Toxin-eating bacteria:** Ingest and metabolise cyanobacteria (microcystins or blue-green algae) that occur in fresh or salt water. More than ten such strains of bacteria have been identified by researchers at Robert Gordon University (*Science Daily* 2009).
- **Nanotechnology:** Under development at D.J. Sanghvi College of Engineering, Mumbai, India, in the form of carbon nanotubes, which can remove toxic elements, sediment and bacteria from water at a faster rate than other filtration systems. At Massachusetts Institute of Technology, researchers are experimenting with nanotechnology for desalination, entailing sheets of graphene, a single-atom thick to filter seawater (Chandler 2012).

- **Ceramic water filters:** Comprise clay filled with numerous miniscule holes that filter bacteria and other pathogens (but not arsenic) at a slow rate (2 L/h). They can be used with silver coatings for greater effect (Brodrick 2010).
- **MadiDrop ceramic water purification disks:** Contain silver or copper particles, which once immersed in water will eliminate most pathogens. These were developed by a University of Virginia-based non-profit humanitarian organisation, PureMadi ('maḓi' = 'water' in Tshivenḓa) (Mandal 2013; Samarrai 2013). MadiDrop must be utilised after the flowerpot filter, which clears the water of sediment (Samarrai 2013).
- **Herbal defluoridation:** Used for water that containing excess fluoride as in India, the Middle East and some African countries. The system makes use of *Tridax procumbens*, a common medicinal herb, to absorb excess fluoride from water at a temperature of about 27°C (*Science Daily* 2013). More recently, even sugar cane bagasse has been successfully demonstrated to adsorb up to 50% of the fluoride content from aqueous solutions (Singh, Latave & Wasewar 2016).

With respect to innovation in sanitation technologies, the HSRC seminar in September 2017 included participation from a range of experts in the sector (HSRC 2017). A major player in this field is the Bill and Melinda Gates Foundation (BMGF), which spends US$4bn per year on health care and sanitation projects. Several technologies have been developed to supplement existing conventional options, including:

- A freestanding toilet that filters the liquid through a membrane. The solid component is dewatered and combusted into a gas, without the use of any external energy source after initiating the process (Cranford University, UK). While it is in use, the unit can be disconnected from the processor if necessary.
- The Caltech (2019) toilet is a photovoltaic (PV)-powered domestic toilet and wastewater treatment system. It harnesses solar energy to power the electro-chemical processing of waste. The system can be used for school toilets or other public toilets and is being tested in India and China (SuSanA.org 2019).
- A waterless system that converts urine fertiliser (University of Cape Town) and affects massive water savings (Davids 2018; YouTube.com 2019).
- A modular unit that operates on grey water (Mywaterloo 2019).

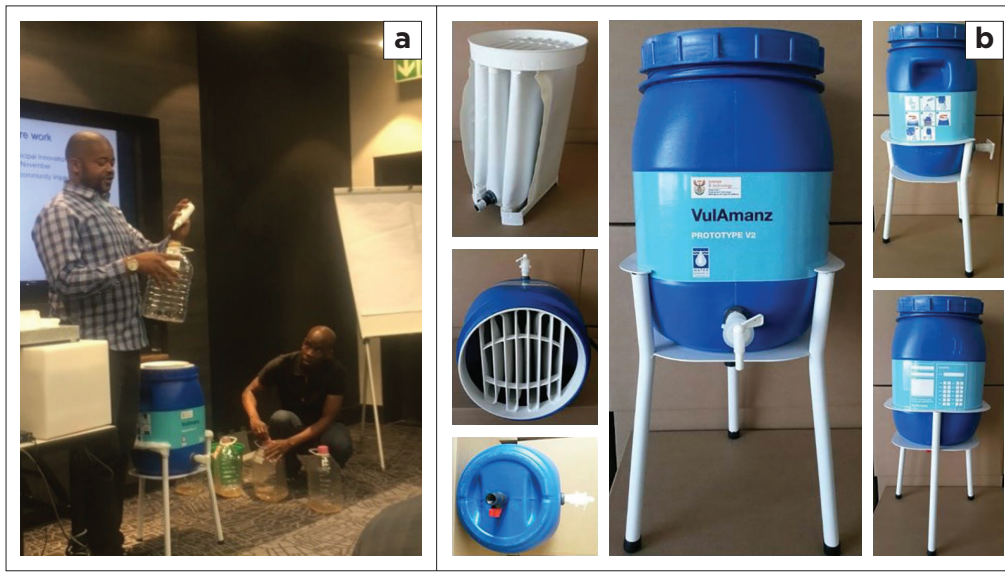
Innovation for inclusive development and water provision in South Africa

One of the programmes in the national Department of Science and Technology (DST) is the Socio-Economic Innovation Partnership Programme. In the interests of enhancing the quality of potable water available to remote rural

communities, the DST established a partnership with the statutory WRC and Professor Lingham Pillay, who had invented a water filtration device known as the VulAmanz Point of Use Water Filtration Device (Figure 8.1). Developing the device was funded by the WRC, a national funding entity for water research, which is allocated a proportion of the income received nationally from consumers of water, in order to fund research.

Three legs support a device comprising a 20-L container that is fitted with a woven fabric membrane that filters out suspended solids in contaminated water. This occurs at a rate of more than 25 L/h. *Escherichia coli* and other solids are removed, and the resultant filtered water emerges at a turbidity level of less than 1.0 nephelometric turbidity unit. The container has a tap on the side through which clean potable water is withdrawn. The device is gravity-driven and Stellenbosch University, South Africa, is experimenting with a pressurised model of the device, which will increase the flow rate. The device comes with a specially designed brush with which the filter membrane should be cleaned every two months. The membrane is expected to last for a four-year period. Every three months, the filter should be disinfected in order to prevent the growth of organic material. This can be achieved inexpensively by filling the container with water and a solution of 100 mL of bleach and letting it stand for several hours before emptying and reusing the device.

The filter is handmade by a delicate and time-consuming process. The cost of the device is about ZAR2 000 factoring in labour and materials. This is more expensive than the maximum target price of US$100 for similar devices



Source: HSRC (2017). Used with the appropriate permission from Mr Blessing Mncube, the HSRC and the editors of this book.
FIGURE 8.1: Mr Blessing Mncube of VulAmanz demonstrating the use of the water filtration device.

used in other parts of the globe, but the cost would decrease once the device is mass-produced. The current capital cost of ZAR2 000 needs to be supplemented by an additional ZAR50 per annum for disinfectant and ZAR200 for maintenance by a municipality or an entrepreneur. Over a four-year lifespan, the total cost amounts to ZAR3 000. Vulamanz Water is registered and holds a right of use licence for the device from WRC.

The use of the device was piloted in South Africa's two most deprived provinces, Limpopo and the Eastern Cape. Villages were selected from within 27 local and district municipalities that had been prioritised for service by the Presidency because of their current reservoir supply of untreated surface water. A total of 525 households in villages of the Capricorn District Municipality, Limpopo, and 500 households in villages across the Mbizana Local Municipality, Eastern Cape, were included in the pilot group. Key criteria for measuring success were technical performance, user acceptability and affordability.

A questionnaire survey tested the views of users in Capricorn. More than 80% (423 of the 525) of user households completed the questionnaire. More than two-thirds (69%) were 'completely satisfied' with the device, and 31% had minor reservations. Further interviews determined that the filtration process was perceived as too slowly. After receiving the explanation of the filtering process, all users expressed satisfaction. In Mbizana, 395 households completed the survey and 91% were completely satisfied with the device, the other 9% complaining about the slowness of the flow rate.

Eight weeks into the piloting, Capricorn District Municipality began to collect water samples each month from the water sources and from the devices used by all participant households for testing at the Capricorn District Municipality Laboratory at the University of Limpopo Turfloop Campus. The results were largely positive as indicated in Table 8.3. The VulAmanz Point of Use Water Filtration Device was subsequently approved by the DST for commercialisation and use by municipalities and the private sector.

TABLE 8.3: POU microbiological results.

Sample ID/code	Sample date	TC (MPN/100 mL)	*E. coli* (MPN/100 mL)
A11a	22 June 2016	> 201	12
A11b	22 June 2016	53	0
A11c	22 June 2016	62	0
A18a	22 June 2016	> 201	109
A18c	22 June 2016	53	0
A27a	22 June 2016	145	31
A27b	22 June 2016	0	0
A27c	22 June 2016	0	0
A33a	22 June 2016	> 201	18
A33b	22 June 2016	0	0

Source: HSRC (2017).
Key: TC, total coliforms; MPN, most probable number; *E. coli*, *Escherichia coli*.

Innovation for inclusive development and sanitation in South Africa

The DST has a Sanitation and Innovation Technology Programme, which comprises a partnership with the Department of Water and Sanitation, the WRC and the BMGF. Again, this configuration exemplifies non-profit public–private partnerships, which are those most likely to make resources available to engage with commercially unattractive technical interventions.

Most sanitation processing in South Africa entails the flushing 6 L–9 L of potable water to be diluted with a further 40 L–50 L of grey water (from showers and baths) for approximately every 200 g of human waste. Thus, sewerage is treated and returned to the environment using conventional municipal sewerage reticulation systems. The South African Sanitation Technology Demonstration Programme was initiated with the intention of developing new sanitation technologies that will create opportunities for new employment and new markets. Several prototypes have been developed for further testing and upscaling if appropriate.

At Cofimvaba, 200 toilet units of the EarthAuger system were installed, in response to the service needs of the district and in partnership with a local manufacturer Rocla, at a unit cost of ZAR7 500. Subsequently, the usage of the units by households has declined, apparently owing to political calls for a reticulated sewerage system for the area. At the time of writing, a community survey was being conducted to determine perceptions in this regard.

Elsewhere, the more communal Caltek unit, which houses 8–10 toilet seats in a closed loop system, is being tested. The system re-uses water continually, and only occasionally requires a top-up. Electro-catalytic reactions break down the human waste, inorganics and organics. Other technologies are from Research Triangle Institute International (RTI) (pyrosis unit), Toronto University and Latrobe University (hydro-thermal carbonisation process pressure cooker system) and the Asian Institute of Technology (hydro-cyclone technology that separates liquids and solids).

A more widely used and implemented system in South Africa (and in South East Asia) is the pour-flush system. The system has been customised by Partners in Development for the South African context. The Asian model comprises a squatting pan. After use, the pan is washed by the user, and anal washing is done. In contrast, the South African model has a sitting pedestal and accommodates the utilisation of toilet paper. From the perspective of the user, the system is, therefore, 'one step closer to the conventional flush toilet' than the Asian model (WRC 2018a). The pour-flush system is definitely an upgrade from the ventilated improved pit latrine (VIP), which is the standard for basic sanitation in many remote areas of the country. Partners in development piloted the system with 25 units in the Edendale area (Slangspruit,

France and Azalea) of Msunduzi municipality (Pietermaritzburg, KwaZulu-Natal). Of particular interest in the pilot project were the extent of user satisfaction, and the characteristics and environmental impact of the resultant sludge that accumulates in the leach pits, in comparison with the sludge associated with the VIP system.

The pour-flush pilot project assessment entailed the extraction of sludge samples from selected leach pits over a period of 11 months. The research team monitored the rate of filling of the pits and conducted chemical, physical and biological analyses of the sludge samples. The findings indicated minimal differences between the chemical compositions of sludge from pour-flush versus VIP leach pits. Physically, the major difference was that the pour-flush pits contained less non-faecal material and therefore took longer to fill up and less time to degrade. It was also found that mechanical emptying of pour-flush pits was easier than that of VIPs owing to the lower presence of non-faecal material in the former. Non-faecal material is a frequent cause of blockage of or damage to pit emptying equipment. It had been anticipated that pour-flush pit sludge would have a higher concentration of ammonia, which would facilitate a self-sanitising environment in the leach pit, but the ammonia was lower than expected and insufficient for self-sanitisation (Neethling et al. 2018).

Another system is the LAtrine DEhydration and PAsteurisation (LaDePa) machine, which is manufactured by particle separation system. The LaDePa processes faecal sludge that has been removed from latrines into dry and pasteurised pellets, by means of convective as well as infrared radiation heating. The pellets are usable as combustible fuel or as a fertiliser or soil conditioner. A small-scale prototype was installed in the Pollution Research Group (PRG) laboratory, at the University of KwaZulu-Natal, Durban (WRC 2018b) in order to enhance comprehension of the drying process and to optimise the operation of the full-scale machine. The drying behaviour of the faecal sludge in the LaDePa was monitored by measurement of moisture, volatile matter and ash content at different heating intensities and residence times. It was found that the optimum drying temperature was in the 100 °C–200 °C range at the medium InfraRed emitter intensity, requiring 20 min to reduce the moisture content to 20%. Other means of expediting the process were found to be minimising the distance between the emitters and the conveyer belt, decreasing the pellet size and increasing the air flowrate in the heating zone, resulting in the enhanced evacuation of the evaporated moisture from the surface of the pellets to the environment (WRC 2018b). The PRG also analysed the *Ascaris* content (an indicator of pathogens) of the processed pellets to determine (1) the extent of pasteurisation (removal of pathogens by heating), (2) the potential for agricultural use (nitrogen, phosphorus and potassium content) and (3) the value as biofuel (calorific

value, thermal conductivity and heat capacity). The findings suggested that the drying-out decreases the concentration of soluble nitrogenous compounds, resulting in a slight increase in thermal diffusivity. In agriculture, phosphorous is released slowly into the soil, while potassium, magnesium and calcium are released more quickly (owing to their solubility in water). Some nitrogen is released as ammonium and nitrites, which are not as easily assimilable by plants as are nitrates, but can be converted into nitrates by means of microbial activity in the soil (WRC 2018b).

Discussion

A substantial demand for innovative technologies to provide potable water and effective sanitation exists among households and communities that are located in remote, undeveloped regions that lack access to reticulation networks. This chapter has listed several such technologies that are currently available, either in prototype or more widely tested and advanced models. Engineers and inventors have designed these technologies for use in developing contexts such as South Africa, in partnership with research NGOs or state-funded research institutions, and usually with funding from non-profit foundations.

Methods for the provision of good-quality potable water include DCMD, the coating of sand grains to filter toxins such as mercury, solar radiation to remove bacteria such as *E. coli* and flocculation to remove clay content and eliminate diarrhoea. A South African invention that can be purchased for less than ZAR2 000 is the VulAmanz Point of Use Water Filtration Device. Piloted in rural Limpopo and the Eastern Cape, it demonstrably produces sufficient purified water for average household use. It comprises a 20-L container with a woven fabric membrane to filter out suspended solids from more than 25 L/h.

Available low-cost off-grid sanitation technologies include the freestanding toilet that filters the liquid through a membrane and then combusts the solid component into a gas, a PV-powered toilet and wastewater treatment system that is being tested in India and China, and a unit that converts urine into electricity. The EarthAuger system can be manufactured locally at a unit cost of ZAR7 500. The Asian pour-flush system has been customised for South Africa by the addition of a sitting pedestal. Piloting in KwaZulu-Natal has demonstrated its superiority to a standard VIP in terms of the less frequent need for pit emptying and quicker degradation of waste material. The LaDePa machine that processes faecal sludge into dry and pasteurised pellets, usable as combustible fuel or fertiliser, is under development at the University of KwaZulu-Natal.

Conclusion

South Africa's national policies and institutions that promote experimentation and prototyping of innovations in the water and sanitation sector are essential. Inclusive development should be the objective as these policies are implemented. Thereby, medium- and long-term developmental dividends will be reaped. The appropriate harnessing of the available mix of ideas, technical skills and entrepreneurial talents has the potential not only to deliver good-quality water and proper sanitation services as societal norms but also to release and enhance our inherent indigenous capacity to devise and implement solutions to our other developmental challenges.

Chapter 9

Towards an inclusive measurement programme for innovation in the informal sector of South Africa

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Introduction[23]

It has often been said that what gets measured, gets managed. While this is usually used within the context of day-to-day business, it applies equally well to the context of innovation. This chapter is about the measurement of innovation, specifically on what is a suitable measurement programme for South Africa, and more broadly, the African continent. Measuring innovation is important for any country (Charmes, Gault & Wunsch-Vincent 2016). It provides 'critical policy evidence to inform strategies for technological upgrading and innovation that can drive the distinctive economic growth paths of middle- or low-income countries' (Kruss 2018, p. 348).

In South Africa, the *White Paper on Science, Technology and Innovation of 2019* (Department of Science and Technology [DST] 2018) provides direction on the path that the country is set to take in harnessing and building its science, technology and innovation (STI) capabilities. Innovation at the local level and in the informal sector is an area of economic activity highlighted in the *White Paper on Science, Technology and Innovation of 2019* as part of a strategy for promoting a sustainable and inclusive development agenda. The informal sector accounts for 17% of total employment, which implies that around 1 : 6 South Africans who are employed works in the informal sector (Fourie 2018). Furthermore, the informal sector contributes about 6% to gross domestic profit (GDP) (Statistics South Africa [StatsSA] 2014). The recent downturn in the national economy over, at least the last five years, combined with the economy-wide economic shock caused by the coronavirus disease of 2019 (COVID-19) pandemic is expected to put upward pressure on informal sector growth, making the informal sector even more important as an avenue of economic activity for the unemployed and for economically at-risk households. Yet, we only tend to measure innovation in formal businesses and in some industrial sectors.

To have a robust representation of the state of innovation in South Africa, there is a need for measurement to go beyond formal businesses alone and extend towards informal businesses and households, the public sector as well as civil society. Our focus in this chapter is on the informal sector as innovation in households and the public sector and social innovation are all areas that are being addressed in measurement programmes in some way (Gault 2018). Given its potential to impact directly on the lives of ordinary people, and those who have historically been left out of STI policy attention, in South Africa and globally, the informal sector is an area where a measurement programme is greatly under-resourced and underemphasised. The measurement of innovation in the informal sector is critical to inform inclusive development strategies as it signals government's commitment to harness STI towards inclusive human development and provides an indicator of improvements in the scale of such an endeavour over time. What we need to determine is how

23. Sections of this chapter represent a substantial reworking of the following publication: CeSTII (2021).

we can capture these kinds of innovation activities that are not yet well understood and bring these realities into the measurement programme.

We argue that to design a programme for measuring innovation in the informal sector, we need to reconsider the *what*, *how* and *who* of measuring innovation. For the determination of measurement needs to be inclusive, we suggest actors involved in innovation in the informal sector need to be part of the innovation policy agenda setting. For innovation in the informal sector, who are the actors that should be involved in the measurement system, in addition to the usual cohort of statisticians, policy-makers and researchers (partners at a local level, such as informal businesses, intermediary actors and so on)? How suitable are our research tools and methodologies for the informal sector?

In an attempt to balance the policy discussion, it is our goal in this chapter to put forward a proposal for such a measurement programme, including a tool that is standardised to the context, and share the lessons we have learnt in implementing a survey of innovation in the informal sector. The chapter firstly provides a brief overview of the history of innovation measurement with a focus on South Africa. It then goes on to discuss what would constitute a measurement programme for the informal sector in the 'What constitutes a measurement programme for the informal sector?' section. The fourth section describes the proposal for measuring innovation in the informal sector, based on our experimentation with a novel methodology and our attempts at developing a standardised tool for the South African context. We also identify ways to begin to build the necessary institutional infrastructure. The chapter concludes with some recommendations for advancing a suitable measurement programme for innovation that includes the informal sector, as a complement to the well-established programmes for research and development (R&D) and innovation in formal businesses.

History of innovation measurement

A focus based on a 'linear model of innovation'

Historically, much of the measurement of innovation on the African continent replicates programmes that originated in developed countries. The earliest surveys on innovation measurement focused on R&D within the framework of what has come to be known as the 'linear model of innovation'. This concept effectively came about through a piece-by-piece construction of heuristics, starting with the idea that innovation was essentially what was done by researchers in institutions dedicated to producing basic research and then applying that basic research (see Godin 2006 for an exposition). However, this immediately raises a question. There are almost immeasurably many more cases of innovation that occur in the world than those done by specialised researchers in laboratories. The defining quality of innovation is that something new is being created from the transformation of knowledge into something useful. Therefore, almost anybody is involved in the process of innovation at

some time or another and not just R&D personnel. Within the economic context, economists (right back to Adam Smith) recognised essentially two modes of innovation, one that may be called 'Doing, Using and Interacting' (DUI) and the other that may be called STI-based innovation (Jensen et al. 2012). The first mode refers to those activities that every person performs typically when confronted with a problem – DUI can be thought of as the type of learning that takes place 'on the job'. This is the mode of innovation that is most important for technological upgrading. The STI mode is distinguished by being that which is informed by scientists, researchers and those with a specialised technical expertise. The linear model of innovation is perhaps the clearest illustration of the emphasis on the STI mode of innovation that measurement has focused on over the last 60 years or so. This focus is reflected in the history and current emphasis of innovation measurement in South Africa.

History of measurement of innovation in South Africa

South Africa has been measuring R&D since the 1960s when such measurement initiatives first started, alongside the implementation of the System of National Accounts (SNA) (UNSNA 1993). The focus here was on the science and technology (S&T) system, measuring the inputs to R&D in formal private and public enterprises, higher education institutions, science councils, government departments and research centres. The implementation of the *White Paper on Science and Technology of 1996* was both a continuation of previous science policies and a departure from the primary focus on S&T.

Internationally, the notion of *innovation* as separate from the S&T system became a policy focus increasingly reflected in measurement programmes that have been continued or implemented from 1990 to date. Innovation measurement became systematised with the introduction of the community innovation survey (CIS) instruments in the 1990s. The focus was on formal businesses, initially only in manufacturing, but expanded to cover services sectors. Both S&T and innovation measurement programmes were focused on Organisation for Economic Co-operation and Development (OECD) countries. The standardisation of methods and tools was, therefore, undertaken within the OECD. By the 1990s, most of these OECD countries were highly developed countries, and the measurement tools were suited to the scope and policy focal areas of these developed countries, naturally so.

South Africa has always had good relationships with many OECD countries and the OECD groups that assist in bringing policy-makers and measurement experts together in the STI sphere. The relationships were established in the days of apartheid, and many of the measurement programmes were adapted from the OECD countries in the days when government thinking treated South Africa as if it were a developed country and not one where the population was

widely diverse in terms of socio-economic outcomes. The effect of this was to leave areas of attention for economic development largely unexplored in policy attention, as well as in measurement. Thus, similar to what has happened in OECD countries, R&D measurement has been performed for several decades. Innovation surveys have had several waves, conducted in a way that attempts to replicate the methodologies and standards of OECD country surveys (Kruss & Ralphs 2021). While formal and large institutions are routinely subjected to monitoring by policy experts using these tools, a critical area of under-attention is that of the informal sector. There has not been a single standardised survey, at the national level, of innovation in the informal sector.

What constitutes a measurement programme for the informal sector?

> An innovation measurement framework covers a defined scope, such as an SNA sector of interest, a jurisdiction or geographic area where data will be collected, a set of relevant phenomena of interest for understanding innovation, and measurement strategies. (*Oslo Manual* 2018)

Therefore, a measurement programme for the informal sector needs to consider each of these facets.

Scope

The coverage should include areas of informal economic activity. This may be a locally defined geographic area of enterprises bound by common socio-economic status, cultural practices and so on. Or, it could equally well be informal economic activity within the borders of a country, at a national level. It will be important to distinguish between these two in the measurement programme we put forth here.

Phenomena of interest

Which phenomena to study depends often on the areas of policy activity that are considered important. Within formal sector innovation surveys, these are discussed at multilateral organisations by policy-makers and measurement professionals, where these country experts bring areas of national interest to the attention of their peers.

Researchers play a role in informing the discussions, based on case study research and other research work on innovation. For the informal sector, not enough is understood about innovation to be able to agree on a set of phenomena of interest that are broadly universal. There are several recent studies on innovation in the informal sector in Africa (see, for instance, Charmes et al. 2016; De Beer, Fu & Wunsch-Vincent 2016; Gault 2018; Konté &

Ndong 2012; Kraemer-Mbula & Konté 2016). Some published empirical work on informal sector innovation in Africa include the work of Bull et al. (2016), also Kraemer-Mbula (2016), Essegbey and Awuni (2016), Jegede et al. (2020a), Ogunjemilua et al. (2020), Oluwale et al. (2020), Jegede (2020a, 2020b). These were mostly sectoral studies that used questionnaires designed for the specific industrial sector, typically conducted by individual researchers, often using a case study approach. A recent exception is the survey conducted by Fu, Mohnen and Zanello (2018). Mustapha et al. (2021) provide a comprehensive summary of the emerging body of research on innovation in the informal sector in Africa. None of these addressed some of the more practical aspects to a survey programme, such as the use of relatively lower-skilled fieldworkers, cognitive testing of survey tools to improve response quality and so on. Such considerations are essential to enable 'scaling-up' of surveys. However, there is still great scope for case study research to inform a suitable innovation measurement programme for the informal sector (Charmes et al. 2016).

Measurement strategies

A plan that brings together the goals and outcomes of measurement is key to realise a programme of measurement. Such a plan needs to be able to outline the purpose of the measurement, the endpoint envisaged and the relevance to key stakeholders of the measurement outputs. Within formal sector measurement paradigms, the objective is typically to stimulate innovation (preferably 'good innovation') in businesses, with the intention that this would promote their growth and technological advancement. Implicit in this strategy, is the belief that such business growth would be beneficial to the development of individuals across civil society. Within the informal sector, because the participants in this economic sector tend to be individuals or small businesses, often of low socio-economic status, it is better suited to promote innovation in businesses towards the goal of economic development at the local level.

In developing a measurement programme for innovation in the informal sector, we argue for the need to reconsider the focus of measurement, how we measure and who we include in the measurement, as well as how we can begin to build the institutional arrangements to support a measurement programme. We address each of these considerations in turn in this section, based on our experimentation with a novel methodology and strategy.

Towards a measurement programme inclusive of the needs of the informal sector

Reconsidering *what* we measure

To transform the lives of ordinary South Africans, we need to recognise that there are several domains of STI application and therefore measurement requirements.

There is the S&T system, which includes institutions such as universities, research centres, science councils, government departments, public and private businesses. A focus here is mostly on R&D, its generation and use. Nowadays, there is also pressure on universities to provide avenues of application for the research developed through their research units and by individual researchers. There is the topic of innovation in the formal business sector, which has become a popular area of measurement both abroad and locally. In this respect, there are well-established tools and methods that have been used in many countries.

Measuring innovation in formal enterprises is a complex and difficult task – one that has evolved over decades through the iterations of the *Oslo Manual*. Even so, this measurement framework and related instruments have been designed for innovation that takes place in mainly formal businesses situated within a developed economic context. This limits the kinds of funding and policy interventions that could be put in place to ensure that STIs are harnessed to include the needs of informal enterprises. The measurement challenges arising in informal contexts are even more daunting, and there is little international precedent.

☐ Adapting the *Oslo Manual* guidelines, as a starting point

Systems approaches are useful for measurement purposes. Our approach considers the basic unit of analysis as a firm in a conception similar to what the *Oslo Manual* adopted, based on the Kline-Rosenberg (Kline & Rosenberg 1986) chain-link model of innovation. Therefore, as a starting point, we adopted an innovation systems framework that builds on and extends the guidelines of the OECD's *Oslo Manual*. The definition of innovation introduced in the latest version of the *Oslo Manual* was found to be suitable for measuring innovation in South Africa's informal sector (OECD/Eurostat 2018):

> [/]nnovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process). (p. 60)

As such (Centre for Science, Technology and Innovation Indicators [CeSTII] 2021):

> While the Oslo Manual (2018) provides useful insights for measuring innovation in the informal sector, the conceptual underpinnings and methodological recommendations for the CIS-type surveys that are used for measuring innovation in the formal sector in South Africa are not suitable [*for the purpose*]. A survey of innovation in the informal sector in South Africa [*must consider*] the typical size of informal [*sector*] businesses, which tend to be survivalist and micro, and the local nature and spatial dynamics of informal sector industries. (p. 9)

Table 9.1 identifies key differences between guidelines on innovation in formal sector businesses, as outlined in the *Oslo Manual* (2018), and insights on the informal sector, based on the emerging body of research on innovation in the informal sector discussed.

TABLE 9.1: Some notable deviations from the *Oslo Manual*.

Oslo Manual	**Informal sector**
R&D in-house or outsourced or combined, formal training	Learning by doing, using, interacting, learning by imitation, learning by producing and searching
Use of universities and government laboratories as sources of ideas for innovation	Serendipity, 'happy accidents', vagaries of realities or 'flashes of insights', indigenous knowledge, intuition, and customers, suppliers and competitors as sources of ideas for innovation
Number of patents applied for and acquisition of external technology/knowledge (patents, industrial design, trade secret)	Complexity of product, secrecy in production process, brand loyalty, non-disclosure agreement
Skills development, level of education, skills in terms of PhDs, number of publications, IPRs and formal training	Traditional apprenticeship system, on-the-job learning, indigenous knowledge systems
Relationship among actors and key stakeholders is largely formal but sometimes informal	Relationship among actors and key stakeholders is largely informal.

Key: R&D, research and development; PhDs, Doctor of Philosophy degrees; IPRs, intellectual property rights.

In adapting the *Oslo Manual* (2018) guidelines, we explored the potential value of an approach developed specifically for studying innovation at the local level, a local innovation and production systems (LIPS) approach.

Adapting a local innovation and production systems approach to the South African informal sector context[24]

The LIPS approach, which was introduced by innovation scholars at RedeSist at the Federal University of Rio de Janeiro in Brazil, integrates innovation systems and development approaches in studying innovation processes (Cassiolato & Martins Lastres 2020). A LIPS is defined as (Lastres & Cassiolato 2005):

> [*A*] group(s) of economic, political and social agents localised in the same area, performing related economic activities, in which formal and informal interdependence and consistent linkages usually result in cooperation and learning processes, with a potential to generate the increase of productive and innovative capabilities. (p. 7)

The LIPS framework emphasises the following aspects:

- **Territorial dimension** as a specific focus of analysis and policy.
- **Link between micro-, meso- and macro-dimensions.**
- **Diversity of activities and actors:** Economic, political and social.
- **Interactive learning:** Creation, assimilation and use of knowledge – innovation.
- **Coordination ('governance'):** Power relations and coordination among actors and activities.
- **Embeddedness:** Common identities and goals, cooperation and commitment of the different actors and the articulation and adherence of production and innovation initiatives to the development of that particular territory (Lastres & Cassiolato 2018).

24. This section of this chapter is based on the following publication: CeSTII (2021).

While it is situated at the intersection between the innovation systems perspective and Latin American structuralism, the building blocks of the framework are the broader understanding of innovation, the focus on social, economic and political agents and contexts, the systemic approach and the observance of micro-, meso- and macro-relationships (Cassiolato et al. 2017). Furthermore, the framework draws attention to the set of economic, political and social actors and their interactions in different territorial layers, including the local, the regional and the global. The focus is on studying the linkages among a range of actors involved in interrelated economic activities, from firms producing goods and services; to suppliers of raw materials, equipment and other inputs; distributors and traders; workers and consumers; organisations geared towards capacity building and training of human resources (HR), information, research, development and engineering; support, regulation and financing; cooperatives, associations, trade unions and other representative bodies, as well as policy design and implementation actors. The LIPS framework places the unit of analysis as the set of agents at the collective level, going beyond the individual organisations, sectors or production chains, establishing a close relationship between the territory and the economic activities (Cassiolato et al. 2017).

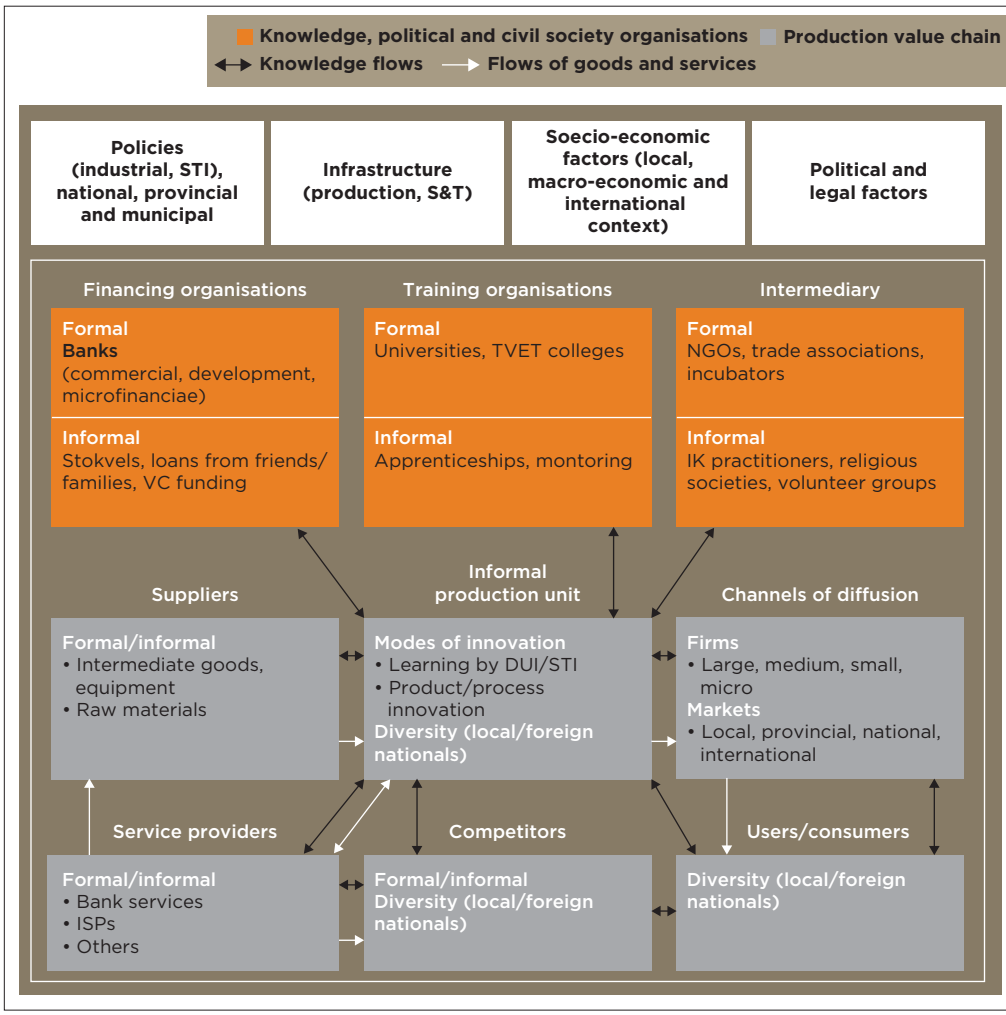
We adapted the LIPS framework by factoring in the peculiarities of the informal sector in South Africa, especially elaborating a range of new actors and key stakeholders within a system, informal forms of linkages among these actors and key stakeholders, as well as the peculiarity of the socio-cultural, political, institutional and technological landscape. The framework adopted for measuring innovation in the informal sector is illustrated in Figure 9.1 and each key component of the system is described.

Informal production unit

The 'informal production unit', at the centre of the system, represents all informal enterprises (micro and small) that are actively involved in economic activities.

In the South African *National Small Business Act 102 of 1996*, micro, small and medium enterprises (MSMEs) are categorised into five stages of development: (1) survivalist, (2) micro, (3) very small, (4) small and (5) medium-sized enterprises. Survivalist and micro-enterprises are known to dominate the informal sector in South Africa, thereby:

> Informal sector enterprises are commonly defined as all private unincorporated enterprises that produce at least some of their goods and services for sale or barter, and that are not registered for tax or a business licence, or do not keep formal accounts (EC et al. 2009; Jegede 2020a). An unincorporated enterprise is a business that does not possess a legal identity separate from that of its owner. While this definition may describe many businesses operating in the informal sector, it does not cover the full range of businesses. For example, businesses may be registered and keep formal accounts, but are similar in character to unincorporated enterprises in the informal



Source: Adapted from Mustapha et al. 2021.
Key: STI, Science, technology and innovation; S&T, science and technology; TVET, technical and vocational educational training; NGOs, non-governmental organisations; VC, vice-chancellor; IK, indigenous knowledge; DUI, 'Doing, Using and Interacting'; ISP, internet service providers.

FIGURE 9.1: Local innovation and production system framework adapted for the informal sector.

> sector, in that they operate from [*shipping containers*] or makeshift premises with limited or no access to basic amenities, and mainly serve the low-income market in the local area. [*We thus propose*] a more bottom-up definition, based on the characteristics identified above as well as how the business owners and others in the local area described their businesses (i.e. informal or formal). (CeSTII 2021, p. 15)

Community-based participatory research techniques are most useful to facilitate such an understanding.

As highlighted in recent work (Jegede et al. 2020b; Jegede 2020b, 2020c), the most prevalent innovation activities in informal businesses relate to learning by doing, using, interacting (Jensen et al. 2007), imitating, producing and searching (Jegede 2020a) modes of innovation and learning. A dimension

common to the informal learning processes by support, training and learning organisations is that knowledge transfer is usually tacit. Several studies (Cross 2011; Marsick & Watkins 2015; Marsick & Volpe 1999) have highlighted the importance of spontaneous and incidental modes of learning among employees in the workplace. Knowledge exchanges at the workplace happen spontaneously and have been a critical success factor for enterprise growth and vibrancy of clusters (Jegede et al. 2020a; Ogunjemilua et al. 2020; Rangaswamy & Densmore 2013). Informal channels of learning have proven to be a breakthrough opportunity for the innovativeness of business and a significant driver of performance (Cross 2011).

Sources of information for innovation

The most common sources of information for innovation identified in recent literature are sources within the market. Jegede et al. (2020a) identified that informal businesses collaborate more with customers, suppliers, competitors as well as formal firms through sub-contracting or outsourcing. In addition, Van Aken and Weggeman (2000) and Kawooya (2012) identified that there is constant interaction between formal and informal components in the economic space. Hence, the sources of information for innovation come from both actors and stakeholders in the formal and informal sectors.

Channels of diffusion of innovation

Innovations in informal settings are diffused through the market in the same ways as innovations in formal settings. Note that innovations from the informal sector are diffused through local markets, provincial markets and national markets onto international markets. A good example is the success story of information and communication technology (ICT) products from the Otigba hardware market in Lagos, Nigeria, in the cluster that comprises informal sector businesses that service the west African market and represents the biggest ICT market in Africa (Jegede et al. 2020a, 2020b). The channels of diffusion of these innovations include other micro firms, small firms, medium firms and large firms.

National, provincial and municipal industrial policies

As shown in Figure 9.1, the production and innovation activities of informal businesses take place within and are shaped by the broader socio-economic, cultural and political context. A review of literature (Charmes 2016; De Beer, Fu & Wunsch-Vincent 2013; Schneider 2002a, 2002b; Tiwari & Herstatt 2012) on MSME suggests that a large amount of support is sourced from the government, predominantly because of its regulative and facilitative roles. Support for MSME development in South Africa is discernible in four main reinforcing types: political; legislative, policy and government strategy; institutional infrastructure and through funding and non-financial

support mechanisms. According to Malefane (2013), an abundance of research on support for MSMEs in South Africa emphasise the roles institutions such as the Industrial Development Corporation (IDC), Department of Trade and Industry and their subsidiaries play in supporting MSMEs.

Basic infrastructure for production

All businesses, formal and informal, require access to infrastructure and basic services. Water, roads, as well as access to electricity, are important municipal services that shape the business environment where informal sector businesses operate. The literature (Jegede 2020b; Kajogbola 1997; Olowu 1995; Oluwale et al. 2020) on innovation and productivity has highlighted the role that the business environment plays in innovation and performance, emphasising access to broadband/Internet services among others. Internet/broadband facilities afford the opportunity for online visibility, which promotes sales and a range of products. The use of computers and other ICT devices makes accounting and record keeping easier. Furthermore, good roads are important for the supply of raw materials, inputs and tools to the firms. Transport services are also important, especially with raw materials and other input commodities usually sourced far away from where they are used in production and with the market sometimes far away from where the goods are produced.

Social and economic factors

Socio-economic factors define the means of life in an environment. Among others, the main socio-economic factors are education, income and occupation. They shape the context of the informal sector (Williams 2006). The level of income in a particular locality or society or business environment decides the expenditure practices and limits of the community, which in turn will shape the local economy. Furthermore, there is a positive correlation between occupation and income – highly paid individuals are usually skilled labour. The educational level of the people living in a society will, therefore, determine the proportion of the society that can be employed or that can venture into business.

Political and legal factors

Political and legal factors also define the business environment of the informal sector. It has been widely acknowledged that political decisions affect the economic landscape for rural or informal sector businesses (De Beer et al. 2014). With changes in policies, the business environment is usually affected. The main political and legal factors are circumscribed by the following policy tools at the national level:

- Tax policies may generally impede the scaling-up of most MSMEs, but some government initiatives are fashioned to support local businesses, both formal and informal.

- Lack of political stability can significantly affect the operations of any business.
- Foreign trade regulations: the political landscape of a country influences the aspiration for a business to expand its operations.
- Governments provide support to domestic companies in financing exports, often through export processing zones. Businesses enjoy reduced tariffs, taxes, customs, procedures or restrictions in an effort to promote trade with other countries.
- Types of subsidies that are usually extended to informal sector businesses include low-interest cash grants and, in rare cases, government-equity participation.
- Many countries continue to require that a certain percentage of a product or an item be manufactured or 'assembled' locally (local content promotion). In some cases, where the capability of domestic firms is low, domestic businesses serve as supplier firms to the larger (sometimes multinational) firms and a significant part of informal sector businesses get to participate through such formal-informal linkages.

Formal and informal support organisations

Formally, the state provides support to all businesses, including informal businesses, generally through policies and through its institutions. In this way, the state acts as a formal support organisation, especially when it does so at the local level. These are aimed at developing new businesses from the 'conception' stage to 'start-up' stage and eventually to the 'scale-up' stage (Adebowale et al. 2014). As starting up or growing any small business is a challenge for most, government support programmes are targeted towards assisting and nurturing new businesses through incubation until the businesses become established (Mytelka & Farinelli 2000). Some of these support services include business advisory services, capacity building, incubation, accelerators, IP protection and technology transfer, creation of science parks, industrial districts, free trade zones, export processing zones, special economic zones and industrial hubs, among others. All of these support organisations provide technical support to micro-enterprises, the informal sector and small businesses in general.

Most studies recognise the role of formal organisations such as government institutions. Several studies failed to highlight the importance of informal support organisations for the successful implementation of innovation in enterprises (Jegede 2020c; Oluwale et al. 2020). Experience in the field has shown that there are a range of informal support organisations that directly or indirectly enable the implementation of innovations (Jegede et al. 2020a, 2020b; Jegede 2020a; Van Aken & Weggeman 2000), including civil society, NGOs and self-help organisations and empowerment programmes from all tiers of government.

☐ *Formal and informal financing organisations*

Informal enterprises may source their funds from formal organisations, such as commercial banks, microfinance banks and development banks, but this is extremely difficult because of regulatory requirements. While commercial banks grant huge loans to enterprises against collateral, microfinance banks do not require collateral and only lend small amounts. Development banks lend a medium to high amount at lower interest rates, compared with the microfinance banks and commercial banks. However, the process of accessing development bank loans is very cumbersome, and usually, businesses find it difficult to meet the requirements. Johnson and Rogaly (1997) found that the main sources of finance for the informal sector are microfinance banks, which grant loans to enterprises without collateral. Against this backdrop, practical experience in the field has shown that informal business operators source their capital from alternative sources of financial organisations.

The majority source their funds from other informal sources, such as family and friends, community funds from stokvels, money from loan sharks and from venture capitalists or business angels. However, to date, studies have not really explored these alternative sources of funding available to informal businesses, and the possible role the alternative financial sources may be playing in the implementation of innovation.

☐ *Formal and informal training and learning organisations*

Formal training and learning organisations include universities, technical and vocational educational training (TVET) colleges and other adult education and training centres. Studies on the informal sector in Africa have shown that a sizeable fraction of employees have tertiary qualifications (Oluwale, Jegede & Olamade 2013). Technical and vocational educational training colleges provide training opportunities and career advancement for young school leavers and produce skilled workers needed at all sectors and levels of the economy (Oluwale et al. 2013). The skills provided by TVET colleges help the trainee to be self-reliant within a trade or craft. Although knowledge from the TVET colleges is very useful and appropriate for the informal sector, Obembe (2014) found that most operators of business in the informal sector have not placed so much value on TVET education. The majority either went to university or learnt on the job through apprenticeships.

Informal training and learning take place via the following processes:

- The traditional apprenticeship system (Akinleye, Oluwale & Ilori 2014; De Beer et al. 2016; Ogunjemilua et al. 2020; Oluwale et al. 2013).
- The indigenous knowledge (IK) system (Jegede et al. 2020b; Jegede 2020a).
- On-the-job learning characterised by learning by doing, using, interacting (De Beer et al. 2016; Kraemer-Mbula et al. 2019; Murphy 2002) as well as learning by imitating, producing and searching (Jegede 2020a).

Innovation intermediaries

Innovation intermediaries include trade unions and industry associations. Their importance cannot be overemphasised in both formal and informal firms. Evidence from the literature (Jegede et al. 2020a; Van Aken & Weggeman 2000) supports the positive association between trade unions, cooperatives and collective action with innovation outcomes.

Scholars (Freel 2000; Jegede et al. 2020a; Kuan & Chau 2001) have stressed the benefits that enterprises enjoy because of proximity to one another, suppliers or equipment, raw materials and customers. Both technical information and financial information are shared in these platforms (Gupta 2012; Mytelka & Farinelli 2000). Informal clustering of related business operators with common interest often results in collective action groups, which help them to collectively negotiate with suppliers of equipment, raw materials and even the government on issues of taxes and subsidies.

The LIPS conceptual framework and Oslo approach allow for an adequate exposition of what needs to be measured with respect to innovation in the informal sector. We now turn to the question of how to go about the measurement process.

Reconsidering *how* we measure

A phased strategy to measuring innovation in the informal sector at a national level

In South Africa, the informal sector is regularly surveyed by the national statistical institute, StatsSA. Nationally representative data on informal sector businesses can be obtained through the Survey of Employers and the Self-Employed (SESE) following a typical 1-2-3 survey design. The 2017 SESE (StatsSA 2019a) showed that 1.8 million people ran informal businesses and that the number of employees was 0.8 million. Therefore, the informal sector provided work for around 2.6 million people, which, given the total employment level (StatsSA 2019b) of 16.2 million, means that the informal sector contributes around 16% of total employment.

The 1-2-3 surveys that have been conducted in Africa, Asia and Latin America (Grabrucker, Grimm & Roubaud 2018; Razafindrakoto, Roubaud & Torelli 2009) bear special mention. These surveys are enterprise-based and consist of three phases, as the name suggests:

1. The *first phase* is a Labour Force Survey (LFS). Many countries conduct an LFS as a matter of routine. The survey is household-based, collecting key indicators on employment levels, and in particular, unemployment statistics. In South Africa, this is known as the Quarterly Labour Force Survey (QLFS). In this phase, employing/self-employing individuals in those households are identified.

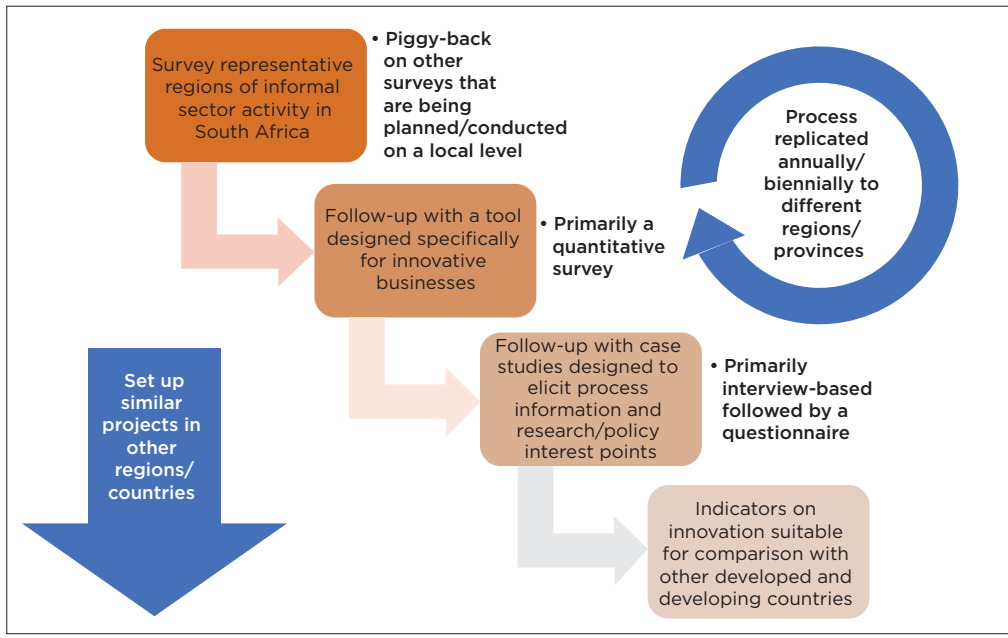
2. The *second phase* follows those identified as self-employed individuals and collects data on their business activities and demographics. The majority of these are identified as informal sector enterprises, in line with the definition of the International Labour Organisation. The data-collection occurs very soon after filtering the informal sector businesses from the first phase, thereby minimising the effect of erratic business demographics. In South Africa, this is known as the SESE. It is conducted every four years.
3. The *third phase* collects income and expenditure from a sample of the households surveyed in the first phase. It captures the demand side of the informal economy by looking at the proportions of informal to formal consumption. South Africa has an income and expenditure survey that measures household consumption patterns. However, it is used primarily for weighting the basket of goods and services in the calculation of the Consumer Price Index and does not distinguish the expenditure of households on the informal sector from that of the formal sector. The survey also has differing reference periods and is run on a different cycle to the SESE.

These surveys provide a potential means for conducting national-level surveys of innovation, provided a standardised tool is available for that purpose, by running the third phase with an innovation survey module.

We, therefore, propose a phased approach to measuring innovation in the informal sector, starting with developing a standardised instrument that is suited to the context (see Figure 9.2).

A mixed methods local innovation and production systems methodology

As illustrated in Figure 9.2, the first phase is to build up an understanding of innovation in informal enterprises across all industries in diverse local settings across South Africa. It may be that the innovation activities within informal businesses in one type of socio-economic area, such as a township setting, do not fit with those in another, such as a rural town, even though they may both be informal sector in scope. Here, we propose a mixed methods LIPS methodology, including a quantitative survey, to understand the scale and nature of innovation and qualitative research techniques that allow for a more in-depth understanding of the specific nature of innovation activities and the broader system. A useful approach is to conduct case study research on key economic activities in the local area, based on the mix of data collected. Case study research is valuable for refining the survey instrument and improving its suitability to context. This approach has a greater chance of producing a valid standardised innovation instrument than to study *ad hoc* sectors of informal activity.



Source: Adapted from Mustapha et al. (2021).

FIGURE 9.2: Measurement strategy for innovation in the informal sector.

Rather than following a simple sequential mixed methods design, we found value in using qualitative research techniques to inform the development of the survey instrument, in an iterative manner. The actual survey instrument development process involved five stages, including desktop research, consultations with informal sector and innovation experts, team workshops, conducting community-based participatory research, specifically digital storytelling[25] and cognitive testing.

With the use of mobile technology, the survey questionnaire can be administered through face-to-face structured interviews with informal sector business owners at their business premises and at times suitable for them. An online survey format using an online survey platform, such as RedCap, allows for relatively rapid and reliable data-collection (see also Charman & Petersen 2018; Charman et al. 2017). In our case, data-collection was conducted over a period of about eight weeks, including the small area census step, with a response rate of 77% (i.e. 996 of a total of 1289 informal businesses identified). The online survey format allows for better monitoring of the field work as it is possible to obtain live results of completed surveys and provide instant feedback to field workers.

25. Digital storytelling is a community-based participatory research technique found to be suitable for research with hard-to-reach communities and for exploring complex concepts and processes such as innovation (see Lambert 2013). The recommended guiding question for understanding the nature and drivers of innovation: 'Tell us a TRUE story about a time when you decided to do something different in the way that you run your business, and what happened'.

Measuring innovation without a suitable sampling frame

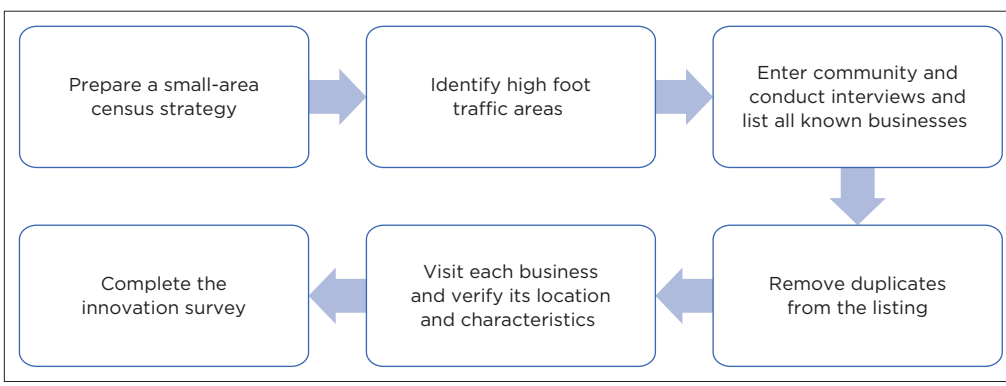
A major challenge to measuring innovation in the informal sector is the lack of a comprehensive listing of businesses. The nature of informal sector businesses is that they are often not registered and frequently start up and shut down. A novel approach is needed to be able to first capture all the businesses as sites within a geographical boundary and then go back to those sites and capture their innovation activities. Even this can be a challenge because of business mobility and the fluid nature of business structures in the informal sector.

The use of an area-based method, such as the small-area census method (Charman et al. 2015), is necessary. Figure 9.3 illustrates the method for conducting a small area census, based on the processes we followed in our study. The main purpose of the design and selection of a local area is to have a contiguous region of economic activity to investigate.

In contrast to other studies, our methodological approach is not dependent on the availability of lists to use as sampling frames, which may or may not be available from informal institutions, within a specific trade or sector. Instead, it adopts a methodology for listing informal businesses using a local area-based approach.

A more suitable classification of economic activities in the informal sector[26]

Assigning standard industrial classification (SIC) codes to businesses in the informal sector is a challenge in the absence of a reliable listing of informal sector businesses. Informal businesses often engage in more than one economic activity that may be completely unrelated. Considering the complexity of economic activities in the informal sector, differentiating the



Source: Author's own work.

FIGURE 9.3: Process for conducting a census of businesses in a local area.

26. This section of this chapter is based on the following publication: CeSTII (2021).

main economic activities from secondary and ancillary activities was not always simple. The following rule was used: the economic activity that generated the most income was identified as the main economic activity.

While the SIC aggregation recommended for the informal sector in South Africa (StatsSA 2010, p. 250) facilitates comparability, the standardised aggregates may not adequately represent the dynamics of economic activities at the local level. For example, hair salons and barbershops are typically significant in township economies but, based on SIC, these are captured as 'other personal service activities'. Another challenge was to classify the economic activities of businesses offering personal, single services such as hemming trousers and repairing handbags. Finally, a large proportion of informal retail businesses in township economies operate from a fixed location and often a fixed structure. It is therefore argued that the recommended 'Retail trade not in stores' category may not be helpful.

To better capture 'real production structures' at the local level, an alternative aggregation was used based on the LIPS framework (Lastres 2012, p. 4). These aggregates are referred to as local innovation and production classification (LIPC) groups. Table 9.2 includes the LIPC groups identified through our study, with the corresponding SIC classes. The LIPC groups were informed by an analysis of the production value chains identified through our study and are based on the SIC codes. The informal sector businesses with related production activities were grouped together to form an initial set of categories. The final LIPC groups were informed by a review of the literature and interviews conducted with informal business owners in the local area.

The LIPC aggregation thus allows for the analysis of economic activities in the informal sector that goes beyond a focus on an individual business or specific industrial sectors. Rather, the focus is on local systems that may be interlinked and include interaction and feedback between producers and users of related goods and services. The LIPS approach also allows for the identification and analysis of support structures and services important for competence building at the local level. The potential value of this alternative LIPC aggregation needs to be further explored through in-depth quantitative and qualitative data analysis.

While the value added by informal sector economic activity is relatively low, compared with that of the formal sector, an often-undervalued feature of the informal sector is its utility as a learning environment for entrepreneurs, other business owners and employees. Therefore, the networks for developing such learning in a systemic fashion within informal sector businesses are a critical explanatory variable. The use of a classification such as the LIPC, which is suited to the LIPS approach as a means of disaggregating results, provides insight in this respect.

TABLE 9.2: Alternative industry classification based on the local innovation and production systems framework.

Category	Title	Sub-category titles	SIC classes
A	**FOOD SERVICES**		
A.I	Animal and fresh produce production	Animal production; fruit and vegetable farming; mixed farming	01130, 01440, 01500
A.2	Bakery products	Manufacture and retail of baked confectionery, such as cakes, and other bakery products	10710
A.3	Wholesale and retail services	Wholesale and retail of live animals, meats, eggs; retail of fruit and vegetables; liquor retail; spazas; mobile tuckshops; and houseshops	47212, 47211, 47220, 47110
A.4	Food and beverage service activities	Events catering and catering equipment rental; fast food cafes/take-aways; taverns	56210, 56101, 56300
A.5	Other	Cooling services; rental of hookah pipes	77100, 77290
B	**BUILDING SERVICES**		
B.I	Construction of buildings	Construction of buildings; bricklaying; roofing	41000, 43909
B.2	Electrical, plumbing and other construction installation activities	Electrician; plumbing and air-conditioning installation	43210, 43220
B.3	Building completion and finishing	Plastering and painting; carpentry; tiling; ceiling fitting; glazing and door fitting; fencing construction	43301, 43302, 43309
B.4	Other	Boilermaker; welding; manufacture of clay building materials; retail sales of building materials	43909, 23920, 47420
C	**HAIRCARE AND COSMETICS**		
C.I	Hairdressing	Hairdressing and beauty treatment	96021
C.2	Retail of hairstyling articles	Wig sales	47610
C.3	Retail of cosmetics and perfume	Perfume sales; cosmetics sales	47620
D	**WEARING APPAREL AND HOMEWARE**		
D.I	Manufacture and retail sale of clothing	Dressmaking/tailors; clothing sales; fashion design; traditional attire and beads sales; fashion accessories sales, such as bags	14100, 47610, 74100
D.2	Manufacture, repair and retail sale of footwear	Shoemakers; shoe repairs; shoe sales	15200, 95230, 47610
D.3	Manufacture, repair and retail of homeware	Upholstery repairing; retail sale of linen; manufacture of traditional rugs/carpets	95240, 47410, 13930

Source: CeSTII (2020a).
Key: SIC, Standard Industrial Classification.

Exploring the understanding of innovation

The importance of qualitative methods

Using the LIPS framework for analysis emphasises the local embeddedness of the innovation and production system within a context. The methodology allowed the meaning of 'informal' to emerge through a grounded theory approach of what business owners perceived their business to be. This is outside of the standard definition of informality. For instance, a business

could be registered, but an owner could still define their business as informal, based on the community it served and key attributes of the business such as a lack of access to basic services. Similarly, to explore the distinct nature of innovation, it was necessary to use qualitative research methods and explain the concept of innovation in simple language to participating informal business owners, based on a broad understanding of innovation. Innovation was explained as something new or doing something differently from the way it has been done before. Framing innovation in this way permitted an understanding of the full range of new and different ways of doing things in the informal sector.

We emphasise the value that a mixed methods methodology adds to the study of innovation in the informal sector. Engagement with community gatekeepers allowed access to the community. The digital storytelling workshops assisted in framing innovation, informality, and gaining insight into the local informal sector. This helped shape the content and rollout of the survey.

The importance of cognitive testing

Cognitive testing is a crucial step to (CeSTII 2021):

> [*A*]ssess the extent to which the draft questionnaire captured the scientific intent of each question. Specific questions that were misunderstood by the respondents or that were difficult to answer [*may*] be improved prior to fielding the survey, thereby increasing the overall quality of the survey data [...] For example, the word 'Apprenticeship' was not easily understood, particularly by isiZulu-speaking respondents. [*Considering that isiZulu was the main spoken language in the study area, it was important to address such issues.*] The term was replaced by a more context-appropriate term suggested by respondents, 'on-the-job-learning'. (pp. 13–14)

Using the measurement of innovation in the informal sector at a local level as a development tool

The usefulness of the local approach that we follow is that it allows policy-makers to use the information gathering as a means of mobilising businesses, local government departments and agencies, knowledge brokers, knowledge producers and financing organisations to stimulate local economic development based on improving the innovation capabilities of local informal businesses. This is better than the situation that holds for formal business innovation, where the innovation data that is gathered needs to be disaggregated to be of more transformative value. Often this is not possible because of challenges in collecting data that has a high enough coverage and response from the field. The local approach circumvents this 'future problem' by building in from the start the 'localness' that allows innovation studies to provide insights.

Reconsidering who we include in the measurement programme

The previous two sections dealing with what and how to measure the informal sector were addressed by the development of a conceptual framework and methodology. To address who should be included in the measurement programme requires touching on issues of policy relevance and the data gap on the continent.

For measuring innovation in the formal sector, South Africa has the capacity and experience in using Oslo Manual methods. However, in the informal sector, there is no manual for measuring innovation. A way of measuring innovation in the informal sector from the ground up had to be developed. As several instances of the African Innovation Outlook have shown (AUDA-NEPAD 2019) there are huge data gaps across the continent and also a quality gap. The African Innovation Outlook programme was the 'first major African-led, politically authorised effort to generate a comprehensive and comparative survey of STI on the continent' (African Union–New Partnership for Africa's Development [AU-NEPAD] 2010). From its inception (AU-NEPAD 2010), some countries that submitted innovation data have dropped out, and new ones have been brought into the process. Overall, the number of countries that submitted data in some form has decreased from twelve (AU-NEPAD 2010) to 10 (AUDA-NEPAD 2019). This is perhaps a reflection of the true commitment that countries have to perform national surveys of formal sector business innovation. It certainly reflects the fact that surveys are conducted based on the availability of funds, which are not routinely committed by the governments of the contributing countries. Could this be because African countries have relatively small formal sectors and therefore do not see the need for such tools?

There are big differences in the methodology used in different African countries, and the coverage in most cases does not comply with the *Oslo Manual* requirements, particularly on the need for including small businesses in the scope. Part of the reason for this failure is that, in African countries, small- and medium-sized businesses are often found in the informal sector. In contrast to OECD countries where the OECD provides a multilateral forum for standardising methodologies and tools, there is no similar structure for African countries. The lack of institutionalisation is a greater gap for informal sector measurement.

To counteract this lack of institutionalisation, the proposal we make is to use the research structure as a means of standardising methodologies and tools of informal sector innovation measurement. Ultimately what would be required is for the government in South Africa, and other countries across Africa, to build a multilateral structure similar to the OECD in order to provide a forum for measurement experts, policy-makers and other key stakeholders to discuss the developmental needs of their countries and the innovation tools

needed to monitor and evaluate them. This will require coordination support by key platforms such as the NEPAD. The first step in that endeavour, prior to the formal establishment of such a structure, is the strengthening of communities of practice. In the case of informal sector innovation, the input from formal and informal local business owners, local, regional and national government, civil society, and other actors engaged in the LIPSs may be used to develop non-STI indicators of innovation in collaboration with innovation researchers. Such inputs would then 'bubble up' towards national-level indicators in the form of a survey tool, developed at the local level and applied at the national level. As we have discussed elsewhere (Mustapha et al. 2021):

> Extending innovation surveys to the informal sector, using the approach proposed, will come at an extra financial cost, but the multiplier effect of harnessing the contribution of the informal sector through inclusive [...] policy informed by measurement cannot be under-estimated. (p. 15)

Conclusion

Although the body of research on innovation in the informal sector has grown in recent years, none of these studies have focused on developing a measurement programme designed to capture and serve the needs of the informal sector. This chapter argues that such a measurement programme is an imperative, for the basic reason that policies tend to speak and respond to those phenomena that have been subjected to measurement programmes. If the measurement programmes follow those designed for developed nations, then the policies in these countries will tend to follow those of developed nations too and vice versa. Measurement programmes for R&D in S&T institutions and innovation in formal businesses have been implemented in several African countries. The informal sector has been excluded from such policy attention. Given that the contribution of the informal sector to their host countries' employment levels and GDP is generally larger than that of the formal business sector, this is a glaring data gap. What is even more glaring is the absence of a strategy for bringing the measurement of innovation in informal settings to the systematic attention of policy-makers.

The reasons for this have been manifold. One aspect that we should point out is that the study of innovation in the informal sector is a relatively recent area of attention by innovation scholars. It is only in the recent past that there have been case studies of innovation in specific industrial sectors. It is even more recent that the construct of using a single conceptual framework, derived from the LIPS framework, has been championed. However, even with this advancement in the field of measurement of innovation, the application was restricted to specific industrial sectors with corresponding survey tools that were adapted to those individual sectors. Also, methodologies have not been standardised, because these were essentially case studies within the informal sector in different African countries. A programme of measurement

also requires that practical implementation matters be addressed. For example, previous work has relied on the labour of specialised researchers in innovation studies to do the case studies. A cost-effective programme requires that the survey should be implementable by relatively low-paid fieldworkers with minimal schooling. Finally, the closest that scholars have come to a measurement strategy was to call for further case study examples. While the need for further study is definitely required, this is not sufficient to amount to a strategy with a clear objective (for example, a national-level set of statistics and indicators, or a database of LIPS at the local level from different regions to inform policy actions) and a sequence of steps to achieve the goals.

This chapter has outlined a methodology and measurement strategy that provides a roadmap to achieve these goals. It draws on the experiences gained from implementing a survey of innovation in the informal sector that is not industry-specific but applies to informal activity in all sectors within a local geographic region. Such an approach has a much greater chance of achieving the goal of a standardised tool than individual *ad hoc* industry-specific innovation surveys or studies.

Because of the way current national surveys of R&D and innovation have been constructed, it is difficult to see the ordinary businessperson, the majority of whom have either survivalist, micro or small businesses, in these tools. Indeed, when one factors in the seemingly intractable problems these surveys experience in obtaining data from small units, ordinary businesspeople become invisible. R&D and business innovation surveys were not designed at the outset to promote understanding of innovation by economic sectors important to developing economies, such as service sectors, for example. Therefore, it should come as no surprise that in practice they have failed to capture the innovation activity of the smaller business, including the informal sector. The needs of informal sector businesses, previously excluded effectively from policy attention, can begin to be addressed by the programme of measurement outlined in this chapter.

Ideally, as alluded to earlier in the chapter, the coordination of R&D and innovation measurement would be well served by a coordinating body for policy-makers and measurement professionals on the continent similar to those maintained by the OECD. Some of these functions have arguably already been taken up in effect by organisations such as AUDA-NEPAD and the African Observatory of STI, through close collaboration among themselves and working with key partner countries. However, the lack of institutionalisation is still a weakness for the measurement of innovation in the informal sector but also for the R&D and business innovation surveys in formal organisations and businesses. In the absence of a coordinating body that would allow for learning to take place among member countries about their measurement programmes, it is necessary for further case studies to be conducted in a more systematic manner. If there is no institutionalised mechanism for feeding the needs of

national policy actors into their survey tools, then much of this learning can be codified at least through the research enterprise. This is something that has been built into the measurement programme outlined in this chapter. Certainly, what would be required is for the few institutions engaged on the continent in the measurement of innovation to put the topic of informal sector innovation permanently on their agenda for implementation.

References

Chapter 1

African Union (AU) 2014, *Science, technology and innovation strategy for Africa (STISA-2024)*, viewed 14 February 2023, <https://au.int/sites/default/files/newsevents/workingdocuments/33178-wd-stisa-english_-_final.pdf>

Ali, I & Zhuang, J 2007, *Inclusive growth toward a prosperous Asia: Policy implications*, Working Paper Series No. 97, Economics and Research Department (ERD) of the Asian Development Bank (ADB), viewed 14 February 2023, <https://www.adb.org/sites/default/files/publication/28210/wp097.pdf>

Bell, M & Pavitt, K 1993, 'Technological accumulation and industrial growth: Contrasts between developed and developing countries', *Industrial Corporate Change*, vol. 2, no. 1, pp. 157–210. https://doi.org/10.1016/j.respol.2004.12.002

Berdegué, J 2005, *Pro-poor innovation systems*, Background Paper, IFAD, Rome, viewed 14 February 2023, <http://www.lamolina.edu.pe/postgrado/pmdas/cursos/innovacion/lecturas/Obligatoria/3%20-%20Berdegue%202005.pdf>

Bradley, SW, McMullen, JS, Artz, K & Simiyu, EM 2012, 'Capital is not enough: Innovation in developing economies', *Journal of Management Studies*, vol. 49, no. 4, pp. 684–717. https://doi.org/10.1111/j.1467-6486.2012.01043.x

Brem, A & Wolfram, P 2014, 'Research and development from the bottom of up: Introduction of terminologies for new products development in emerging markets', *Journal of Innovation and Entrepreneurship*, vol. 3, no. 9, pp. 1–22. https://doi.org/10.1186/2192-5372-3-9

Cozzens, SE 2010, 'Innovation and inequality', in RE Smits, S Kuhlmann & P Shapira (eds.), *The theory and practice of innovation policy: An international research handbook*, Chapter 15, Edward Elgar, Cheltenham.

Cozzens, SE & Sutz, J 2012, *Innovation in informal settings: A research agenda*, viewed 14 February 2023, <https://www.idrc.ca/sites/default/files/sp/Documents%20EN/iid-framework-july-29.pdf>

Daniels, C, Ustyuzhantseva, O & Yao, W 2017, 'Innovation for inclusive development, public policy support and triple helix: Perspectives from BRICS', *African Journal of Science, Technology, Innovation and Development*, vol. 9, no. 5, pp. 513–527. https://doi.org/10.1080/20421338.2017.1327923

Department of Science and Technology (DST) 2019, *White paper on science, technology and innovation: Science, technology and innovation enabling inclusive and sustainable South African development in a changing world*, viewed 14 February 2023, <https://www.dst.gov.za/images/2019/White_paper_web_copyv1.pdf>

Fagerberg, J, Srholec, M & Verspagen, B 2010, 'The role of innovation in development', *Review of Economics and Institutions*, vol. 1, no. 2, pp. 1–29. https://doi.org/10.5202/rei.v1i2.2

George, G, McGahan, AM & Prabhu, J 2012, 'Innovation for inclusive growth: Towards a theoretical framework and a research agenda', *Journal of Management Studies*, vol. 49, no. 4, pp. 661–683. https://doi.org/10.1111/j.1467-6486.2012.01048.x

Hammond, AL, Kramer, WJ, Karz, RS, Tran, JT & Walker, C 2007, *The next 4 billion: Market size and business strategy at the base of the pyramid*, World Resources Institute (WRI) and International Finance Corporation (IFC), Washington, viewed 14 February 2023, <https://documents1.worldbank.org/curated/en/779321468175731439/pdf/391270Next040billion.pdf>

Hanna, NK 2010, *Enabling enterprise transformation: Business and grassroots innovation for the knowledge economy*, Springer, New York.

Hickey, S 2013, *Thinking about the politics of inclusive development: Towards a relational approach*, ESID Working Paper No. 1, viewed 14 February 2023, <https://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID2563136_code1050353.pdf?abstractid=2425235&mirid=1>

High-Level Political Forum on Sustainable Development 2020, *Launching the decade of action at a time of crisis: Keeping the focus on the SDGs while combatting COVID-19*, viewed 14 February 2023, <https://sustainabledevelopment.un.org/content/documents/26298HLPF_2020_impact_COVID19.pdf>

Independent Evaluation Group 2013, *World Bank Group support for innovation and entrepreneurship: An independent evaluation*, viewed 14 February 2023, <https://ieg.worldbankgroup.org/sites/default/files/Data/reports/innovation_eval.pdf>

International Development Research Centre (IDRC) 2011, *Innovation for inclusive development, program prospectus for 2011–2016*, viewed 14 February 2023, <http://www.slideshare.net/uniid-sea/october-2011-innovation-for-inclusivedevelopment-program-prospectus-for-20112016>

Johnson, B & Andersen, AD 2012, *Learning, innovation and inclusive development: New perspectives on economic development strategy and development aid*, Globelics Thematic Report, Vol. 2011/2012, Aalborg Universitetsforlag, Aalborg, viewed 14 February 2023, <https://www.researchgate.net/publication/272795954_Learning_Innovation_and_Inclusive_Development_-_New_perspectives_on_economic_development_strategy_and_development_aid>

Khan, R 2016, 'How frugal innovation promotes social sustainability', *Sustainability*, vol. 8, no. 10, p. 1034. https://doi.org/10.3390/su8101034

Kraemer-Mbula, E & Wamae, W (eds.) 2010, *Innovation and the development agenda*, The Organisation for Economic Co-operation and Development (OECD)/International Development Research Centre (IDRC), Ottawa.

Kruss, G, Petersen, I, Rust, J & Tele, A 2017, *Promoting a science, technology and innovation policy for inclusive development in South Africa*, HSRC Policy Brief, viewed 14 February 2023, <http://www.hsrc.ac.za/uploads/pageContent/8380/03_HSRC%20POLICY%20BRIEF%20SciTech%20Innovation.pdf>

Kumar, V, Chand, VS, Zhang, L, Odora Hoppers, CA, Zhang, W, Esders, M & Gupta A 2013, 'Grassroots innovations for inclusive development: Need for a paradigmatic shift', *Vikalpa*, vol. 38, no. 3, pp. 103–107. https://doi.org/10.1177/0256090920130307

Marcelle, G 2014, 'Science technology and innovation policy that is responsive to innovation performers', in S Kuhlmann & G Ordonez-Matamoros (eds.), *International research handbook on science, technology and innovation policy in developing countries: Rationales and relevance*, Edward Elgar Publishing, Cheltenham.

Nelson, RR 1993, *National innovation systems: A comparative analysis*, Oxford University Press, Oxford.

Organisation for Economic Co-operation and Development (OECD) 2012, *Innovation for development: A discussion of the issues and an overview of work of the OECD Directorate for Science, Technology and Industry*, viewed 14 February 2023, <https://www.oecd.org/innovation/inno/50586251.pdf>

Organisation for Economic Co-operation and Development (OECD) 2015, *Innovation policies for inclusive development: Scaling up inclusive innovations*, OECD Publishing, Paris, viewed 14 February 2023, <https://www.oecd.org/innovation/inno/scaling-up-inclusive-innovations.pdf>

Organisation for Economic Co-operation and Development (OECD) 2021, *Inequality*, viewed 14 February 2023, <https://www.oecd.org/social/inequality.html>

Overseas Development Institute (ODI) 2010, *Millennium development goals report card: Measuring progress across countries*, viewed 14 February 2023, <http://www.odi.org.uk/sites/odi.org.uk/files/odi-assets/publications-opinion-files/6172.pdf>

Paunov, C 2013, *Innovation and inclusive development: A discussion of the main policy issues*, OECD Science, Technology and Industry Working Papers, No. 2013/01, OECD Publishing, Paris.

Prahalad, CK 2012, 'Bottom of the pyramid as a source of breakthrough innovations', *Journal of Product Innovation Management*, vol. 29, no. 1, pp. 6–12. https://doi.org/10.1111/j.1540-5885.2011.00874.x

Radjou, N, Prabhu, J & Ahuja, S 2013, *Jugaad innovation think frugal, be flexible, generate breakthrough growth*, Jossey-Bass, San Francisco.

Santiago, F 2014, 'Innovation for inclusive development', *Innovation and Development*, vol. 4, no. 1, pp. 1–4. https://doi.org/10.1080/2157930X.2014.890353

Smith, A 2013, *Method: Situating pathways in historical contexts*, Social, Technological and Environmental Pathways to Sustainability (STEPS) Centre, viewed 14 February 2023, <http://steps-centre.org/wp-content/uploads/Situating-pathways-in-historical-contexts.pdf>

Smith, A, Fressoli, M, Abrol, D, Arond, E & Ely, A 2016, *Introducing grassroots innovation movements*, Routledge, New York.

Sonne, L 2010, *Pro-poor, entrepreneur-based innovation and its role in rural development*, Working Paper Series No 037, United Nations University – Maastricht Economic and Social Research and Training Centre on Innovation and Technology (UNU_MERIT), viewed 14 February 2023, <https://www.merit.unu.edu/publications/wppdf/2010/wp2010-037.pdf>

Sustainable Development Goals Fund n.d., *Millennium development goals*, viewed 14 February 2023, <https://www.sdgfund.org/mdgs-sdgs>

Swedish International Development Cooperation (SIDA) 2015, *Support to innovation and innovation systems within the framework of Swedish Research Cooperation*, Position Paper, viewed 14 February 2023, <https://cdn.sida.se/publications/files/sida61924en-support-to-innovation-and-innovation-systems.pdf>

United Nations (UN) n.d., *Transforming our world: The 2030 agenda for sustainable development*, viewed 14 February 2023, <https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf>

United Nations Conference on Trade and Development (UNCTAD) 2012, *Pro-poor technology, innovation and entrepreneurship policies*, viewed 14 February 2023, <https://unctad.org/system/files/official-document/ciimem1d12_en.pdf>

United Nations Development Programme (UNDP) 2020, *Grassroots innovation: Missing link in the innovation ecosystem in South Africa*, viewed 14 February 2023, <https://www.za.undp.org/content/south_africa/en/home/library/other-publications/rapid-assessment-report.html>

Van Gent, S 2017, *Beyond buzzwords: What is 'inclusive development?'*, viewed 14 February 2023, <https://includeplatform.net/wp-content/uploads/2017/09/Beyond-buzzwords.pdf>

Von Zedtwitz, M, Corsi, S, Søberg, PV & Frega, R 2015, 'A typology of reverse innovation', *Journal of Product Innovation Management*, vol. 32, no. 1, pp. 12–28. https://doi.org/10.1111/jpim.12181

Weyrauch, T & Herstatt, C 2017, 'What is frugal innovation? Three defining criteria', *Journal of Frugal Innovation*, vol. 2, no. 1, pp. 1–17. https://doi.org/10.1186/s40669-016-0005-y

World Bank 2008, *World development report 2008: Agriculture for development*, viewed 14 February 2023, <http://www.ilo.org/public/libdoc/igo/P/03632/03632(2008).pdf>

World Health Organization (WHO) 2019, *Maternal mortality*, viewed 14 February 2023, <https://www.who.int/news-room/fact-sheets/detail/maternal-mortality>

Chapter 2

Becker, G 1993, *Human capital: A theoretical and empirical analysis, with special reference to education*, 3rd edn., University of Chicago Press, London.

Bowles, S & Gintis, H 1975, 'The problem with human capital theory: A Marxian critique', *American Economic Review*, vol. 65, no. 2, pp. 74–82.

Boyer, R 2006, *Employment and decent work in the era of flexicurity*, PSE Working Papers halshs-00590452, UN Department of Economic and Social Affairs, New York.

Burroni, L & Keune, M 2011, 'Flexicurity: A conceptual critique', *European Journal of Industrial Relations*, vol. 17, no. 1, pp. 75–91. https://doi.org/10.1177/0959680110393189

Cassiolato, JE & Lastres, HMM 2008, *Discussing innovation and development: Converging points between the Latin American school and the Innovation Systems perspective?*, Globelics Working Paper Series (08-02).

Chang, H-J 2003, 'Introduction', in H-J Chang (ed.), *Rethinking development economics*, Anthem Press, London.

Fine, B 1999, 'A question of economics: Is it colonizing the social sciences?', *Economy and Society*, vol. 28, no. 3, pp. 403–425. https://doi.org/10.1080/03085149900000011

Fine, B & Saad-Filho, A 2014, 'Politics of neoliberal development: Washington Consensus and the post-Washington Consensus', in H Weber (ed.), *The politics of development: A survey*, Routledge, London, pp. 154–166.

Foucault, M 1970, 'The order of discourse' (Inaugural lecture at the Collège de France), in R Young (ed.), *Unifying the text: A post-structuralist reader*, Routledge and Kegan Paul, London.

Foucault, M 2004, *The birth of biopolitics: Lectures at the Collége de France 1978–1979*, Palgrave Macmillan, Hampshire.

Gupta, J, Pouw, NRM & Ros-Tonen MAF 2015, 'Towards an elaborated theory of inclusive development', *European Journal of Development Research*, vol. 27, no. 4, pp. 541–559. Https://doi.org/10.1057/ejdr.2015.30

Hayek, FA 1942, 'Scientism and the study of society, Part I', *Economica*, vol. 9, no. 35, pp. 267–291. https://doi.org/10.2307/2549540

Hayek, FA 1943, 'Scientism and the study of society, Part II', *Economica*, vol. 10, no. 37, pp. 34–63. https://doi.org/10.2307/2549653

Hayek, FA 1944, 'Scientism and the study of society, Part III', *Economica*, vol. 11, no. 41, pp. 27–39. https://doi.org/10.2307/2549942

Heeks, R, Amalia, M, Kintu, R & Shah, N 2013, *Inclusive innovation: Definition, conceptualisation and future research priorities*, Development Informatics Working Paper Series, No. 53, Centre for Development Informatics, Institute for Development Policy and Management, SEED, Manchester.

Heeks, R, Foster, C & Nugroho, Y 2014, 'New models of inclusive innovation for development', *Innovation and Development*, vol. 4, no. 2, pp. 175–185. https://doi.org/10.1080/2157930X.2014.928982

Institute for Economic Research on Innovation (IERI) 2014, *Revisiting some of the theoretical and policy aspects of innovation and development*, IERI Working Paper Series, IERI Working Paper 2014-1, Institute for Economic Research on Innovation, viewed 12 September 2019, <https://ieri.org.za/publications/revisiting-some-theoretical-and-policy-aspects-innovation-and-development>

Lenoir, R [1974] 1989, *Les exclus: Un Francais sur Dix*, Editions du Seuil, Paris.

Lundvall, B-Å (ed.) 1992, *National innovation systems: Towards a theory of innovation and interactive learning*, 2nd edn, Anthem Press, London.

Lundvall, B.-Å (ed.) 2016, *The learning economy and the economics of hope*, Anthem Press, London.

Macroeconomic Research Group (MERG) 1993, *Making democracy work: A framework for macroeconomic policy in South Africa*, Centre for Development Studies, University of the Western Cape, Cape Town.

Maharajh, R 2016, 'Racial capitalism, apartheid and the negotiated post-apartheid Constitutional democracy', in M Scerri (ed.), *The emergence of systems of innovation in South(ern) Africa: Long histories and contemporary debates*, MISTRA and Real African Publishers, Johannesburg.

Munck, R 2013, 'The Precariat: A view from the South', *Third World Quarterly*, vol. 34, no. 5, pp. 747–762. https://doi.org/10.1080/01436597.2013.800751

Nelson, RR & Winter, SG 1982, *An evolutionary theory of economic change*, Harvard University Press, Cambridge.

Organisation for Economic Co-operation and Development (OECD) 2015, *Innovation policies for inclusive development*, Organisation for Economic Development and Cooperation, Paris.

Phiria, MZ, Molotja, N, Makelane, H, Kupamupindi, T & Ndinda, C 2016, 'Inclusive innovation and inequality in South Africa: A case for transformative social policy', *Innovation and Development*, vol. 6, no. 1, pp. 123–139. https://doi.org/10.1080/2157930X.2015.1047112

Republic of South Africa (RSA) 1996a, *Growth, employment and redistribution: A macroeconomic strategy*, Department of Finance, Pretoria.

Republic of South Africa (RSA) 1996b, *White Paper on science and technology: Preparing for the 21st century*, Department of Arts, Culture, Science and Technology, Pretoria.

Republic of South Africa (RSA) 2007, *Innovation towards a knowledge-based economy: Ten-year plan for South Africa (2008–2018)*, Department of Science and Technology, Pretoria.

Republic of South Africa (RSA) 2011, *National development plan: Vision for 2030*, National Planning Commission, Pretoria.

Republic of South Africa (RSA) 2019, *White paper on science, technology and innovation: Science, technology and innovation enabling inclusive and sustainable South African development in a changing world*, Department of Science and Technology, Pretoria.

Scerri, M 2009, *The evolution of the South African system of innovation since 1916*, Cambridge Scholars Publishing, Newcastle upon Tyne.

Scerri, M 2014, 'Modes of innovation and the national systems of innovation of the BRICS Economies', *STI Policy Review*, vol. 5, no. 2, pp. 20–42.

Scerri, M 2019a, *Human capabilities and the evolutionary prospects for systems of innovation in sub-Saharan Africa*, IERI Working paper WP2019-002, viewed 12 September 2019, <https://ieri.org.za/publications/human-capabilities-and-evolutionary-prospects-systems>

Scerri, M 2019b, *Organised labour and the national system of innovation in South Africa*, IERI Working paper WP2019-006, viewed 12 September 2019, <https://ieri.org.za/publications/organised-labour-and-national-system-innovation-south-africa>

Scerri, M 2020, *Systems of innovation and economic theory*, Cambridge Open Engage, viewed 22 June 2020, <https://www.cambridge.org/engage/coe/article-details/5eb5721e279bd8001c8ed11b>

Scerri, M & Maharajh, R 2016, 'The policy environment and policy options for the South African system of innovation', in M Scerri (ed.), *The Emergence of Systems of Innovation in South(ern) Africa: Long Histories and Contemporary Debates*, MISTRA and Real African Publishers, Johannesburg.

Schumacher, EF 1973, *Small is beautiful: Economics as if people mattered*, Blond & Briggs, London.

Schumpeter, JA [1943] 2010, *Capitalism, socialism and democracy*, Routledge, Oxford.

Sen, A 1997, 'Editorial: Human capital and human capability', *World Development*, vol. 25, no. 12, pp. 1959–1961. https://doi.org/10.1016/S0305-750X(97)10014-6

Sen, A 1999, *Development as freedom*, Anchor Books, New York.

Sen, A 2000, *Social exclusion: Concept, application and scrutiny*, Social Development Papers No. 1, Asian Development Bank.

Sen, G 2001, 'Development studies or development economics: Moving forward from TINA', Draft paper prepared for the discussion at the UNRISD meeting on The Need to Rethink Development Economics, Cape Town, South Africa, 07–08 September, viewed 12 September 2019, <http://www.unrisd.org/unrisd/website/document.nsf/(httpPublications)/431D06319E99764EC1256BC9004A65EA?OpenDocument>

Standing, G 2011, *The precariat: The new dangerous class*, Bloomsbury Publishing Plc, London.

Stigler, GJ & Becker, GS 1977, 'De gustibus non est disputandum', *The American Economic Review*, vol. 67, no. 2, pp. 76–90.

Stigler, JG 1984, 'Economics: The imperial science?', *The Scandinavian Journal of Economics*, vol. 86, no. 3, pp. 301–313. https://doi.org/10.2307/3439864

Streeck, W, Crouch, C, Boyer, R, Amable, B, Hall, PA & Jackson, G 2005, 'Dialogue on "Institutional complementarity and political economy"', *Socio-Economic Review*, vol. 3, no. 2, pp. 359–382. https://doi.org/10.1093/SER/mwi015

UNCTAD (United Nations Conference on Trade and Development) 2016, *African continental free trade area: Advancing Pan-African integration some considerations*, viewed 14 February 2023, <https://unctad.org/en/PublicationsLibrary/webditc2016d5_en.pdf>

Utz, A & Dahlman, C 2007, 'Promoting inclusive innovation', in MA Dutz (ed.), *Unleashing India's innovation: Toward sustainable and inclusive growth*, World Bank, Washington, pp. 105–129.

World Bank 2010, *Innovation policy: A guide for developing countries*, The International Bank for Reconstruction and Development/The World Bank, Washington.

World Economic Forum (WEF) 2016, *The future of jobs: Employment, skills and workforce strategy for the Fourth Industrial Revolution*, World Economic Forum, Geneva.

World Economic Forum (WEF) 2018, *The future of jobs report 2018*, World Economic Forum, Geneva.

Chapter 3

African Regional Intellectual Property Organization 2015, *Swakopmund protocol on the protection of traditional knowledge & expressions of folklore*, viewed 14 February 2023, https://www.wipo.int/tk/en/databases/tklaws/articles/article_0044.html#:~:text=The%20protection%20of%20traditional%20knowledge%20under%20this%20Protocol%20shall%20not,holders%20within%20the%20traditional%20context

African Union 1975, *Inter-African convention establishing an African technical co-operation programme*, African Union, viewed October 2021, <https://au.int/en/treaties/inter-african-convention-establishing-african-technical-co-operation-programme>

African Union (AU) 2014, *On the wings of innovation: Science, technology and innovation for Africa 2024 STRATEGY (STISA-2024)*, viewed 14 February 2023, https://au.int/sites/default/files/newsevents/workingdocuments/33178-wd-stisa-english_-_final.pdf

Bíziková, L, Sedová, T & Szapuová, M 2007, *Why gendered science matters: How to include gender dimension into research projects*.

Blackston, W 1765, *Commentaries on the laws of England / by William Blackstone*, Clarendon Press, Oxford.

Bogdan-Martin, D 2018, *Calling time on the digital gender divide*, International Trade Forum, International Trade Centre, pp. 18–19.

Bradley, SW, McMullen, JS, Artz, K & Simiyu, EM 2012, 'Capital is not enough: Innovation in developing economies', *Journal of Management Studies*, vol. 49, no. 4, pp. 684–717. Https://doi.org/10.1111/j.1467-6486.2012.01043.x

Chant, S 2015, *The 'feminization of poverty': A reflection of 20 years after Beijing*, UNRISD.

Crasnow, S 2020, 'Feminist perspectives on science', in EN Zalta (ed.), *The Stanford encyclopedia of philosophy*, Metaphysics Research Lab, Stanford University.

Ester, M 2012, *Has not science debunked biblical Christianity*?, viewed 14 February 2023, http://www.sfu.ca/~allen/HasScienceDebunkedChristianity.pdf

Flores, M, Canetta, L, Castrovinci, A, Pedrazzoli, P, Longhi, R & Boër, C 2008, 'Towards an integrated framework for sustainable innovation', *International Journal of Sustainable Engineering*, vol. 1, no. 4, pp. 278–286. https://doi.org/10.1080/19397030802496339

Foxon, T & Pearson, P 2008, 'Overcoming barriers to innovation and diffusion of cleaner technologies: Some features of a sustainable innovation policy regime', *Journal of Cleaner Production*, vol. 16, no. 1, pp. 148–161. https://doi.org/10.1016/j.jclepro.2007.10.011

Franzway, S, Sharp, R, Mills, J & Gill, J 2009, 'Engineering ignorance: The problem of gender equity in engineering', *Frontiers: A Journal of Women Studies*, vol. 30, no. 1, pp. 89–106. https://doi.org/10.1353/fro.0.0039

Hadjimanolis, A 1999, 'Barriers to innovation for SMEs in a small less developed country (Cyprus)', *Technovation*, vol. 19, no. 9, pp. 561–570. https://doi.org/10.1016/S0166-4972(99)00034-6

Irion, K 2009, 'Separated together: The international telecommunications union and civil society', *International Journal of Communications Law and Policy*, vol. 13, pp. 95–113. https://doi.org/10.2139/ssrn.2065755

Jackson, LW 2009, 'Educate the women and you change the world: Investing in the education of women is the best investment in a country's growth and development', in *Forum on public policy online*, ERIC, s.l.

Kahn, MJ 2008, 'Africa's plan of action for science and technology and indicators: South African experience', *African Statistical Journal*, vol. 6, pp. 163–176.

Kameri-Mbote, PG 2002, 'Gender dimensions of law, colonialism and inheritance in East Africa: Kenyan women's experiences', *Verfassung und Recht in Übersee/Law and Politics in Africa, Asia and Latin America*, vol. 35, no. 3, pp. 373–398. https://doi.org/10.5771/0506-7286-2002-3-373

Kastens, RF & Okhoya, CN 2007, 'The gender dimension [The connection between women and achieving the world's Millennium Development Goals should not be underestimated]', IAEA Bulletin (Online), vol. 49.

Kusumaningsih, W & Herman, T 2018, 'Gender differences in algebraic thinking ability to solve mathematics problems', *Journal of Physics: Conference Series*, vol. 1013, a012143, viewed 14 February 2023, https://iopscience.iop.org/article/10.1088/1742-6596/1013/1/012143/pdf

Lapenne, J 2010, 'Patent cooperation treaty (PCT)', *Journal of the Patent and Trademark Office Society*, vol. 92, no. 2, pp. 192–207.

Malbon, J, Lawson, C & Davison, M 2014, *The WTO agreement on trade-related aspects of intellectual property rights*, Edward Elgar Publishing, Cheltenham. https://doi.org/10.4337/9781781006047

McAdam, R, McConvery, T & Armstrong, G 2004, 'Barriers to innovation within small firms in a peripheral location', *International Journal of Entrepreneurial Behavior & Research*, vol. 10, no. 3, pp. 206–221. https://doi.org/10.1108/13552550410536780

Naffine, N 1990, *Law and the sexes: Explorations in feminist jurisprudence*, Allen & Unwin, Sydney.

National Academies of Sciences, Engineering and Medicine 2020, *Promising practices for addressing the underrepresentation of women in science, engineering, and medicine: Opening doors*, National Academies Press, Washington DC.

National Research Council 1987, *Infrastructure for the 21st century: Framework for a research agenda*, National Academies Press, Washington DC.

Oketch, SA 2014, 'The changing image of women in Francis Imbuga's Oeuvre', PhD thesis, Nelson Mandela Metropolitan University, Gqeberha.

Pateman, C 1988, *The sexual contract*, Stanford University Press, Palo Alto.

Schwab, K 2017, *The Fourth Industrial Revolution: Klaus Schwab*, 1st edn, Portfolio Penguin, London.

Smart, C 1989, *Feminism and the power of law*, Routledge, New York.

The United Nations Educational, Scientific and Cultural Organization 2019, *Science, technology and innovation policy for the East African Community validated for adoption by member states*, United Nations Educational, Scientific and Cultural Organization, viewed 30 October 2020, <https://en.unesco.org/news/science-technology-and-innovation-policy-east-african-community-validated-adoption-member>

Wamae, W 2008, *STI [science, technology and innovation] policy research and the STI policy environment in Africa: A scoping paper for the IPS [innovation, policy and science] program area of IDRC*, International Development Research Centre, Ottawa. http://hdl.handle.net/10625/35608

Wambeti, ND 2016, 'Technology incubation centres for International Youth Development (A case study of Kenya)', PhD thesis, University of Nairobi.

World Intellectual Property Organization 2005, *WIPO's work on traditional knowledge and folklore receives broad support*, viewed 30 October 2020, <https://www.wipo.int/pressroom/en/prdocs/2005/wipo_upd_2005_251.html>

Zanello, G, Fu, X, Mohnen, P & Ventresca, M 2016, 'The creation and diffusion of innovation in developing countries: A systematic literature review', *Journal of Economic Surveys*, vol. 30, no. 5, pp. 884–912. https://doi.org/10.1111/joes.12126

Chapter 4

Alsos, GA, Hytti, U & Ljunggren, E 2016, 'Gender and innovation: An introduction', in *Research handbook on gender and innovation*, Edward Elgar Publishing, Cheltenham.

Alsos, GA, Ljunggren, E & Hytti, U 2013, 'Gender and innovation: State of the art and a research agenda', *International Journal of Gender and Entrepreneurship*, vol. 5, no. 3, pp. 236–256. Https://doi.org/10.1108/IJGE-06-2013-0049

Andersson, S, Berglund, K, Gunnarsson, E & Sundin, E 2012, *Promoting innovation: Policies, practices and procedures*, Swedish Governmental Agency for Innovation Systems, Stockholm.

Blake, MK & Hanson, S 2005, 'Rethinking innovation: Context and gender', *Environment and Planning A*, vol. 37, no. 4, pp. 681–701. https://doi.org/10.1068/a3710

Chataway, J, Hanlin, R & Kaplinsky, R 2014, 'Inclusive innovation: An architecture for policy development', *Innovation and Development*, vol. 4, no. 1, pp. 33–54. Https://doi.org/10.1080/2157930X.2013.876800

Daniels, CU, Ustyuzhantseva, O & Yao W 2017, 'Innovation for inclusive development, public policy support and triple helix: Perspectives from BRICS', *African Journal of Science, Technology, Innovation and Development*, vol. 9, no. 5, pp. 513–527. https://doi.org/10.1080/20421338.2017.1327923

Department of Arts, Culture, Science and Technology 1996, *White paper on science and technology*, Government of the Republic of South Africa, Pretoria.

Department of Science and Technology 2002, *South Africa's national research and development strategy*, Government of the Republic of South Africa, Pretoria.

Department of Science and Technology 2019, *White paper on science, technology and innovation*, Government of South Africa, Pretoria.

Figuères, CM & Eugelink, H 2014, 'The role of ICTs in poverty eradication: More than 15 years' experience from the field', in H Kaur & X Tao (eds.), *ICTs and the millennium development goals*, Springer, Boston, pp. 199–222.

Foster, C & Heeks, R 2013, 'Conceptualising inclusive innovation: Modifying systems of innovation frameworks to understand diffusion of new technology to low-income consumers', *The European Journal of Development Research*, vol. 25, no. 3, pp. 333–355. https://doi.org/10.1057/ejdr.2013.7

Guma, PK 2020, 'Incompleteness of urban infrastructures in transition: Scenarios from the mobile age in Nairobi', *Social Studies of Science*, vol. 50, no. 5, pp. 728–750. Https://doi.org/10.1177/0306312720927088

Hopkins, P 2019, 'Social geography I: Intersectionality', *Progress in Human Geography*, vol. 43, no. 5, pp. 937–947. https://doi.org/10.1177/0309132517743677

Molefi, KA 2009, 'Resisting Westernity and refusing development', in KK Bhavnani, J Foran, P Kurian & D Munshi (eds.), *On the edges of development: Cultural interventions*, Routledge, pp. 67–73.

Nählinder, J, Tillmar, M & Wigren, C 2015, 'Towards a gender-aware understanding of innovation: A three-dimensional route', *International Journal of Gender and Entrepreneurship*, vol. 7, no. 1, pp. 66–86. https://doi.org/10.1108/IJGE-09-2012-0051

National Advisory Council on Innovation 2006, *The South African national system of innovation: Background report to the OECD country review*, NACI, Pretoria.

National Planning Commission (NPC) 2012, *The national development: Vision 2030*, Government of South Africa, Pretoria.

Organisation for Economic Co-operation and Development (OECD) 2015, *Innovation policies for inclusive growth*, OECD Publishing, Paris.

Raven, R, Schot, J & Berkhout, F 2012, 'Space and scale in socio-technical transitions', *Environmental Innovation and Societal Transitions*, vol. 4, pp. 63–78. https://doi.org/10.1016/j.eist.2012.08.001

Richter, M 2013, 'Business model innovation for sustainable energy: German utilities and renewable energy', *Energy Policy*, vol. 62, pp. 1226–1237. https://doi.org/10.1016/j.enpol.2013.05.038

Schäpke, N, Omann, I, Wittmayer, JM, Van Steenbergen, F & Mock, M 2017, 'Linking transitions to sustainability: A study of the societal effects of transition management', *Sustainability*, vol. 9, no. 5, p. 737. https://doi.org/10.3390/su9050737

Schot, J & Steinmueller, WE 2018, 'Three frames for innovation policy: R&D, systems of innovation and transformative change', *Research Policy*, vol. 47, no. 9, pp. 1554–1567. https://doi.org/10.1016/j.respol.2018.08.011

Sharma, K 1994, 'Gender, environment and structural adjustment', *Economic and Political Weekly*, vol. 29, no. 18, pp. 5–11.

Smith, A, Stirling, A & Berkhout, F 2005, 'The governance of sustainable socio-technical transitions', *Research Policy*, vol. 34, no. 10, pp. 1491–1510. https://doi.org/10.1016/j.respol.2005.07.005

Statistics South Africa (StatsSA) 2020, *National poverty lines*, viewed 14 February 2023, <http://www.statssa.gov.za/publications/P03101/P031012020.pdf>

Stiglitz, JE 2016, *Inequality and economic growth*, viewed 27 February 2023, <https://www8.gsb.columbia.edu/faculty/jstiglitz/sites/jstiglitz/files/Inequality%20and%20Economic%20Growth.pdf>

Sutherland, C, Reynaert, E, Dhlamini, S, Magwaza, F, Lienert, J, Riechmann, ME, Buthelezi, S, Khumalo, D, Morgenroth, E, Udert, KM & Sindall, RC 2021, 'Socio-technical analysis of a sanitation innovation in a peri-urban household in Durban, South Africa', *Science of the Total Environment*, vol. 755, no. Pt 2, a143284. https://doi.org/10.1016/j.scitotenv.2020.143284

United Nations (UN) 2018, *Sustainable development goals*, viewed 14 February <https://sdgs.un.org/goals/goal5>

Wainstein, ME & Bumpus, AG 2016, 'Business models as drivers of the low carbon power system transition: A multi-level perspective', *Journal of Cleaner Production*, vol. 126, pp. 572–585. Https://doi.org/10.1016/j.jclepro.2016.02.095

Willis, K 2011, *Theories and practices of development*, Routledge, London.

Chapter 5

Academy of Science of South Africa (ASSAf) 2019, *Academy of Science of South Africa (ASSAf)*, viewed 12 February 2021, <https://nationalgovernment.co.za/units/view/195/academy-of-science-of-south-africa-assaf>

Cilliers, P 1998, *Complexity & postmodernism: Understanding complex systems*, Routledge, London.

Cooper, C 2018, *citizen science: How ordinary people are changing the face of discovery*, The Overlook Press, New York.

Du Plessis, H 2020a, *MISTRA working paper: Linking transdisciplinarity practice to South African science, technology and innovation policy*, viewed n.d., <www.MISTRA.org>

Du Plessis, H 2020b, *Linking transdisciplinarity practice to South African science, technology and innovation policy reflections on how transdisciplinarity can play a role in assessing the challenges facing South Africa, and in creating the means to think, act and innovate to address these challenges*, A MISTRA Working Paper, 26 April, pp. 1–34, viewed 30 May 2022, <https://mistra.org.za/wp-content/uploads/2020/05/Working-Paper-Linking-Transdisciplinarity-Practice-to-South-African-Science-Technology-and-Innovation-Policy-Final-Final-280420.pdf>

Du Plessis, H, Sehume, J & Martin, L 2014, *The concept and application of transdisciplinarity in intellectual discourse and research*, Real Africa Publishers, Johannesburg.

Durant, J 1994, 'What is scientific literacy?', *European Review*, vol. 2, no. 1, pp. 83–89.

Dusek, V 2006, *Philosophy of technology: An introduction*, Basil Blackwell, Malden.

Fortey, R 2008, *Dry storeroom no 1: The secret life of the Natural History Museum*, Alfred A Knopf, New York.

Ferguson, N 2017, *The square and the tower: Networks, hierarchies and the struggle for global power*, Allen Lane an imprint of Penguin Books, London.

Gibbons, M & Gummett, P (eds.) 1984, *Science, technology and society today*, Manchester University Press, Manchester.

Gibbons, M, Limoges, C, Nowotny, H, Schwartzman, S, Scott, P & Trow, M (eds.) 1994, *The new production of knowledge: The dynamics of science and research in contemporary societies*, SAGE Publications, London.

Hardt, M & Negri, A 2000, *Empire*, Harvard University Press, London.

Hart, T, Jacobs, P, Ramoroka, K, Mangqalaza, H, Mhula, A, Ngwenya, M & Letty, B 2014, *Social innovation in South Africa's rural municipalities: Policy implications*, HSRC, Pretoria.

Hountondji, P 1997, *Endogenous knowledge: Research trails*, CODESRIA.

Ihde, D 1993, *Philosophy of technology: An introduction*, Paragon House, New York.

Iizuka, M 2013, *Innovation systems framework: Still useful in the new global context?* UNUMERIT Working Paper Series No. 005, United Nations University, Maastricht Economic and social Research and training centre on Innovation and Technology, Maastricht.

Iizuka, M & SadreGhazi, S 2011, 'Understanding dynamics of pro-poor innovation: Mapping the disputed areas', *presented at the DIME Final conference*, UNU-MERIT, Maastricht.

Irwin, A 2018, *citizen science: A study of people, expertise and sustainable development*, Routledge, London.

Jantsch, E 1972, 'Towards interdisciplinarity and transdisciplinarity in education and innovation', in *Interdisciplinarity problems of teaching and research in universities*, OECD, Paris, pp. 97–121.

Jeppie, S & Diagne, SB (eds.) 2008, *The meanings of Timbuktu*, HSRC Press, Cape Town.

Klein, J 1996, *Crossing boundaries: Knowledge, disciplinarities and interdisciplinarities*, University Press of Virginia, Charlottesville.

Klein, J 2004, 'Interdisciplinarity and complexity: An evolving relationship', *E:CO Special Double Issue*, vol. 6, no. 1–2, pp. 2–10.

Klein, J 2014, 'Discourses of transdisciplinarity: Looking back to the future', *Futures*, vol. 63, pp. 68–74.

Klein, J, Grossenbacher-Mansuy, W, Haberli, R, Bill, A, Scholz, R & Welti, M (eds.) 2001, *Transdisciplinarity: Joint problem-solving among science, technology and society: An effective way for managing complexity*, Birkhauser Verlag, Basel.

Laugier, S 2013, 'The will to see: Ethics and moral perceptions of sense', *Graduate Faculty Philosophical Journal*, vol. 34, no. 2, pp. 263–281. https://doi.org/10.5840/gfpj201334219

Lewenstein, B 2016, 'Can we understand citizen science?', *JCOM*, vol. 15, no. 1, p. E.

Maddox, B 2017, *Reading the rocks: How Victorian Geologists discovered the secret of life*, Bloomsbury, London.

Mayer-Schönberger, V & Cukier, K 2013, *Big data: A revolution that will transform how we live, work and think*, John Murray Publishers, London.

Miller, J 1983, 'Scientific literacy: A conceptual and empirical review', *Daedalus*, vol. 112, no. 2, pp. 29–48.

Miller, J 1998, 'The measurement of civic scientific literacy', *Public Understanding of Science*, vol. 7, no. 3, pp. 203–223.

Munro, I 2002, 'Empire: The coming of the control society', *Ephemera: Critical Dialogues on Organisation*, vol. 2, no. 2, pp. 175–185.

Nabudere, D 2012, *Afrikology and transdisciplinarity: A restorative epistemology*, Africa Institute of South Africa, Pretoria.

Nowotny, H, Scott, P & Gibbons, M 2002, *Re-thinking science: Knowledge and the age public in an age of uncertainty*, Polity Press, Cambridge.

Parsons, T 2010, *The rule of empires: Those who build them, those who endured them and why they always fall*, Oxford University Press, Oxford.

Robinson, L, Cawthray, J, West, S, Bonn, A & Ansine, J 2018, 'Ten principles of citizen science: Innovation in open science, society and policy', in S Hecker, M Haklay, A Bowser, Z Makuch, J Vogel & A Bonn (eds.), *Citizen Science: Innovation in Open Science, Society and Policy*, UCL Press, London, pp. 1–23. https://doi.org/10.14324/111.9781787352339.

Scrope, G 1827, *Geology and extinct volcanoes of central France*, Printed and published by W Phillips, George Yard, Lombard Street, London.

Shen, B 1975, 'Scientific literacy and the public understanding of science', in S Day (ed.), *Communication of scientific information*, Karger, Basel, pp. 44–52.

Shrivastava, A & Kothari, A 2012, *Churning the earth: The making of global India*, Penguin, New Delhi.

Shumba, O 1999, 'Critically interrogating the rationality of western science vis-à-vis scientific literacy in non-western developing countries', *Zambezia*, vol. XXXVI, no. i, pp. 55–75.

Smith, BH 2018, *Practicing relativism in the Anthropocene: On science, belief and the humanities*, Open Humanities Press, London.

Smith, PD 2003, *Einstein*, Haus Publishing Limited, London.

South African Department of Science and Technology 2012, *Research and development*, viewed 12 February 2021, <https://pmg.org.za/committee-meeting/28916/>

Valiani, S 2012, *Rethinking unequal exchange: The global integration of nursing labour markets*, University of Toronto Press, Toronto.

Chapter 6

Abrahams, L 2020, 'Innovation entanglement at three South African tech hubs', *The African Journal of Information and Communication (AJIC)*, vol. 26, pp. 1–29. https://doi.org/10.23962/10539/30358

Altenburg, T 2009, 'Building inclusive innovation systems in developing countries: Challenges for IS research', in B Lundvall, K Joseph, C Chaminade & J Vang (eds.), *Handbook of innovation*

systems and developing countries: Building domestic capabilities in a global setting, Edward Elgar Publishing, Cheltenham.

Andreoni, A, Kaziboni, L & Roberts, S 2021, 'Metals, machinery, and mining equipment industries in South Africa: The relationship between power, governance, and technological capabilities', in A Andreoni, P Mondliwa, S Roberts & F Tregenna (eds.), *Structural transformation in South Africa: The challenges of inclusive industrial development in a middle-income country*, Oxford University Press, Oxford.

Bhorat, H, Lilenstein, K, Oosthuizen, M & Thornton, A 2020, *Structural transformation, inequality, and inclusive growth in South Africa*, United Nations University WIDER Working Paper 2020/50, UNU WIDER, Helsinki.

Blom, K & Nkado, E 2020, 'POPIA, GDPR – or both?', *Polity*, viewed 28 February 2021, <https://www.polity.org.za/article/popia-gdpr-or-both-2020-11-30>

Breznitz, D, Ornston, D & Samford, S 2018, 'Mission critical: The ends, means, and design of innovation agencies', *Industrial and Corporate Change*, vol. 27, no. 5, pp. 883–896. https://doi.org/10.1093/icc/dty027

Bronstein, V & Olivier, M 2015, *An evaluation of the regulatory framework governing state-owned enterprises (SOEs) in the Republic of South Africa*, Technical Report, The Presidency, Pretoria.

Chipkin, I & Lipietz, B 2012, *Transforming South Africa's racial bureaucracy new public management and public sector reform in contemporary South Africa*, Public Affairs Research Institute, Johannesburg.

Companies and Intellectual Property Commission (CIPC) n.d., *Functions of the commission*, viewed 28 February 2021, <http://www.cipc.co.za/index.php/about/our-functions/>

Competition Commission (CC) 2020, *Competition in the digital economy – for public comments*, viewed 28 February 2021, <http://www.compcom.co.za/wp-content/uploads/2020/10/Competition-in-the-Digital-Economy-Report-7-September-2020.pdf>

Competition Commission (CC) n.d., *Data market inquiry*, viewed 28 February 2021, <http://www.compcom.co.za/newsletter/data-market-inquiry/>

Cooke, P 2008, 'Regional innovation systems: Origin of the species', *International Journal of Technological Learning, Innovation and Development*, vol. 1, no. 3, pp. 393–409. https://doi.org/10.1504/IJTLID.2008.019980

Council for Scientific and Industrial Research (CSIR) 2020a, *An overview of the CSIR strategy*, Council for Scientific and Industrial Research, Pretoria.

Council for Scientific and Industrial Research (CSIR) 2020b, *CSIR shareholder's compact cycle commencing 1 April 2020*, Council for Scientific and Industrial Research, Pretoria.

Cunningham, S 2012, *The fundamentals of innovation system promotion for development practitioners*, Mesopartner, Pretoria.

Daniels, C, Schot, J, Chataway, J, Ramirez, M, Steinmueller, E & Kanger, L 2020, 'Transformative innovation policy: Insights from Colombia, Finland, Norway, South Africa, and Sweden', in MBG Cele, T Luescher & A Willson Fadiji (eds.), *Innovation policy: Global debates and local experiences*, HSRC Press, Cape Town.

Daniels, C, Ustyuzhantseva, O & Yao, W 2017, 'Innovation for inclusive development, public policy support and triple helix: Perspectives from BRICS', *African Journal of Science, Technology, Innovation and Development*, vol. 9, no. 5, pp. 513–527. https://doi.org/10.1080/20421338.2017.1327923

Department of Communications and Digital Technologies (DCDT) 2017, *National e-government strategy and roadmap*, Government Gazette No. 41241, DCDT, Pretoria.

Department of Public Enterprises (DPE) 2007, *Introduction to the competitive supplier development programme*, DPE, Pretoria, viewed 30 October 2021, <https://www.gov.za/documents/introduction-competitive-supplier-development-programme>

Department of Science and Innovation (DSI) 2019, *White paper on science, technology and innovation*, DSI, Pretoria.

Department of Trade and Industry (DTIC) n.d.a, *Trade and export*, DTIC, Pretoria, viewed 28 February 2021, <http://www.thedtic.gov.za/sectors-and-services-2/1-4-2-trade-and-export/>

Department of Trade and Industry (DTIC) n.d.b, *Special economic zone (SEZ)*, DTIC, Pretoria, viewed 28 February 2021, <http://www.thedtic.gov.za/sectors-and-services-2/industrial-development/special-economic-zones/>

Department of Trade and Industry (DTIC) n.d.c, *Broad-based black economic empowerment*, DTIC, Pretoria, viewed 28 February 2021, <http://www.thedtic.gov.za/financial-and-non-financial-support/b-bbee/broad-based-black-economic-empowerment/>

Department of Trade and Industry (DTIC) n.d.d, *B-BBEE procurement and transformation,* DTIC, Pretoria, viewed 28 February 2021, <http://www.thedtic.gov.za/financial-and-non-financial-support/b-bbee/b-bbee-procurement-transformation-verification/>

Department of Trade and Industry (DTIC) n.d.e, *Support programme for industrial innovation (SPII)*, DTIC, Pretoria, viewed 28 February 2021, <http://www.thedtic.gov.za/financial-and-non-financial-support/incentives/support-programme-for-industrial-innovation-spii/>

Department of Trade and Industry (DTIC) n.d.f, *Innovation and technology funding instruments*, DTIC, Pretoria, viewed 28 February 2021, <http://www.thedtic.gov.za/financial-and-non-financial-support/incentives/innovation-and-technology-funding-instruments/>

Drechsler, W & Karo, E 2017, 'Confucian public administration and innovation policy: A conceptual perspective – Mencius, Max Weber and the Mandate of Heaven', *paper presented at the 3rd International conference on Public Policy (ICPP3), Singapore*, 28–30 June.

Edquist, C & Hommen, L 2008, 'Comparing national systems of innovation in Asia and Europe: Theory and comparative framework', in C Edquist & L Hommen (eds.), *Small country innovation systems: Globalization, change and policy in Asia and Europe*, Edward Elgar Publishers, Cheltenham.

Edquist, C & Johnson, B 1997, 'Institutions and organizations in systems of innovation', in C Edquist (ed.), *Systems of innovation*, Pinter Publishers, London.

Eyewitness News 2016, 'How Gauteng govt is incubating a business innovation culture in townships', *Eyewitness News*, 18 November, viewed February 2021, <https://ewn.co.za/2016/11/18/ekasilabs-how-gauteng-government-is-instilling-a-culture-of-business-innovation-townships>

Foster, C & Heeks, R 2015, *Policies to support inclusive innovation*, Development informatics working paper, 61, Centre for Development Informatics, Institute for Development Policy and Management, SEED, University of Manchester, Manchester.

Franco, JC 2008, 'Making land rights accessible: Social movements and political-legal innovation in the rural Philippines', *The Journal of Development Studies*, vol. 44, no. 7, pp. 991–1022. Https://doi.org/10.1080/00220380802150763

Fressoli, M, Arond, E, Abrol, D, Smith, A, Ely, A & Dias, R 2014, 'When grassroots innovation movements encounter mainstream institutions: Implications for models of inclusive innovation', *Innovation and Development*, vol. 4, no. 2, pp. 277–292. Https://doi.org/10.1080/2157930X.2014.921354

Gupta, AK 2006, 'From sink to source: The Honey Bee Network documents indigenous knowledge and innovations in India', *Innovations: Technology, Governance, Globalization*, vol. 1, no. 3, pp. 49–66. https://doi.org/10.1162/itgg.2006.1.3.49

Hart, TG, Booyens, I & Sinyolo, S 2020, 'Innovation for development in South Africa: Experiences with basic service technologies in distressed municipalities', *Forum for Development Studies*, vol. 47, no. 1, pp. 23–47. https://doi.org/10.1080/08039410.2019.1654543

Hood, C 1991, 'A public management for all seasons?', *Public Administration*, vol. 69, no. 1, pp. 3–19. https://doi.org/10.1111/j.1467-9299.1991.tb00779.x

Human Sciences Research Council (HSRC) 2020, *Human Sciences Research Council strategic plan 2020–2025*, Human Sciences Research Council, Pretoria.

Industrial Development Corporation (IDC) n.d., *Gro-E youth scheme*, IDC, Johannesburg, viewed 28 February 2021, <https://www.idc.co.za/gro-e-youth-scheme/>

Information Regulator (IR) 2020, *Annual performance plan for the 2020/21 financial year*, Information Regulator, Johannesburg.

Jacobs, PT, Habiyaremye, A, Fakudze, B, Ramoroka, K & Jonas, S 2019, 'Producing knowledge to raise rural living standards: How universities connect with resource-poor municipalities in South Africa', *The European Journal of Development Research*, vol. 31, no. 4, pp. 881–901. Https://doi.org/10.1057/s41287-019-0192-5

Kahn, MJ 2013, 'Rhetoric and change in innovation policy: The case of South Africa', *Science, Technology and Society*, vol. 18, no. 2, pp. 189–211. https://doi.org/10.1177/0971721813489447

Kankanhalli, A, Zuiderwijk, A & Tayi, GK 2017, 'Open innovation in the public sector: A research agenda', *Government Information Quarterly*, vol. 34, no. 1, pp. 84–89. https://doi.org/10.1016/j.giq.2016.12.002

Kaplan, D 2021, 'Challenges and constraints for government agencies supporting firm level innovation: Some reflections from South Africa', in C Daniels, M Dosso & J Amadi-Echendu (eds.), *Entrepreneurship, technology commercialisation, and innovation policy in Africa*, Springer, Cham.

Karo, E & Kattel, R 2015, 'Economic development and evolving state capacities in Central and Eastern Europe: Can "smart specialization" make a difference?', *Journal of Economic Policy Reform*, vol. 18, no. 2, pp. 172–187. https://doi.org/10.1080/17487870.2015.1009068

Karo, E & Kattel, R 2016a, *How to organize for innovation: Entrepreneurial state and organizational variety*, Working papers in technology governance and economic dynamics No. 66, The Other Canon Foundation, Tallinn University of Technology, Tallinn.

Karo, E & Kattel, R 2016b, 'Innovation and the state: Towards an evolutionary theory of policy capacity', Working papers in technology governance and economic dynamics No. 72, The Other Canon Foundation, Tallinn University of Technology, Tallinn.

Kraemer-Mbula, E, Lorenz, E, Takala-Greenish, L, Jegede, OO, Garba, T, Mutambala, M & Esemu T 2019, 'Are African micro-and small enterprises misunderstood? Unpacking the relationship between work organisation, capability development and innovation', *International Journal of Technological Learning, Innovation and Development*, vol. 11, no. 1, pp. 1–30. https://doi.org/10.1504/IJTLID.2019.097411

Kruss, G 2010, 'How do universities develop interactive capabilities to promote social innovation and development in South Africa?', *Globelics 2010 8th International conference*, Kuala Lumpur, 01–03 November.

Kruss, G 2012, 'Reconceptualising engagement: A conceptual framework for analysing university interaction with external social partners', *South African Review of Sociology*, vol. 43, no. 2, pp. 5–26. https://doi.org/10.1080/21528586.2012.694240

Kruss, G & Lorentzen, J 2011, 'The South African innovation policies: Potential and constraint', in JE Cassiolato & V Vitorino (eds.), *BRICS and development alternatives: Innovation systems and policies*, Anthem Press, London.

Laranja, M, Uyarra, E & Flanagan, K 2008, 'Policies for science, technology and innovation: Translating rationales into regional policies in a multi-level setting', *Research Policy*, vol. 37, no. 5, pp. 823–835. https://doi.org/10.1016/j.respol.2008.03.006

Lee, RG & Petts J 2013, 'Adaptive governance for responsible innovation', in R Owen, J Bessant & M Heintz (eds.), *Responsible innovation: Managing the responsible emergence of science and innovation in society*, John Wiley & Sons, Chichester.

LaunchLab n.d., *LaunchLab*, viewed 30 January 2021, <https://launchlab.co.za/>

Maloa, F 2020, 'The relationship between the determinants of executive remuneration in South African state-owned enterprises', *SA Journal of Human Resource Management*, vol. 18, no. 16, a1250. https://doi.org/10.4102/sajhrm.v18i0.1250

Marwala, T 2019, 'Fourth Industrial Revolution: Let's all get to work in a synchronised manner', *Daily Maverick*, viewed 28 February 2021, <https://www.dailymaverick.co.za/article/2019-07-05-fourth-industrial-revolution-lets-all-get-to-work-in-a-synchronised-manner/>

Masilela, T 2008, *Governance challenges: Considerations in structuring agencies to support innovation*, Faculty Seminar, Faculty of Economics and Finance, 09 September, Tshwane University of Technology, Garankuwa.

Masutha, M & Rogerson, CM 2014, 'Small enterprise development in South Africa: The role of business incubators', *Bulletin of Geography: Socio-economic Series*, vol. 26, no. 26, pp. 141–155. https://doi.org/10.2478/bog-2014-0050

Mazzucato, M 2013, *The entrepreneurial state: Debunking public vs private sector myth*, Anthem Press, London.

Mintzberg, H 1989, *Mintzberg on management: Inside our strange world of organizations*, The Free Press, New York.

Mostert, L 2020, 'Playing safely with personal information inside a regulatory sandbox', *Polity*, 03 November, viewed 28 February 2021, <https://www.polity.org.za/article/playing-safely-with-personal-information-inside-a-regulatory-sandbox-2020-11-03>

Mulgan, G 2006, 'The process of social innovation', *Innovations: Technology, Governance, Globalization*, vol. 1, no. 2, pp. 145–162. https://doi.org/10.1162/itgg.2006.1.2.145

Mustapha, N, Khan, F, Kondlo, LO, Takatshana, S, Ralphs, GP & Whisgary, D 2017, *South African national survey of intellectual property and technology transfer at publicly funded research institutions: Inaugural baseline study: 2008–2014*, Commissioned by the Department of Science and Technology, Pretoria.

National Integrated Cyberinfrastructure System (NICIS) n.d., viewed n.d., <https://nicis.ac.za/>

National Treasury 2016, *National Treasury SCM instruction No 4A of 2016/2017: Central supplier database*, National Treasury, Pretoria.

National Treasury 2022, *Explanatory memorandum on the taxation laws amendment bill, 2021*, 25 January, National Treasury, Pretoria, viewed 28 February 2022, <http://www.treasury.gov.za/comm_media/press/2022/2021TaxActs/Explanatory%20Memoradum%20to%202021%20Taxation%20Laws%20Amendment%20Bill-25%20%20January%202022.pdf>

Ndabeni, LL, Rogerson, CM & Booyens, I 2016, 'Innovation and local economic development policy in the Global South: New South African perspectives', *Local Economy*, vol. 31, no. 1–2, pp. 299–311. https://doi.org/10.1177/0269094215621865

Open Government Partnership (OGP) 2019, *Independent reporting mechanism (IRM): South Africa end-of-term report 2016 – 2018*, OGP, viewed 28 February 2021, <https://www.opengovpartnership.org/documents/south-africa-end-of-term-report-2016-2018/>

OpenIX n.d., *Innovation programmes*, viewed 30 January 2021, <https://www.theinnovationhub.com/innovation-programmes/openix-5>

Organisation for Economic Co-operation and Development (OECD) 1999, *Managing national innovation systems*, OECD, Paris, viewed 28 February 2021, <https://www.oecd-ilibrary.org/industry-and-services/managing-national-innovation-systems_9789264189416-en>

Organisation for Economic Co-operation and Development (OECD) 2007, *OECD reviews of innovation policy: South Africa 2007*, OECD, Paris, viewed 28 February 2021, <https://www.oecd-ilibrary.org/science-and-technology/oecd-reviews-of-innovation-policy-south-africa-2007_9789264038240-en>

Organisation for Economic Co-operation and Development (OECD) 2010, *Public procurement programmes for small firms – SBIR-type programmes*. *OECD Innovation Policy Platform*, OECD, Paris, viewed 28 February 2021, <http://www.oecd.org/innovation/policyplatform/48136807.pdf>

Organisation for Economic Co-operation and Development (OECD) 2017, *Making innovation benefit all: Policies for inclusive growth*, OECD, Paris.

Organisation for Economic Co-operation and Development (OECD) 2019, *Embracing innovation in government: Global trends 2019*, OECD, Paris.

Owen, R, Pansera, M, Macnaghten, P & Randles, S 2020, 'Organisational institutionalisation of responsible innovation', *Research Policy*, vol. 50, no. 1, a104132. https://doi.org/10.1016/j.respol.2020.104132

Parliamentary Monitoring Group (PMG) 2018, *SA research infrastructure roadmap & integrated cyber infrastructure system: South Korea/Japan study tour*, National Assembly Committee: Science and Technology, 5 September, viewed February 2021, <https://pmg.org.za/committee-meeting/27006/>

Petersen, IH & Kruss, G 2019, 'Promoting alignment between innovation policy and inclusive development in South Africa', *Development Southern Africa*, vol. 36, no. 3, pp. 351–375. https://doi.org/10.1080/0376835X.2018.1490175

Petersen, IH & Kruss, G 2020, 'Towards a coherent and inclusive NSI: Building network alignment through strengthening dynamic interactive capabilities', in MBG Cele, T Luescher & A Willson Fadiji (eds.), *Innovation policy: Global debates and local experiences*, HSRC Press, Cape Town.

Plantinga, P & Adams, R 2020, 'Rethinking open government as innovation for inclusive development: Open access, data and ICT in South Africa', *African Journal of Science, Technology, Innovation and Development*, vol. 13, no. 3, pp. 1–9. https://doi.org/10.31235/osf.io/hmt8v

Plantinga, P & Adams, R 2021, 'Can open government support innovation for inclusive development? A case study of public innovation policy and management in South Africa', *International Journal of Technological Learning, Innovation and Development*, vol. 13, no. 2, pp. 142–167. https://doi.org/10.1504/IJTLID.2021.116339

Razzano, G 2021, *The politics of AI and data: Media and elections in South Africa*, AI & Data series 8, Policy Action Network, HSRC, viewed 28 February 2021, <https://policyaction.org.za/ai-data-topical-guide-series>

Reddy, P 2011, *Global innovation in emerging economies*, Routledge, New York.

Reyneke, M 2020, 'Helping to undo the red tape that ties up social entrepreneurs in bureaucratic knots', *Daily Maverick*, 15 November, viewed 30 January 2021, <https://www.dailymaverick.co.za/article/2020-11-15-helping-to-undo-the-red-tape-that-ties-up-social-entrepreneurs-in-bureaucratic-knots/>

Rothaermel, FT, Agung, SD & Jiang, L 2007, 'University entrepreneurship: A taxonomy of the literature', *Industrial and Corporate Change*, vol. 16, no. 4, pp. 691–791. https://doi.org/10.1093/icc/dtm023

SAnews 2020, 'New programme to incubate small businesses in townships and rural areas', *SAnews*, 05 November, viewed 28 February 2021, <https://www.sanews.gov.za/south-africa/new-programme-incubate-small-businesses-townships-and-rural-areas>

Scerri, M & Lastres, HM 2013, *The role of the state: BRICS national systems of innovation*, Routledge, New Delhi.

Schillo, RS & Robinson, RM 2017, 'Inclusive innovation in developed countries: The who, what, why, and how', *Technology Innovation Management Review*, vol. 7, no. 7, pp. 34–46. https://doi.org/10.22215/timreview/1089

Senyolo, MP, Long, TB, Blok, V & Omta, O 2018, 'How the characteristics of innovations impact their adoption: An exploration of climate-smart agricultural innovations in South Africa', *Journal of Cleaner Production*, vol. 172, pp. 3825–3840. https://doi.org/10.1016/j.jclepro.2017.06.019

Sibanda, M 2021, *Nuts & bolts: Strengthening Africa's innovation and entrepreneurship ecosystems*, Jonathan Ball Publishers, Cape Town.

South Africa Startup Act 2021, *South Africa Startup Act, position paper – update September 2021*, viewed February 2022, <https://www.startupact.co.za/progress>

South African Human Rights Commission (SAHRC) 2020, *Media advisory: Workshop on 'Fourth industrial revolution (4IR) and human rights: Challenges and opportunities for national human rights institutions'*, SAHRC, 04 March, viewed 30 January 2021, <https://www.sahrc.org.za/index.php/sahrc-media/news-2/item/2284-media-advisory-workshop-on-fourth-industrial-revolution-4ir-and-human-rights-challenges-and-opportunities-for-national-human-rights-institutions>

Technology Innovation Agency (TIA) 2020, *TADF – call for expression of interest*, viewed 30 November 2020, <https://www.tia.org.za/blog/2020/10/16/tadf-call-for-expression-of-interest/>

Technology Innovation Agency (TIA) n.d.a, *TIA*, viewed 30 January 2021, <https://www.tia.org.za/>

Technology Innovation Agency (TIA) n.d.b, *Innovation for inclusive development*, viewed 30 January 2021, <https://www.tia.org.za/programmes/#1574887338678-90fc442b-25a9>

The Innovation Hub (TIH) n.d., *The Innovation Hub*, viewed January 2021, <https://www.theinnovationhub.com/>

The Presidency 2019, *Address by President Cyril Ramaphosa to the 1st South African digital economy summit, Gallagher Convention Centre, Johannesburg*, The Presidency, Pretoria, viewed 30 January 2022, <https://www.thepresidency.gov.za/speeches/address-president-cyril-ramaphosa-1st-south-african-digital-economy-summit%2C-gallagher>

Tonurist, P & Karo, E 2016, 'State-owned enterprises as instruments of innovation policy', *Annals of Public and Cooperative Economics*, vol. 87, no. 4, pp. 623–648. https://doi.org/10.1111/apce.12126

Tuksnovation n.d., *Tuksnovation*, viewed 30 January 2021, <https://tuksnovation.co.za/>

Wu, X, Ramesh, M & Howlett, M 2015, 'Policy capacity: A conceptual framework for understanding policy competences and capabilities', *Politics and Society*, vol. 34, no. 3, pp. 165–171. Https://doi.org/10.1016/j.polsoc.2015.09.001

Chapter 7

Abarquez, I & Murshed, Z 2004, *Community-based disaster risk management: Field practitioner's' handbook Asian disaster*, Preparedness Center, Pathumthani.

Aitsi-Selmi, A, Blanchard, K & Murray, V 2016, 'Ensuring science is useful, usable and used in globaldisasterv risk reduction and sustainable development: A view through the Sendai framework lens', *Palgrave Communications*, vol. 2, p. 16016. https://doi.org/10.1057/palcomms.2016.16

Alexander, DE 2014, 'Communicating earthquake risk to the public: The trial of the "L'aquila Seven"', *Natural Hazards*, vol. 72, no. 2, pp. 1159–1173. https://doi.org/10.1007/s11069-014-1062-2

Allen, K 2006, 'Community-based disaster preparedness and climate adaptation: Local capacity-building in the Philippines', *Disasters*, vol. 30, no. 1, pp. 81–101. https://doi.org/10.1111/j.1467-9523.2006.00308.x

Aspinall, W 2011, 'Check your legal position before advising others', *Nature*, vol. 477, a251. Https://doi.org/10.1038/477251a

Ashwini Roy AS, 2018, 'Disaster risk reduction', *Journal of Emerging Technologies and Innovative Research (JETIR)*, vol. 5, no. 8, pp. 265–276. http://doi.one/10.1729/Journal.18240

Benessia, A & De Marchi, B 2017, 'When the earth shakes … and science with it: The management and communication of uncertainty in the L'aquila earthquake', *Futures*, vol. 91, pp. 35–45. Https://doi.org/10.1016/j.futures.2016.11.011

Blackburn, S 2014, 'The politics of scale and disaster risk governance: Barriers to decentralisation in Portland, Jamaica', *Geoforum*, vol. 52, pp. 101–112. https://doi.org/10.1016/j.geoforum.2013.12.013

Blackburn, S & Pelling, M 2018, 'The political impacts of adaptation actions: Social contracts, a research agenda', *Wires: Climate Change*, vol. 9, no. 6, a549. https://doi.org/10.1002/wcc.549

Cadag, JRD & Gaillard, JC 2012, 'Integrating knowledge and actions in disaster risk reduction: The contribution of participatory mapping', *Area*, vol. 44, no. 1, pp. 100–109. https://doi.org/10.1111/j.1475-4762.2011.01065.x

Chagutah, T 2014, 'Towards improved public awareness for climate related disaster risk reduction in South Africa: A participatory development communication perspective', Tigere Chagutah PhD candidate in Communication Studies, North-West University, Potchefstroom.

Donovan, A, Ayala, IA, Eiser, J & Sparks, R 2018, 'Risk perception at a persistently active volcano: Warnings and trust at Popocatépetl Volcano in Mexico, 2012–2014', *Bulletin of Volcanology*, vol. 80, no. 5, p. 47. https://doi.org/10.1007/s00445-018-1218-0

Donovan, A, Bravo, M & Oppenheimer, C 2013, 'Co-production of an institution: Montserrat volcano observatory and the social dependence on science', *Science and Public Policy*, vol. 40, no. 2, pp. 171–186. https://doi.org/10.1093/scipol/scs078

Donovan, A, Eiser, JR & Sparks, RSJ 2015, 'Expert opinion and probabilistic volcanic risk assessment', *Journal of Risk Research*, vol. 20, no. 6, pp. 1–18. https://doi.org/10.1080/13669877.2015.1115425

Donovan, A & Oppenheimer, C 2015, 'Resilient science: The civic epistemology of disaster risk reduction', *Science and Public Policy*, vol. 43, no. 3, pp. 363–374. https://doi.org/10.1093/scipol/scv039

Gaillard, JC & Mercer, J 2013, 'From knowledge to action: Bridging gaps in disaster risk reduction', *Progress in Human Geography*, vol. 37, no. 1, pp. 93–114. https://doi.org/10.1177/0309132512446717

Haughton, G & White, I 2017, 'Risky spaces: Creating, contesting and communicating lines on environmental hazard maps', *Transactions of the Institute of British Geographers*, vol. 43, no. 3, pp. 435–448. https://doi.org/10.1111/tran.12227

Henman, P 2018, 'Of algorithms, apps and advice: Digital social policy and service delivery', *Journal of Asian Public Policy*, vol. 12, no. 1, pp. 71–89. https://doi.org/10.1080/17516234.2018.1495885

Hu, H, Lei, T, Hu, J, Zhang, S & Kavan, P 2018, 'Disaster mitigation and general innovative response to climate change: Evidence from modern and historical china', *International Journal of Disaster Risk Reduction*, vol. 28, pp. 522–544. https://doi.org/10.1016/j.ijdrr.2018.01.022

Huesca, R 2003, 'Participatory approaches to communication for development', in Mody (ed.), *International and development communication: A 21st century perspective*, pp. 209–226, SAGE Publications, London.

Izumi, T, Shaw, R, Ishiwatari, M, Djalante, R & Komino, T 2019, *30 innovations for disaster risk reduction by IRIDeS*, 80 pages, Keio University, the University of Tokyo, UNU-IAS, CWS Japan.

Klein, N 2008, *The shock doctrine: The rise of disaster capitalism*, Penguin, London.

Kruger, F, Bankoff, G, Cannon, T, Orlowski, B & Schipper, L (eds.) 2015, *Cultures and disaster: Understanding cultural framings in disaster risk reduction*, Routledge Studies in Hazards, Disaster Risk and Climate Change, Routledge, Abingdon.

Lane, SN, Odoni, N, Landström, C, Whatmore, SJ, Ward, N & Bradley, S 2011, 'Doing flood risk science differently: An xperiment in radical scientific method', *Transactions of the Institute of British Geographers*, vol. 36, no. 1, pp. 15–36. https://doi.org/10.1111/j.1475-5661.2010.00410.x

Lauer, M 2012, 'Oral traditions or situated practices? Understanding how indigenous communities respond to environmental disasters', *Human Organization*, vol. 71, no. 2, pp. 176–187. Https://doi.org/10.17730/humo.71.2.j0w0101277ww6084

Mehdi, J, Nejat, A, Ghosh, S, Jin, F & Cao, G 2019, 'Social media data and post-disaster recovery', *International Journal of Information Management*, vol. 44, pp. 25–37. https://doi.org/10.1016/j.ijinfomgt.2018.09.005

Melkote, SR 2003, 'Development communication theories', in Mody (ed.) *International and development communication: A 21st-century perspective*, Sage, London, pp. 129–146.

Melkote, SR & Kandath, KP 2001, 'Barking up the wrong tree? An inward look at the discipline and practice of development communication', in SR Melkote & S Rao (eds.), *Critical issues in communication: Looking inward for answers (Essays in honour of K.E. Eapen)*, SAGE Publications, New Delhi, pp. 189–204.

Melkote, SR & Steeves, HL 2001, *Communication for development in the third world: Theory and practice for empowerment*, 2nd edn., SAGE Publications, New Delhi.

Mercer, J, Kelman, I, Taranis, L & Suchet-Pearson, S 2010, 'Framework for integrating indigenous and scientific knowledge for disaster risk reduction', *Disasters*, vol. 34, no. 1, pp. 214–239. Https://doi.org/10.1111/j.1467-7717.2009.01126.x

Mileti, D 2010, *Warning messages and public response: Social science research findings and applications for practice*, Start Slide Briefing.

Pelling, M 2011, *Adaptation to climate change: From resilience to transformation*, Routledge, London.

Scolobig, A, Prior, T, Schröter, D, Jörin, J & Patt, A 2015, 'Towards people-centred approaches for effective disaster risk management: Balancing rhetoric with reality', *International Journal of Disaster Risk Reduction*, vol. 12, pp. 202–212. https://doi.org/10.1016/j.ijdrr.2015.01.006

Servaes, J 2004, 'Multiple perspectives on development communication', in CC Okigbo & F Eribo (eds.), *Development communication in Africa*, Rowman and Littlefield, Lanham, pp. 55–64.

Singhal, A, Usdin, S, Scheepers, E, Goldstein, S & Japhet, G 2004, 'Entertainment-education strategy in development communication', in CC Okigbo & F Eribo (eds.), *Development communication in Africa*, Rowman and Littlefield, Lanham, pp. 141–153.

Skinner, C & Rampersad, R 2014, 'A revision of communication strategies for effective disaster risk reduction: A case study of the South Durban basin, KwaZulu-Natal, South Africa', *Jàmbá: Journal of Disaster Risk Studies,* vol. 6, no. 1, p. 10. https://doi.org/10.4102/jamba.v6i1.132

Slovic, P 2016, 'Understanding perceived risk: 1978–2015', *Environment: Science and Policy for Sustainable Development*, vol. 58, no. 1, pp. 25–29. https://doi.org/10.1080/00139157.2016.1112169

Slovic, P, Finucane, ML, Peters, E & Macgregor, DG 2004, 'Risk as analysis and risk as feelings: Some thoughts about affect, reason, risk, and rationality', *Risk Analysis*, vol. 24, no. 2, p. 311. Https://doi.org/10.1111/j.0272-4332.2004.00433.x

Stirling, A 2008, 'Opening up and closing down', *Science, Technology & Human Values*, vol. 33, no. 2, pp. 262–294. https://doi.org/10.1177/0162243907311265

Stirling, A 2010, 'Keep it complex', *Nature*, vol. 468, no. 7327, pp. 1029–1031. https://doi.org/10.1038/4681029a

Twigg, J 2004, *Disaster risk reduction: Mitigation and preparedness in development and emergency programming*, Overseas Development Institute, London.

United Nations Inter-Agency Secretariat of the International Strategy for Disaster Reduction (UNISDR) 2004, *Living with risk: Turning the tide on disasters towards sustainable development*, ISDR, Geneva.

United Nations Inter-Agency Secretariat of the International Strategy for Disaster Reduction (UNISDR) 2013, *Using science for disaster risk reduction: Report to the UNISDR scientific and technical advisory group*, UNISDR, Geneva.

Veil, SR, Buehner, T & Palenchar, MJ 2011, 'A work-in-process literature review: Incorporating social media in risk and crisis communication', *Journal of Contingencies and Crisis Management*, vol. 19, no. 2, pp. 110–122. https://doi.org/10.1111/j.1468-5973.2011.00639.x

Waisbord, S 2005, 'Five key ideas: Coincidences and challenges in development communication', in O Hemer & T Tufte (eds.), *Media and global change: Rethinking communication for development*, Clacso, Buenos Aires, pp. 77–90.

Wilson, M 2007, *At the heart of change: The role of communication sustainable development*, Panos, London.

Wilson, TM, Stewart, CA, Bickerton, H, Baxter, PJ, Outes, V, Villarosa, G & Rovere EI 2013, *Impacts of the June 2011 Puyehue-Cordón Caulle volcanic complex eruption on urban infrastructure, agriculture and public health*, GNS Science, Lower Hutt.

Wisner, B, Blaikie, P, Cannon, T & Davis, I 2004, *At risk: Natural hazards, people's vulnerability and disasters*, 2nd edn, Routledge, London.

Chapter 8

Brodrick, S 2010, *The ultimate suburban survivalist guide: The smartest money moves to prepare for any crisis*, John Wiley and Sons, viewed 31 March 2013, <http://books.google.com/books?id=Imh5a-V_qaIC&pg=PA132&dq=henry+doulton+water+filter&hl=en&sa=X&ei=DfhYUe3MCoXC4AOI5oCwBA&ved=0CD4Q6AEwAA#v=onepage&q=henry%20doulton%20water%20filter&f=false>

California Institute of Technology (Caltech) 2019, viewed n.d., <https://innovation.caltech.edu/patent/CIT-6330>

Chandler, DL 2012, 'A new approach to water desalination', *MIT News*, 2 July, viewed 31 March 2013, <http://web.mit.edu/newsoffice/2012/graphene-water-desalination-0702.html>

Chang, H, Liang, H, Qu, F, Liu, B, Yu, H, Du, X, Li, G & Snyder SA 2017, 'Hydraulic backwashing for low-pressure membranes in drinking water treatment: A review', *Journal of Membrane Science*, vol. 540, pp. 362–380. https://doi.org/10.1016/j.memsci.2017.06.077

Davids, N 2018, *UCT urine project zips to the top of the pile*, viewed n.d., <https://www.timeslive.co.za/news/south-africa/2018-02-21-uct-urine-project-zips-to-the-top-of-the-pile/>

Dawney, B & Pearce, JM 2012, 'Optimizing the solar water disinfection (SODIS) method by decreasing turbidity with NaCl', *Journal of Water, Sanitation and Hygiene for Development*, vol. 2, no. 2, pp. 87–94, viewed 03 April 2013, <http://www.iwaponline.com/washdev/002/washdev0020087.htm>

Global Hydration 2019, *Common methods of water purification*, viewed 23 April 2019, <https://globalhydration.com/waterborne-disease/common-methods-of-water-purification/>

Greenemeier, L 2012, 'A fine brine: New desalination technique yields more drinkable water', *Scientific American*, 21 May, viewed n.d., <http://www.scientificamerican.com/article.cfm?id=desalination-membrane-tech>

Human Sciences Research Council (HSRC) 2016a, *South African Social Attitudes Survey (SASAS)-2016: Survey dataset*, viewed 4 March 2019, <https://sasas.hsrc.ac.za/home>

Human Sciences Research Council (HSRC) 2016b, *Report on innovative sanitation technology business breakfast*, viewed n.d., https://repository.hsrc.ac.za/bitstream/handle/20.500.11910/13344/10696.pdf?sequence=1&isAllowed=y

Human Sciences Research Council (HSRC) 2017, *Report on point of use water filtration device for rural household water treatment workshop, viewed n.d., https://repository.hsrc.ac.za/bitstream/handle/20.500.11910/13344/10696.pdf?sequence=1&isAllowed=y*

Juma, C 2015, *The new harvest: Agricultural innovation in Africa*, 2nd edn., Oxford University Press.

Kiger, PJ 2019, *10 Innovations in water purification*, viewed n.d., <https://science.howstuffworks.com/environmental/green-tech/sustainable/10-innovations-water-purification10.htm>

Kruss, G & Gastrow, M 2015, *Linking universities and marginalised communities*, HSRC Press, Cape Town.

Lorentzen, J 2010, 'Low-income countries and innovation studies: A review of recent literature', *African Journal of Science, Technology, Innovation and Development*, vol. 2, no. 3, pp. 46–81.

Mandal, A 2013, 'Nanoparticles – what are nanoparticles?', *News-medical Net*, viewed 01 April 2013, <http://www.news-medical.net/health/Nanoparticles-What-are-Nanoparticles.aspx>

Mywaterloo 2019, The product, viewed n.d., <https://mywaterloo.co.za/the-product/>

Neethling, J, Kubheka, N, Majozi, S & Still, D 2018, *WRC Project K5/2812: Long-term monitoring and assessment of pour-flush technology in South Africa. Deliverable 2: Compilation of pour-flush projects in South Africa, research materials, and data-collection plan*, Revision 1, Partners in Development (Pty) Ltd & Water Research Commission, Pretoria.

Samarrai, F 2013, 'U.Va. nonprofit organization, PureMadi, develops innovative water purification tablet for developing world', *UVA Today*, 05 February, viewed 01 April 2013, <https://news.virginia.edu/content/uva-nonprofit-organization-puremadi-develops-innovative-water-purification-tablet-developing>

Science Daily 2009, *Novel bacterial strains clear algal toxins from drinking water*, 10 September, viewed 31 March 2013, <https://www.sciencedaily.com/releases/2009/09/090907013806.htm>

Science Daily 2011a, *'Super Sand' for better purification of drinking water*, 23 June, viewed 31 March 2013, <http://www.sciencedaily.com/releases/2011/06/110622102831.htm>

Science Daily 2011b, *'Plastic bottle' solution for arsenic-contaminated water threatening 100 million people*, 01 September, viewed 31 March 2013, <http://www.sciencedaily.com/releases/2011/08/110831205923.htm>

Science Daily 2013, *Herbal defluoridation of drinking water*, 05 March, viewed 31 March 2013, <http://www.sciencedaily.com/releases/2013/03/130305100928.htm>

Shi, X, Tal, G, Hankins, NP & Gitis, V 2014, 'Fouling and cleaning of ultrafiltration membranes: A review', *Journal of Water Engineering*, vol. 1, pp. 121–138. https://doi.org/10.1016/j.jwpe.2014.04.003

Singh, K, Latave, DH & Wasewar, KL 2016, 'Removal of fluoride from aqueous solution by using low-cost sugarcane bagasse: Kinetic study and equilibrium isotherm analyses', *Journal of Hazardous, Toxic, and Radioactive Waste*, vol. 20, no. 3, pp. 1–13. https://doi.org/10.1061/(ASCE)HZ.2153-5515.0000309

South Africa 1996, *The constitution*, viewed n.d., <https://www.gov.za/documents/constitution/chapter-2-bill-rights#7>

Stone, M 2010, 'Travel light, drink safe water', *Morning Sentinel*, 28 March, viewed 01 April 2013, <http://www.onlinesentinel.com/news/travel-light-drink-safe-water_2010-03-27.html>

SuSanA.org 2019, *Self-contained, PV-powered domestic toilet and wastewater treatment system*, viewed 24 April 2019, <https://www.susana.org/en/knowledge-hub/projects/database/details/57>

Water.org 2013, *Introduction to opportunities in water, sanitation and hygiene. Toolkit 1: Water, sanitation and microfinance toolkits, finance*, viewed 14 February 2023, https://water.org/documents/53/Water.org_Toolkit_1_-_Intro_to_Opportunities_in_WASH_Microfinance.pdf

Water.org 2019, *Water crisis*, viewed 04 March 2019, <https://water.org/our-impact/water-crisis/>

Water Research Commission (WRC) 2018a, *Volume 1: Characteristics of faecal sludge from Pour-Flush latrines*, Report to the Water Research Commission by Pollution Research Group, University of KwaZulu-Natal, Ms. Aoife Byrne, Ms. Anusha Singh, Dr. Santiago Septien Stringel, Konstantina Velkushanova, Prof Chris Buckley, WRC Report No. 2137/1/18, WRC, Pretoria.

Water Research Commission (WRC) 2018b, *Volume 2: LADEPA. Characterisation of on-site sanitation material and products: VIP latrines and Pour-Flush toilets*, Report to the Water Research Commission by Pollution Research Group, University of KwaZulu-Natal. Simon Mirara, Anusha Singh, Santiago Septien Stringel, Konstantina Velkushanova, Prof Chris Buckley, WRC Report No. 2137/2/18, WRC, Pretoria.

World Health Organisation (WHO) & United Nations Children's Fund (UNICEF) 2016, *Safely managed drinking water services – thematic report on drinking water 2016*, WHO Press, Geneva.

World Health Organisation (WHO) & United Nations Children's Fund (UNICEF) 2017, *Progress on drinking water, sanitation and hygiene. Update and SDG baselines*, WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene, s.l.

Youtube.com 2019, *Recycled urine is liquid gold*, online video, YouTube, viewed n.d., <https://www.youtube.com/watch?v=vNSgQ7rAYZ0>

Zularisam, AW, Ismail, AF & Salim, R 2006, 'Behaviours of natural organic matter in membrane filtration for surface water treatment – a review', *Desalination*, vol. 194, no. 1–3, pp. 211–231. Https://doi.org/10.1016/j.desal.2005.10.030

Chapter 9

Adebowale, BA, Diyamett, B, Lema, R & Oyelaran-Oyeyinka, O 2014, 'Innovation research and economic development in Africa: Introduction', *African Journal of Science, Technology, Innovation and Development*, vol. 6, no. 5, pp. v–xi. https://doi.org/10.1080/20421338.2015.1010774

Akinleye, AF, Oluwale, BA & Ilori, MO 2014, 'Factors driving grassroot innovation: The case of the auto-mechanics in Nigeria', in *12th Globelics conference 2014*, September 2014, Addis Ababa.

African Union – New Partnership for Africa's Development (AU-NEPAD) 2010, *African innovation outlook 2010*, AU-NEPAD, Pretoria, viewed n.d., <http://www.hsrc.ac.za/uploads/pageContent/8073/June2011_NEPAD_AIO_2010_English.pdf>

AUDA-NEPAD 2019, *African innovation outlook 2019*, AUDA-NEPAD, Johannesburg, viewed 16 March 2021, <https://au.int/sites/default/files/documents/38122-doc-aio_3rd_edition_final_eng_repro.pdf>

Bloch, CW & Bugge, MM 2013, 'Public sector innovation – from theory to measurement', *Structural Change and Economic Dynamics*, vol. 27, pp. 133–145. https://doi.org/10.1016/j.strueco.2013.06.008

Breschi, S & Malerba, F 1997, 'Sectoral innovation systems, technological regimes, schumpeterian dynamics, and spatial boundaries', in C Edquist (ed.), *Systems of innovation: Technologies, institutions and organisations*.

Bull, C, Daniel, S, Kinyanjui, M & Hazeltine, B 2016, 'A study of the informal metalworking sector in Nairobi', in E Kraemer-Mbula & S Wunsch-Vincent (eds.), *The informal economy in developing nations*, Cambridge University Press, pp. 100–145.

Cassiolato, JE, De Matos, MGP & Lastres, HMM 2014, 'Innovation systems and development', in B Currie-Alder, R Kanbur, DM Malone & R Medhora (eds.), *Internal development: Ideas, experience, and prospects*, Oxford University Press, Uncorrected Proof Version, pp. 566–580.

Cassiolato, JE, Lastres, HMM & Maciel, M (eds.) 2003, *Systems of innovation and development: Evidence from Brazil*, Edward Elgar Publishing, Cheltenham.

Cassiolato, JE, Lastres, HMM, Szapiro, M & De Matos, MGP 2017, *Local production and innovation systems in Brazil: A balance of 20 years*, RedeSist Working Paper TD DIT-No. 04/2017, viewed n.d., <www.redesist.ie.ufrj.br>

Cassiolato, JE & Lastres, HMM 2020, 'The framework of "local productive and innovation systems" and its influence on STI policy in Brazil', *Economics of Innovation and New Technology*, vol. 29, no. 7, pp. 784–798. https://doi.org/10.1080/10438599.2020.1719650

Centre for Science, Technology and Innovation Indicators (CeSTII) 2020a, *Innovation in the informal sector survey statistical report: Baseline survey in sweetwaters, KwaZulu-Natal, 2017–2018*, Human Sciences Research Council, Pretoria.

Centre for Science, Technology and Innovation Indicators (CeSTII) 2020b, *Innovation in the informal sector project: Food case study report*, Human Sciences Research Council, Pretoria.

Centre for Science, Technology and Innovation Indicators (CeSTII) 2021, *Innovation in the South African informal sector survey – statistical report baseline survey in sweetwaters, KwaZulu-Natal, 2017–2018*, Human Sciences Research Council, Cape Town.

Charman, A & Petersen, L 2018, 'Informal micro-enterprises in a township context: A spatial analysis of business dynamics in five Cape Town localities', in F Fourie (ed.), *The South African informal sector: Creating jobs, reducing poverty*, HSRC Press, Pretoria.

Charmes, J 2016, 'The informal economy: Definitions, size, contribution and main characteristics', in E Kraemer-Mbula & S Wunsch-Vincent (eds.), *The informal economy in developing nations: Hidden engine of innovation*, Cambridge University Press, Cambridge.

Charmes, J, Gault, F & Wunsch-Vincent, S 2016, 'Formulating an agenda for the measurement of innovation in the informal economy', in E Kraemer-Mbula & S Wunsch-Vincent (eds.), *The informal economy in developing nations: Hidden engine of innovation*, Cambridge University Press, Cambridge.

Cozzens, S & Sutz, J 2014, 'Innovation in informal settings: Reflections and proposals for a research agenda', *Innovation and Development*, vol. 4, no. 1, pp. 5–31. https://doi.org/10.1080/2157930X.2013.876803

Cross, J 2011, *Informal learning: Rediscovering the natural pathways that inspire innovation and performance*, John Wiley & Sons.

De Beer, J & Amstrong, C 2015, 'Open innovation and knowledge appropriation in African micro and small enterprises', *African Journal of Information and Communication*, vol. 16, pp. 60–71. https://doi.org/10.23962/10539/19315

De Beer, J, Fu, K & Wunsch-Vincent, S 2013, *The informal economy, innovation and intellectual property – concepts, metrics and policy considerations*, Economic Research Working Paper No. 10, WIPO Economics & Statistics Series, World Intellectual Property Organization, Geneva, pp. 1–75.

De Beer, J, Fu, K & Wunsch-Vincent, S 2016, 'Innovation in the informal economy', in E Kraemer-Mbula & S Wunsch-Vincent (eds.), *The informal economy in developing nations*, Cambridge University Press, Cambridge.

De Jong, JPJ & Von Hippel, E 2013, 'User innovation: Business and consumers', in F Gault (ed.), *Handbook of innovation indicators and measurement*, Edward Elgar Publishing, Cheltenham, pp. 109–132.

Egbetokun, AA, Oluwadare, AJ, Ajao, BF & Jegede, OO 2017, 'Innovation systems research: An agenda for developing countries', *Journal of Open Innovation: Technology, Market and Complexity*, vol. 3, no. 25, pp. 1–16. https://doi.org/10.1186/s40852-017-0076-x

Essegbey, G & Awuni, S 2016, 'Herbal medicine in the informal sector of Ghana', in E Kraemer-Mbula & S Wunsch-Vincent (eds.), *The informal economy in developing nations*, Cambridge University Press, Cambridge, pp. 194–231.

Essegbey, GO, Awuni, S, Essegbey, IT, Akuffobea, M & Micah, B 2014, 'Country study on innovation, intellectual property and the informal economy: Traditional herbal medicine in Ghana', *Paper CDIP/13/INF/2, prepared for the Committee on Development and Intellectual Property (CDIP), Thirteenth Session*, Geneva, Switzerland, 19–23 May.

European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations & World Bank 2009, *System of national accounts 2008*, United Nations Editions, New York.

Fourie, F 2018, 'Informal sector employment in South Africa: An enterprise analysis using the SESE', in F Fourie (ed.), *The South African informal sector: Creating jobs, reducing poverty*, HSRC Press, Pretoria.

Freel, M 2000, 'External linkages and product innovation in small manufacturing firms', *Entrepreneurship & Regional Development*, vol. 12, no. 3, pp. 245–266. Https://doi.org/10.1080/089856200413482

Freeman, C 1994, 'The economics of technical change', *Cambridge Journal of Economics*, vol. 18, no. 5, pp. 463–514. https://doi.org/10.1093/oxfordjournals.cje.a035286

Freeman, C & Soete, L 2007, *Science, technology and innovation indicators: The twenty-first century challenges*, OECD Publishing, Paris.

Fu, X, Mohnen, P & Zanello, G 2018, 'Innovation and productivity in formal and informal firms in Ghana', *Technological Forecasting and Social Change*, vol. 131, pp. 315–325. https://doi.org/10.1016/j.techfore.2017.08.009

Gault, F 2008, 'Science, technology and innovation indicators: Opportunities for Africa', *African Statistical Journal*, vol. 6, pp. 141–162.

Gault, F 2010, *Innovation strategies for a global economy: Development, implementation, measurement and management*, International Development Research Centre, Ottawa.

Gault, F 2018, 'Defining and measuring innovation in all sectors of the economy', *Research Policy*, vol. 47, no. 3, pp. 617–622. https://doi.org/10.1016/j.respol.2018.01.007

Godin, B 2006, 'The linear model of innovation', *Science, Technology, & Human Values*, vol. 31, no. 6, pp. 639–667. https://doi.org/10.1177/0162243906291865

Grabrucker, K, Grimm, M & Roubaud, F 2018, 'The informal sector in sub-Saharan Africa: A comparative perspective', in F Fourie (ed.), *The South African informal sector: Creating jobs, reducing poverty*, HSRC Press, Pretoria.

Gupta, AK 2012, 'Innovations for the poor by the poor', *International Journal of Technological Learning, Innovation and Development*, vol. 5, no. 1/2, pp. 28–39. https://doi.org/10.1504/IJTLID.2012.044875

Jegede, O, Jegede, O & Mustapha, M 2020a, 'Informal sector measurement of openness, collaboration and innovation in Africa: The case of Otigba hardware microenterprises cluster in Africa', in M Muchie & A Baskaran (eds.), *Science, technology and innovation indicators: Lessons from development experience in Africa*, Published by Africa World Press, Trenton, pp. 241–270.

Jegede, OO 2020a, 'Dynamics of innovation in microenterprises in Southern Nigeria', *International Journal of Innovation, Creativity and Change*, vol. 13, no. 12, pp. 809–828.

Jegede, OO 2020b, 'Open development and scaling-up in clustered micro-firms in Nigeria', *African Journal of Science, Technology, Innovation and Development*, vol. 12, no. 6, pp. 689–698. https://doi.org/10.1080/20421338.2020.1718363

Jegede, OO 2020c, 'Dynamics of knowledge diffusion in the informal settings: A case study approach', *Journal of Entrepreneurship Education*, vol. 23, no. 1, pp. 1–20.

Jegede, OO, Oluwale, BA, Ogunjemiluia, EM & Ajao, BF 2020b, 'From start up to scale up: Indicators showing the role of knowledge sharing in clustered microenterprises in Nigeria', in M Muchie & A Baskaran (eds.), *Science, technology and innovation indicators: Lessons from development experience in Africa*, Africa World Press, Trenton, pp. 315–342.

Jensen, M, Johnson, B, Lorenz, E & Lundvall, BA 2007, 'Forms of knowledge and modes of innovation', *Research Policy*, vol. 36, no. 5, pp. 680–693.

Johnson, S & Rogaly, B 1997, *Microfinance and poverty reduction*, Oxfam, Oxford, p. 99.

Kajogbola, OO 1997, *Technology capabilities of the informal sector footwear manufacturers (Aba and Onitsha as case studies)*, NISER Occasional Paper No. 6, National Institute of Science Education and Research, Khurda.

Kawooya, D 2012, *Diffusion and transfer of IP-related innovation and technology between formal and informal sectors in Uganda*, Open African Innovation Research and Training.

Kline, SJ & Rosenberg, N 1986, 'An overview of innovation', *European Journal of Innovation Management*, vol. 38, pp. 275–305. https://doi.org/10.1108/14601069810368485

Konté, A 2012, *Measuring innovation in the informal sector*, The African Observatory of Science, Technology and innovation, viewed n.d., <www.aosti.org>

Konté, A & Ndong, M 2012, 'The informal ICT sector and innovation processes in Senegal', *African Journal of Science, Technology, Innovation and Development*, vol. 4, no. 3, pp. 61–97.

Kraemer-Mbula, E & Konté, A 2016, 'Innovation policy and informal economy: Towards a new policy framework', in E Kraemer-Mbula & S Wunsch-Vincent (eds.), *The informal economy in developing nations*, Cambridge University Press, Cambridge, pp. 296–335.

Kraemer-Mbula, E 2016, 'Informal manufacturing of home care products in South Africa', in E Kraemer-Mbula & S Wunsch-Vincent (eds.), *The informal economy in developing nations*, Cambridge University Press, pp. 146–193.

Kraemer-Mbula, E, Lorenz, E, Takala-Greenish, L, Jegede, OO, Garba, T, Mutambala, M & Esemu, T 2019, 'Are African micro-and small enterprises misunderstood? Unpacking the relationship between work organisation, capability development and innovation', *International Journal of Technological Learning, Innovation and Development*, vol. 11, no. 1, pp. 1–30. https://doi.org/10.1504/IJTLID.2019.10018585

Kraemer-Mbula, E & Tau, V 2014, 'Country study on innovation, intellectual property and the informal economy: Informal manufacturers of home and personal care products in South Africa', *paper CDIP/13/INF/4, prepared for the Committee on Development and Intellectual Property (CDIP), Thirteenth Session*, Geneva, Switzerland, 19–23 May.

Kruss, G 2018, 'Towards an agenda for measuring innovation in emerging African economies: What can we learn from the case of South Africa?', *International Journal of Technological Learning, Innovation and Development*, vol. 10, no. 3/4, pp. 347–365. https://doi.org/10.1504/IJTLID.2018.10014916

Kruss, G & Ralphs, G 2021, 'The value of a "fixed" mandate for the knowledge commons: A history of the HSRC's role in R&D and innovation measurement (1966–2018)', in C Soudien, S Swartz & G Houston (eds.), *2016, Society, research and power: A history of the Human Sciences Research Council from 1929 to 2019*, HSRC Press, Cape Town.

Kuan, KK & Chau, PY 2001, 'A perception-based model for EDI adoption in small businesses using a technology-organization-environment framework', *Information & Management*, vol. 38, no. 8, pp. 507–521. https://doi.org/10.1016/S0378-7206(01)00073-8

Lastres, HMM & Cassiolato, JE 2005, 'Systems of innovation, clusters and industrial districts: Analytical and policy implications of convergence and differences in the approaches', in *paper presented at the third Globelics International conference*, Pretoria, South Africa, 01 November, viewed 14 February 2023, <www.redesist.ie.ufrj.br>

Lundvall, BA (ed.) 1992, *National systems of innovation: Towards a theory of innovation and interactive learning,* Anthem Press, London.

Malefane, SR 2013, 'Small medium, and micro enterprise and local economic-base restructuring – a South African local government perspective', *Journal of Public Administration*, vol. 48, no. 4, pp. 671–690.

Marsick, V & Watkins, K 2015, *Informal and incidental learning in the workplace (Routledge Revivals)*, Routledge, London.

Marsick, VJ & Volpe, M 1999, 'The nature and need for informal learning', *Advances in Developing Human Resources*, vol. 1, no. 3, pp. 1–9. https://doi.org/10.1177/152342239900100302

Murphy, JT 2002, 'Networks, trust, and innovation in Tanzania's manufacturing sector', *World Development*, vol. 30, no. 4, pp. 591–619. https://doi.org/10.1016/S0305-750X(01)00131-0

Mustapha, N, Kruss, G, Jegede, O, Petersen, I & Bortagaray, I 2021, 'Measurement of innovation in the informal sector in Africa: The importance to industrial policy', *Innovation and Development*, pp. 1–18. https://doi.org/10.1080/2157930X.2021.1887614

Mytelka, L & Farinelli, F 2000, *Local clusters, innovation systems and sustained competitiveness*, UNU/INTECH discussion papers, prepared for the meeting on local productive clusters and innovation.

Nelson, RR 1993, *National innovation systems: A comparative analysis*, viewed n.d., https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1496195

Obembe, JJ 2014, 'The role of diffusion in technological learning in the furniture industry: A case study of Southwestern Nigeria', *International Journal of Technical Research and Applications*, vol. 2, no. 4, pp. 53–57.

OECD/Eurostat 2005, 'Oslo Manual: Guidelines for collecting and interpreting innovation data', in *The measurement of scientific, technological and innovation activities*, 3rd edn, OECD Publishing, Paris/Eurostat, Luxembourg.

OECD/Eurostat 2018, 'Oslo Manual 2018: Guidelines for collecting, reporting and using data on innovation', in *The measurement of scientific, technological and innovation activities*, 4th edn., OECD Publishing, Paris.

Ogunjemilua, EM, Oluwale, BA, Jegede, OO & Ajao, BF 2020, 'The nexus of knowledge sharing and innovations in the informal sector: The case of Otigba hardware cluster in Nigeria', in J Larimo, M Marinov, S Marinova & T Leposky (eds.), *International business and emerging economy firms. Palgrave studies of internationalization in emerging markets*, Palgrave Macmillan, Cham, pp. 275–299.

Olowu, D 1995, *The informal sector in Nigeria: Some analytical and development issues*, CBN/NISER, Ibadan.

Oluwale, B, Jegede, O, Ajao, B & Ogunjemilua, E 2020, 'Connecting the dots between knowledge, openness, networking and partnership in a Nigerian cluster: The case of Otigba market cluster', in B Angathever & M Muchie (eds.), *Innovation for sustainable integrated development in Africa*, Africa World Press, Trenton, pp. 203–224.

Oluwale, BA, Jegede, OO & Olamade, OO 2013, 'Technical and vocational skills depletion in Nigeria and the need for policy intervention', *International Journal of Technical and Vocational Education*, vol. 5, no. 6, pp. 100–109.

Porter, ME 2000, 'Locations, clusters, and company strategy', in *The Oxford handbook of economic geography*, Oxford University Press, Oxford, pp. 253, 274.

Rangaswamy, N & Densmore, M 2013, 'Understanding Jugaad: ICTD and the tensions of appropriation, innovation and utility', *International conference on Information and Communication Technologies ICTD 2013*, Cape Town.

Razafindrakoto, M, Roubaud, F & Torelli, C 2009, 'Measuring the informal sector and informal employment: The experience drawn from 1-2-3 surveys in African countries', *African Statistical Journal*, vol. 9, pp. 88–147.

Rogerson, C 2000, 'Local economic development in an era of globalisation: The case of South African cities', *Tijdschrift voor economische en sociale geografie*, vol. 91, no. 4, pp. 397–411. https://doi.org/10.1111/1467-9663.00126

Schneider, FG 2002a, *Size and measurement of the informal economy in 110 countries around the world*, Department of Economics, Johannes Kepler University of Linz, Linz.

Schneider, FG 2002b, *The size and development of the shadow economies of 22 transition and 21 OECD countries*, IZA Discussion Paper No. 514, viewed n.d., <https://ssrn.com/abstract=320083>

Statistics South Africa (StatsSA) 2010, *South African Statistical Quality Assessment Framework (SASQAF): Operational standards and guidelines*, 1st edn, Statistics South Africa, Pretoria.

Statistics South Africa (StatsSA) 2014, *Survey of employers and the self-employed: 2013*, Statistics South Africa, Pretoria.

Statistics South Africa (StatsSA) 2019a, *Survey of employers and the self-employed: 2017*, Statistics South Africa, Pretoria.

Statistics South Africa (StatsSA) 2019b, *Quarterly Labour Force Survey (QLFS), 4th Quarter 2018*, Statistics South Africa, Pretoria.

Stuart, E, Samman, E & Hunt, A 2018, *Informal is the new normal. Improving the lives of workers at risk of being left behind*, Overseas Development Institute, London.

Tiwari, R & Herstatt, C 2012, *India – a lead market for frugal innovations?* Technology and Innovation Management Working Paper No 67 TIM/TUHH, pp. 1–42.

Van Aken, JE & Weggeman, MP 2000, 'Managing learning in informal innovation networks: Overcoming the Daphne- dilemma', *R&D Management*, vol. 30, no. 2, pp. 139–149.

Williams, CC 2006, *The hidden enterprise culture: Entrepreneurship in the underground economy*, Edward Elgar Publishing, Cheltenham.

Williams, CC 2014, 'Explaining cross-national variations in the commonality of informal sector entrepreneurship: An exploratory analysis of 38 emerging economies', *Journal of Small Business and Entrepreneurship*, vol. 27, no. 2, pp. 191–212. https://doi.org/10.1080/08276331.2015.1004959

Index

A
academic disciplines, 72

C
citizen science, 67–70, 72, 74–78, 80–82, 84

D
disaster, 111–123

E
economic growth, 2–3, 5, 11–12, 16, 23, 26, 32, 39, 51, 53, 58, 63, 69, 80, 138
environment, 40, 42–43, 46, 49, 69, 78–79, 87, 91, 93, 97, 102, 112, 120, 127, 129, 133–134, 148, 155
evolutionary economics, 16–17, 25, 27

F
Fourth Industrial Revolution (4IR), 17, 22–23, 32, 58–59, 102

G
gender inequality, 57
gender mainstreaming, 36, 61–62
gender, 5, 12, 18, 21, 31–38, 40–46, 50–58, 61–65, 69, 120
government, 2–4, 7, 13–14, 51, 55, 58–62, 69–70, 73, 75, 79–80, 83, 86, 89–101, 103–104, 108, 112, 114, 117, 120, 122–123, 138, 140, 142, 144, 147–149, 151, 157–159
grassroots innovation, 9, 11, 15, 53, 67–72, 74, 76, 78–84, 91

H
human capabilities, 16, 21–22, 26–28, 60

I
improved sanitation, 125–126, 128, 130, 132, 134, 136
inclusive development, 1–4, 6, 8, 11–12, 15–20, 22, 24, 26–28, 30–31, 49, 53, 58–59, 67, 85, 88–89, 91, 93, 95, 98–101, 103, 108, 111, 125, 130, 133, 136–138
inclusive, 1–20, 22, 24, 26–28, 30–31, 36–37, 47, 49–50, 53–59, 61–62, 65, 67, 79, 85, 88–89, 91–93, 95, 98–101, 103–108, 111–120, 122, 125, 130, 133, 136–140, 142, 144, 146, 148, 150, 152, 154, 156, 158–160
inclusiveness, 11, 92
informal sector, 3, 24, 137–139, 141–155, 157–161
innovation and development, 53, 57
innovation for inclusive development, 1–2, 12, 15–18, 20, 22, 24, 26, 28, 30–31, 49, 67, 85, 111, 125, 130, 133, 137
innovation policy, 3–4, 24, 30, 41–42, 50, 55, 62–63, 87, 89, 139
innovation, 1–20, 22–24, 26–34, 36–38, 40–47, 49–50, 52–65, 67–72, 74, 76, 78–109, 111–113, 115–116, 118–121, 123, 125–126, 130, 133, 137–161
intersectionality, 52

M
measurement of innovation, 138–140, 157, 159–161

N
neoliberal economics, 18–19

P
potable water, 125–136

R
risk communication, 111–118, 120–123
risk reduction, 112–113, 115, 117, 122

S
science, 2–3, 6–7, 13, 17–19, 23, 26–27, 31–38, 40–47, 53, 55, 58–61, 63, 67–70, 72, 74–84, 88, 93–94, 96, 113, 123, 129–130, 137–138, 140, 142–143, 146, 149
South Africa, 1–4, 6, 8, 10, 12–15, 17, 25–31, 49–50, 52, 54–56, 58–62, 64–65, 67, 79–80, 85–89, 93, 96, 98, 101, 103, 108, 111, 125–128, 130, 132–140, 143, 145, 147–148, 151–153, 155, 158
systems of innovation, 16, 24, 27, 55, 58, 62–63, 87

T
technology, 2–3, 6–7, 10–13, 15–17, 19, 23, 26–27, 31–34, 36–46, 53, 55, 58–61, 63–64, 69–70, 76–77, 79, 81–83, 87–91, 94, 96–101, 107, 112–113, 115, 117, 123, 129–130, 133, 137–138, 140, 143–144, 146–147, 149, 153

transdisciplinarity, 67–68, 70, 72–74, 76, 78, 80, 82, 84
transformation, 1, 3, 13–15, 31–32, 42, 47, 49, 58, 62–64, 67, 85, 98–99, 111, 125, 137, 139
Transformative Innovation Policy, 50, 62–63

W
White Paper on Science, Technology and Innovation, 26, 88

Science, technology and innovation (STI) are generally accepted as major growth drivers and can help address poverty and directly improve the well-being of different social groups. However, under certain circumstances, STIs can reinforce social exclusion and inequalities. This book examines the relationship between IID and income inequality and opportunity by exploring discourses around directionality and innovation for inclusive development (IID). It seeks to unpack the concept of IID and what it means in a country such as South Africa – a country characterised by endemic poverty, deepening inequality, and high unemployment rates. The book is original and based on a critique of existing literature to expose specific issues or bolster particular arguments about the role of IID in equitable and inclusive development. Various scholars have written this book based on their knowledge of multiple notions of IID, how it can be applied, and how such knowledge can benefit policy, programmes, and practices. Unlike other books, this one is intended for a much wider audience and to be used in the field of innovation for inclusive development.

The book contributes to understanding IID and its application in low- and middle-income countries. It uses specific examples to demonstrate technical and contextual factors that affect its impact. Most studies on IID have been done in developed countries, and this book intends to fill this knowledge gap and raise an understanding of the enablers and constraints of its application.

This book is based on a series of chapters authored based on a systematic review of relevant literature, empirical work on local innovations, and a series of policy dialogues on IID, which the Human Sciences Research Council (HSRC) conducted in the last ten years.

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