Science, Technology and Innovations for Sustainable Human Settlements (STI4SHS) Roadmap

A roadmap to deploy innovations and technology to achieve green, smart and sustainable human settlements in the context of 4th Industrial Revolution

science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

human settlements
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Human Settlements
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LIST OF FIGURES

LIST OF TABLES

ABBREVIATION	DESCRIPTION
4IR	Fourth Industrial Revolution
AfCFTA	African Continental Free Trade Area
AI	Artificial Intelligence
BIM	Building Information Modelling
BRL	Business Readiness Level
CPD	Continuing Professional Development
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs (now DEFF)
DEFF	Department of Environment, Forestry and Fisheries
DHS	Department of Human Settlements (now DHSWS)
DHSWS	Department of Human Settlements, Water & Sanitation
DoRA	Division of Revenue Act
DPME	Department of Monitoring and Evaluation
DSI	Department of Science and Innovation (formerly DST)
DST	Department of Science and Technology (now DSI)
DTI	Department of Trade and Industr
GERD	Gross expenditure on research and development
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HCD	Human Capital Development
HSDG	Human Settlements Development Grant
IBT	Innovative Building Technology
ICT	Information and Communication Technology
IoT	Internet of Things
I&TT	Innovation and Transformative Technologies
IUDF	Integrated Urban Development Framework
IWMS	Integrated Workplace Management System
KPI	Key Performance Areas
LL	Living Laboratory
M&E	Monitoring and Evaluation
MLP	Muliti-level Perspective
MOOC	Massive Open Online Course
MRL	Market Readiness Level
MTSF	Medium-term Strategic Framework
NDP	National Development Plan
NHBRC	National Home Builders Registration Council
NMISA	National Metrology Institute of South Africa
NSI	National System of Innovation
NUA	New Urban Agenda
PHDA	Priority Housing Delivery Areas
PMU	Project Management Unit
R&D	Research and Development
RDI	Research Development and Innovation
RFID	Radio-Frequency Identification
SABS	South African Bureau of Standards

ABBREVIATION	DESCRIPTION
SADC	Southern African Development Community
SALGA	South African Local Government Association
SANS	South African National Standards
SANSA	South African National Space Agency
SDG	Sustainable Development Goal
SHS	Sustainable Human Settlements
SMME	Small, micro, medium enterprises
STI	Science, Technology and Innovation
TIA	Technology Innovation Agency
TIP	Technology Innovation Policy
TRL	Technology Readiness Level
TVET	Technical and Vocational Education and Training
UISP	Upgrading Informal Settlements Programme
uKESA	Urban Knowledge Exchange South Africa
WCDHS	Western Cape Department of Human Settlements
WRC	Water Research Commission

SECTION A:

INTRODUCTION

Foreword

Mr Bonginkosi Emmanuel "Blade" Nzimande
Minister of Higher Education, Training, Science and Innovation

The transition to an environmentally, and socioeconomically sustainable future is dependent on successful adoption of appropriate technological innovation, and that Science Innovation and Transformative Technologies (SITT) can potentially pave the way to achieve the progressive realisation of the constitutional right to access to adequate housing and the pursuit of improved quality of household life.

Furthermore, the effective application of SITT can be a transformative instrument in addressing South Africa's most urgent and significant societal challenges, such as to stimulate sustainable, decent work opportunities.

In order to achieve successful mainstreaming of SITT, it is necessary to ensure that investment is prioritised and targeted and that barriers are effectively removed.

The Department of Science and Innovation is therefore pleased to present this roadmap which sets a ten-year framework to unlock the potential of South Africa's human settlements for a decent standard of living, that is safe, resilient and sustainable by means of mainstreaming science, technology and innovation in our households and neighbourhoods.

The vision articulated in this roadmap is the result of keen analysis, extensive collaboration of key partners and intensive input from sector stakeholders over the preceding year. It sets strategic direction for co-ordinating and shaping human capital development, the R&D agenda, enabling environment and investment.

As such, the interests and perspectives of multiple stakeholders including civil society, business, academia and a range of governmental actors are reflected. You are invited to review the draft roadmap and add your voice as we move to implementation.

Foreword

Ms Lindiwe Sisulu
Minister of Human Settlements,
Water and Sanitation

In its quest to deliver on its mandate in a quicker and more ecologically-sensitive manner, whilst maintaining quality, the National Department of Human Settlements has implemented a number of catalytic projects. These have sought to address urban spaces, transformation and industry, through projects that demonstrate and promote innovation in terms of the master spatial plan, as well as through the use of innovative material and technologies.

Furthermore it has invested in the professionalisation of the sector, by establishing a Chair in Human Settlements Education at Nelson Mandela University; a Human Settlements Chair at Mangosuthu University of Technology; and a Centre for Sustainable Human Settlements Education at Fort Hare University.

In its 2017 Summit, the Department of Human Settlements took a resolution to up-scale innovation and transformative technologies, for connectivity, resilience, economy and dignity. It sought to harness innovation to address rapid urbanisation and technology gaps in human settlements.

At the 2020 Human Settlement Indaba, participants adopted a declaration on strategic partnerships to transform human settlements for spatial justice and social cohesion. This declaration included, inter alia to “ensure a systematic but progressive approach to ITT through the Science and Innovation Transformative Technologies Ten-Year Road Map.”

The Indaba was attended by the Ministries of Co-operative Governance and Traditional Affairs, Public Works and Infrastructure, Agriculture, Land Reform and Rural Development, MECs of Human Settlements, mayors, banking institutions, developers, civil society and community-based organisations.

By leveraging investments to date, and the opportunities, afforded by science, technology and innovation, I believe that the SITT 4 SHS Roadmap establishes the blueprint to achieve the strategic objectives set out at the Indaba.

It will stimulate investment and shape public and private partnerships to support the department to deliver on its mandate to facilitate the creation of sustainable human settlements and improve the quality of household life for South Africans.

Executive Summary

Dr Phil Mjwara
Director-General:
Department of Science and Innovation

The Science Technology and Innovation White Paper (2019) recognises that innovation has to adequately respond to a world in transition. A shift from thinking of systems in isolation to the entire socio-technical systems and the values underlying them is crucial in order to achieve change. Such a transition entails a greater focus on smart, sustainable and inclusive development supported by responsible research and innovation and a network of actors driving change to societal challenges such as the provision of quality shelter and smart communities.

Whilst a socio-technical systems approach is necessary, technologies such as artificial intelligence has a vital role in dealing with land shortages, land degradation, informal settlements and slums upgrades, over-population, flooding and decongestion of cities.

Artificial intelligence (AI) and the Internet of Things (IoT) provides opportunity for transition to Society 5.0. Society 5.0 is about smart communities where technology and innovation is used to solve social problems such as health, smart delivery of basic services, mobility and improved standards of living. There are many opportunities for AI in improving livelihoods in urban life. AI can speed up information flows; production processes and decision making; and 3D printed buildings and houses. In this way we can optimise the construction and the delivery of human settlements.

We now know that the Fourth Industrial Revolution (4IR) provides opportunity to harness technology to plan, deliver, monitor and optimise infrastructure to the benefit of socioeconomic and sustainable development. To illustrate this, many cities characterised as smart, is a result of urban leaders increasingly tapping into new streams of data to manage performance of their cities, often in real time, which is key for transformative and inclusive urban development.

The question is how do we mobilise a 'whole of society' and the 'whole of government' effort to enable transition to smart communities, settlements and cities? How do we ensure that South Africa has a systemic approach towards this transition whilst ensuring that job opportunities are created and SMME's are supported to take advantage of Society 5.0 revolution.

The Science, Technology and Innovation for Sustainable Human Settlements Roadmap is a strategic transformation framework that provides the basis for planning, co-ordination and making decisions for introducing innovations to support the National Department of Human Settlement's effort to transform human settlements into smart settlements in order to realise and harness the Fourth Industrial Revolution opportunities for this sector.

Executive Summary

Mr Mbulelo Tshangana
Director-General:
Department of Human Settlements

The Minister approved the draft Human Settlements Framework for Spatial Transformation and Consolidation which includes the 58 Priority Housing Development Areas (preliminary declaration). Innovation and Transformative Technologies (I&TT) is one channel that will be used to implement the Human Settlements Framework for Spatial Transformation and Consolidation in the MTSF 2019-24.

The vision of the I&TT Human Settlements (HS) framework embraces the President's State of the Nation Address 2019, and Minister Sisulu's Budget Speech July 2019 that is "the new smart city".

Institutionally, the Human Settlements Sector has established an I&TT HS Task Team with chairmanship in the NDHS. I&TT has been proposed for inclusion in the new department structure as part of the Research Directorate, with roles and responsibilities articulated in the MTSF document. Enabler 5 as discussed in the Framework is part of the MTSF document 2019-24.

1. Purpose of the Document

The purpose of this document is to articulate the STI4SHS roadmap as a high-level framework for human settlements stakeholders and industry stakeholders to plan, reflect, invest and make decisions and prioritise key initiatives, actions and niches (programmes, projects, strategies and initiatives) that should be supported and implemented in the sector in order to achieve smart communities and Society 5.0. through technology and innovation.

This Roadmap serves as a transformative policy framework designed to guide, stimulate investment, embed, expand and institutionalise niches and initiatives at systems level that should be supported to achieve transition to smart settlements through innovation over the next ten years (2020–2029). In this context, this Roadmap document serves as an implementation plan to guide implementation and scaling up of technologies and innovations in the Sustainable Human Settlements sector in support of the National Department of Human Settlement's Innovation for Transformative Technologies Framework , the STI White Paper, the DSI Decadal Plan and the White Paper on Sustainable Human Settlements and ultimately support and position government as an enabler of innovation in society.

The current document merges the STI4SHS Roadmap which maps current niches with the I&TT Framework and which forecasts possible niches for the disruption of current regimes to ensure transformed sustainable human settlements.

2. Background and Introduction

The South African government adopted the National Development Plan (NDP), a long-term plan to reduce poverty and inequality by 2030, which recognises the crucial importance of STI in accelerating South Africa's socio-economic development. To make South Africa a more globally competitive economy, both government and industry need to scale up innovation radically. The National Department of Human Settlements's Innovation and Transformative Technologies Framework notes that the radical strength of current innovations, as mapped in this document, is not sufficient for the distabilisation of current regimes.

The NDP acknowledges that advances in technological innovation, the production of new knowledge, research collaboration and the application of knowledge through teaching are vital for a thriving economy.

Similarly, the United Nations adopted the 2030 Agenda for Sustainable Development, titled "Transforming Our World", which also aims to improve the well-being of people. The 2030 Agenda, to which South Africa is a signatory, consists of 17 sustainable development goals (SDGs) and 169 targets. SDG 11 is about making cities and human settlements inclusive, safe, resilient and sustainable.

Both nationally and internationally, there is an increasing recognition of the role of STI in human settlements.

By 2030, countries should substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, adaptation to climate change and resilience to disasters. These outcomes can be achieved only through smart approaches and the use of innovation in the development of human settlements.

The Department of Science and Innovation envisages building a South Africa for the future through hubs of innovation. To enable the creation of innovative cities, neighbourhoods and smart human settlements, the Department established a unit for Science, Technology and Innovation (STI) for Sustainable Human Settlements (SHS). This directorate works in partnership with the national Department of Human Settlements to drive and deliver innovation for the sector. The work of the Unit also requires collaboration with a number of public and private sector stakeholders to support the demonstration of alternative and innovative building systems, water provision and purification technologies, alternative energy solutions and information communication technologies in human settlements.

The unit and its partners are also exploring decision-support tools to expedite the creation of a more digitised business environment and processes that will enable the realisation of a digital enterprise by the sector. Transformative, self-sustaining, liveable and carbon-neutral neighbourhoods and cities, and improved service delivery across government can only be achieved if we transform business processes from paper-based processes to digital processes and when we influence societal and cultural attitudes to become more open to alternative methods in housing.

With urban growth and the migration of people from rural areas to urban centres, cities have become the pillars for development and economic growth, and increasingly play a pivotal role in the world's achievement of the Sustainable Development Goals. However, urbanisation continue to place immense pressure of city infrastructure and household income.

As we move forward we need to be aware that sustainable human settlements will have to be digitally, physically and economically smart to cope with these environmental and economic pressures. They will have to deploy information communication technologies to stimulate citizen action and combat crime. They will have to transform energy infrastructure and employ carbon neutral construction methods. Innovative finance instruments will be needed to enable citizens and businesses to share assets and resources and create employment.

3. Problem Statement

The number of sporadic and unco-ordinated initiatives demonstrating the potential of technologies for human settlements, household services and improving the settlements in terms of energy efficiency, construction and planning processes as well as smart living as a response to climate change and attainment of green buildings, has been on the increase. These include 3D design and printing of new building typologies and the use of alternative building materials; and smart sensors for efficient management of water and energy consumption at a household level. South Africa, as a leading country in the world in terms of the delivery of sustainable human settlements, is well poised to be a leading country and a pioneer of the next generation of smart settlements through science, technology and innovation. A conscious effort needs to be made to recognise this as an opportunity to be exploited in a manner that supports and stimulates growth of SMME's and new products.

In order to capture the full value and opportunities presented by the Fourth Industrial Revolution for the sustainable human settlements sector for South Africa, the Department of Science and Innovation (DSI), in partnership with the Council for Scientific and Industrial Research (CSIR) Built Environment and the National Department of Human Settlements, have embarked on a process to define and develop a ten-year Science, Technology and Innovation for Sustainable Human Settlements Roadmap (STI4SHS) as a long-term implementation, investment and transition plan to deliver significant socio-economic impact for South Africa via a coherent and targeted portfolio of STI for human settlements interventions, niches and initiatives that should be implemented in order to attain transformative outcomes spelled out in the SDG11 as we well as the New Urban Agenda.

However, this change will not be attained without altering the established social routines and regulatory regimes and current practices. The whole of "society approach" to smart settlements will only be achieved if policy makers recognise that these three major challenges:

- General lack of innovation uptake and mainstreaming in the housing sector;
- Lack of investment in innovation; and
- Conservatism and less modernised approach to human settlements.

These can only be addressed if space is created for:

- Experimentation with innovation within the policy space.
- Policy instruments for enabling uptake that can be timed-out temporarilyon a small scale as technology demonstration projects.
- Experimental spaces, environments and relaxing normal policy conditions to introduce new technologies.
- Facilitate societal experiments and learning through doing things differently; and
- Innovation governance culture and changing societal attitudes and behaviour, and promote learning new things and unlearning inefficient practices.

Figure 1: Pentagonal map of the STI4SHS Roadmap

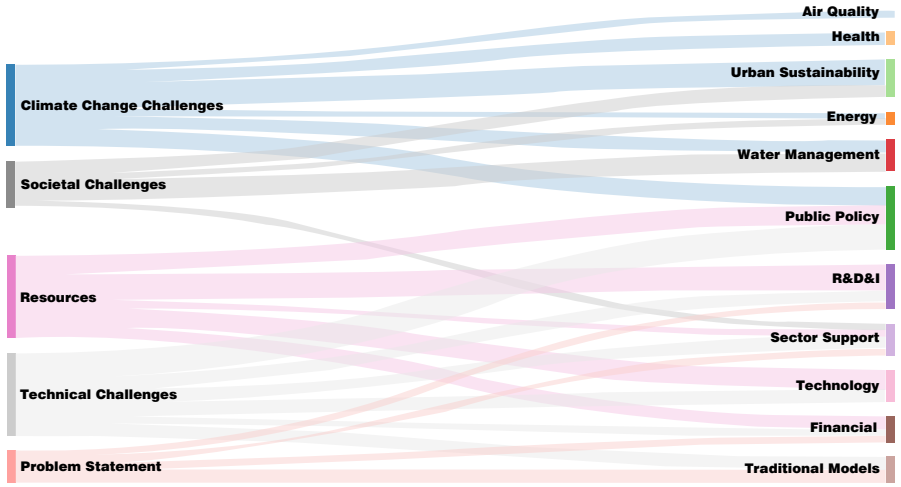

Figure 2: Summary of the problem statements by themes

4. Perspective of the National Department of Human Settlements: Framework for Innovation and Transformative Technologies

4.1. Introduction and Background

The National Department of Human Settlements developed the Innovation and Transformative Technologies for the human settlements sector (I&TT HS) framework which dates as far back as the Medium-term Strategic Framework (MTSF) 2008/9-2013/14 and MTSF 2014/15-2018/19.

The development of the framework has cross-linked various policies and legislations within the human settlements landscape as national commitments and priorities documentation.

Over a period of a decade, from 2009-2019, the I&TT HS Framework had key milestones and activities which culminated in various conferences and round table discussions advocating for opening up the sector to adopt innovations and technologies as depicted by Figure 3 below.

2019 Sept 12
Design of the Social Contract/2019/24 Innovation and Transformative Technologies Chapter of the MTSF for Human Settlements

2019 May 29
Round Table on Innovation and Transformative Technologies consultation of ITTHS Framework

2019
Community of Practice in ITT Launch

2017
Human Settlements Development Summit Commission 4 on Upscaling Innvation and Transformative Technologies: Building Smart Communities

2017
Human Settlements Round Table / 2017 Human Settlements Conference

2011
National Round Table on Innovation Building Technologies / Alternative building Technology Conference

2009
Department of Human Settlements Indaba

Figure 3: Figure showing key milestones of the I&TT HS framework

4.2. I&TT HS Framework

The I&TT HS Framework recognises and seeks to solve problems outlined below:

4.2.1. A lack of ITT policy to guide directionality of technologies to follow a systematic approach as ligned to the priorities of the National Department of Human Settlements (NDHS).

4.2.2. Current human settlements service delivery regimes are strong, and proposed technologies and innovations are perceived to be costly and are thus failing to disrupt or destabilise current socio-technical regime of this sector.

4.2.3. Technological innovations proposed for the human settlements sector are taken as an end in itself and not advanced on a regular basis (at least annually or every two years).

4.2.4. The sustainable human settlements sector has not realised the full potential of the power of innovation and technology in spatial transformation.

The problems identified by the I&TT HS Framework are similar to some identified by the Roadmap in that the I&TT HS also acknowledges the lack of policy to guide the directionality of innovation and technology niches. They both agree that there is lack of co-ordination and alignment of niches in the human settlements sector which leads to silo or island niches which therefore do not take collective advantage as an opportunity for regime destabilisation.

4.3. I&TT HS Enablers

To achieve the envisaged human settlements, the ITT Framework as seen in the below diagram, provides six enabler technological areas for the human settlements sector as adapted from the 2018 White Paper of Science, Technology and Innovation.

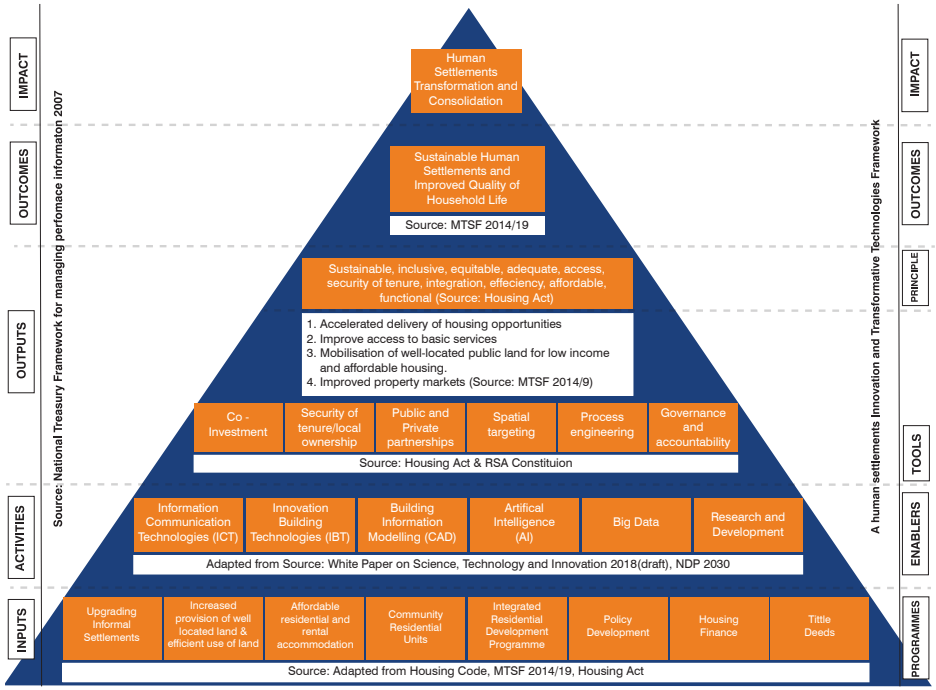

Figure 4: The Structure of the Innovation and Transformation Technologies Framework

4.3.1. Enabler 1: Information Communication Technologies (ICT)

This enabler calls for the use of ICTs in human settlements to generate inclusive, integrated and functional neighbourhoods, with prosperous property markets. ICT will empower people starting with the Informal Settlements Programme through internet-based public participation, hence strengthening the relationship between people and government, businesses, and other people within the human settlements sector.

4.3.2. Enabler 2: Innovation Building Technologies (IBT)

Human settlements developments will use the following methods, processes, materials, and norms and standards for IBT in order to achieve adequate affordable housing:
1. DHS – Red book for design
2. National Home Builders Registration Council (NHBRC) – IBT guidelines

3. SANS 10400-XA (2011) The application of the National Building Regulations Part X: Environmental sustainability
4. Part XA: Energy usage in buildings
5. SANS 10400, Part T deals with fire protection.
6. SANS 10313 (2010) Protection against lightning
7. Agrément SA approved list of building materials

IBT guidelines have been developed by the NHBRC for the Human Settlements sector. All projects that intend to use IBTs must comply with the NHBRC IBT approval process.

4.3.3. Enabler 3: Building Information Modelling (BIM)

The creation of liveable neighbourhoods, functional property markets and adequate housing will use digitised technologies, creating passive design enabled by BIM through various software such as 3D printing, 3D images of the building and the spaces between. All human settlements development plans will be done in two dimensional (2D), three dimensional (3D) and printed in 3D. This enables scenario planning and design in the HS sector. In addition, the sector will pre-diagnose shortfalls in the construction value chain, life in the shelter, and the space between buildings.

4.3.4. Enabler 4: Artificial Intelligence

Human settlements, in the creation of liveable neighbourhoods and adequate housing, will use artificial intelligence such as robots/robotics for the analysis of existing conditions of the population, construction, and drones used for monitoring the construction processes.

4.3.5. Enabler 5: Big Data

Big data, among other things, will analyse the following:

- Areas of urgent housing need where there is an established high demand and low supply of housing opportunities.
- Areas requiring upgrading and/or redevelopment for purposes of delivering housing choices including subsidised housing.
- Areas requiring improved access to infrastructure, amenities and services; and
- Areas that support the integration of different housing typologies, land uses and economic development.

4.3.6. Enabler 6: Research and Development

Research on innovation and transformation building technologies will keep the sector abreast with cutting-edge discoveries ahead to the present information revolution.

4.4. Partnerships for the Innovative and Transformative Technologies for Human Settlements Framework

The STI4SHS Roadmap, as seen in Section F of this document, maps existing niches against their KPIs and also against the transformative outcomes of the Transformative Innovation Policy (TIP). Different to the Roadmap, the I&TT HS framework maps possible niches in the sustainable human settlements sector against possible partnerships, as seen in the tables below. The table shows both alignment and misalignment of these possible initiatives with the transformative outcomes of the TIP and to the Roadmap clusters.

Table 1: Mapping of the current and existing initiatives and partnerships of the I&TTHS

Year/Duration	Sector	Partnership	Leader	Initiative	Transformative Outcome Addressed	Roadmap Cluster/ Pathway
2019-24	ICT	DHS +DEA +WRC	WRC	Water sensitive design	Shielding, Learning	Strategic Projects
			WRC	Sustainable water behaviour	Learning	Culture of Innovation
			WRC	Climate change and weather variability	Learning	Strategic Projects
			WRC	Water quality and health	Learning	Strategic Projects
			WRC	Smart water taps	Shielding, Learning	Strategic Projects
2019-24	Academy	DHS + GIFA + NHBRC+BBC+ WRC	DHS	Establishment of a training academy for innovation building	Learning, Networking	Directed Capability
			NHBRC	National Human Settlements Training Academy	Learning, Networking	Directed Capability
			NHBRC	Operational IBT innovation Technology school at EMHIH	Learning, Networking	Directed Capability
			GIFA	Build Design Academy South Africa	Learning, Networking	Directed Capability
			GIFA	Establishment of Gauteng built environment centre	Learning, Networking	Directed Capability
			WRC	Premiere knowledge hub	Shielding, Learning, Networking	Digitised Enterprise

Year/Duration	Sector	Partnership	Leader	Initiative	Transformative Outcome Addressed	Roadmap Cluster/ Pathway
2019-24	Training	DHS+GIFA+ NHBRC + BBC	DHS	Design and conduct education programmes on owning platforms through I&TT platforms	Learning	Directed Capability
			DEA	Train town planners in the 9 provinces on green buildings	Learning, Networking	Directed Capability
			GIFA	Training of BE professionals on innovation building technologies	Learning, Networking	Directed Capability
			GIFA	Training of municipality BE professionals on innovation building technologies	Learning, Networking	Directed Capability
			GIFA	Training of plans examiners on IBTs	Learning, Networking	Directed Capability
	Training	DHS + NHBRC + BBC	DHS	Training inspectors on IBTs	Learning, Networking	Directed Capability
			DHS	Conduct education programmes on owning a home through I&TT platforms	Learning, Networking	Directed Capability
			DHS	Conduct I&TT-based education	Learning	Directed Capability
			DHS	Design programmes on owning an issue title deed to homeowners within 6 months of occupation	Institutionalisation	Directed Capability
			BBC	Knowledge hubs for BE professionals	Shielding, Networking	Digitised Enterprise
			WRC	Product and industry development		

Year/Duration	Sector	Partnership	Leader	Initiative	Transformative Outcome Addressed	Roadmap Cluster/ Pathway
	Youth	DEA+ WRC + DHS	DEA	Train town-planners in the 9 provinces on green buildings- GIZ funded	Learning	Directed Capability
			WRC	Young Engineers Programme	Shielding	Directed Capability
			DHS	Youth Symposium on Innovation and Transformative Technologies (4IR)	Learning, Networking	Directed Capability
			GIFA	Training of students on IBT	Learning	Directed Capability
			BBC	Establishment of 34 assembly and distribution centres as part of youth entrepreneurship development	Shielding, upscaling	Directed Capability
	Women	DHS + GIFA	GIFA	Design a programme for including women in NDoHS projects	Institutionalisation	Directed Capability
	Research Materials	NHBRC + WRC	NHBRC	Complete construction of an IBT that meets the 'Green First-Zero Energy Model Village'	Technology Pipeline	Technology
			NHBRC	Construction Work Quality and Consumer Satisfaction Index	Institutionalisation	Culture of Innovation
			NHBRC	Exploring ways to provide affordable IBT houses without increasing cost	Upscale	Technology Diffusion
			BBC	Manufacturing Development Plan	-	-
	Big Data	NHBRC + WRC	NHBRC	Dynamic Human Settlements IBT Database	-	Digitised Enterprise
			NHBRC	Highlight neighbourhoods with vital infrastructure and services	-	-
			NHBRC	Research on designs and materials that ensure Green First Zero energy requirements	Learning	Directed Capability

Year/Duration	Sector	Partnership	Leader	Initiative	Transformative Outcome Addressed	Roadmap Cluster/ Pathway
	Research		NHBRC	African Portal on technology and Innovation Solutions	-	Digitised Enterprise
	Village Model	NHBRC + WRC + WC + DHS + BBC	NHBRC	Research on designs and materials that ensure Green First Zero	Learning	Directed Capability
			WRC	Future house with integrated energy systems	-	Strategic Projects
	Big Data, BIM	DHS + SANSA	SANSA	Imagery change monitoring of human settlements	Learning	-
	Policy	NHBRC + WRC + DHS + BBC	DHS	Develop policy on innovation	Institutionalisation	Culture of Innovation
	International Programmes	WRC + DHS + GIFA	GIFA	Develop international student exchange programmes	Learning	Directed Capability
			WRC	Develop a Young Engineers Programme at national level and also as an international exchange programme	Learning	Directed Capability
	R&D manuals/ publications	NHBRC+WRC + DHS	DHS	Roll out of the Red Book	Upscaling	Technology Diffusion
			WRC	Water sensitive design and water planning publication	-	Directed Capability
			GIFA	Produce Manual with prototype subsidy houses for customers to select from, must be accessible online	Expectation Dynamics	Digitised Enterprise

Year/Duration	Sector	Partnership	Leader	Initiative	Transformative Outcome Addressed	Roadmap Cluster/ Pathway
	ICT and AI	NHBRC + WRC+ DHS	WC	Machine-designed houses	-	Strategic Projects
			WC	Develop app for housing allocation/needs	-	Digitised Enterprise
			WRC	Waste water futures	-	Strategic Projects
			WRC	Water sensitive settlements	-	Strategic Projects
			WRC	Water quality futures	-	Strategic Projects
			WRC	Off-grid sanitation	-	Strategic Projects
	R&D Professional Development	GIFA + BBC+ DHS	GIFA	Training of students on IBTs	Learning	Directed Capability
			GIFA	Practical experience (2 weeks/annum) for 4th year students on IBT project construction sites	Learning	Directed Capability
			GIFA	Develop online CPD content on IBTs for universities and BE professionals	Learning	Digitised Enterprise
			BBC	Construction Development Plan (training and licensing of contractors)	Learning	Directed Capability

5. Situational Analysis

5.1. Introduction

5.1.1. Property Sector

The Property Sector Charter Council measured the size of the property market in South Africa at R5.8 trillion in 2016. Formal residential property accounts for nearly three-quarters of property owned in South Africa, and grew from an estimated R3 trillion at the end of 2010 to R3.9 trillion. The total economic contribution to GDP of the residential property sector was R103.7 billion, while it contributed R20.1 billion to the fiscus through various forms of tax in 2012. A telling part of the research is that, whilst informal residential property is quantified by the number of households provided by the Department of Human Settlements, it has been assigned no value.

5.1.2. Gini Coefficient

With a Gini coefficient of 0.63 in 2015, South Africa is one of the most unequal societies in the world. A recent World Bank report indicated that the top 1% of South Africans own 70.9% of the country's wealth while the bottom 60% controls 7% of the country's assets. Africa Check estimated that 30 million people, or 55% of the population of South Africa in 2015, lived on less than R1000/month

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5.1.3. Household Income Expenditure

Existing spatial patterns and poor housing reinforce poverty levels by requiring poorer households to spend a large proportion of their household incomes on travel and basic services. Low-income households spend, on average, 20% of their incomes on transport and 34% on food. Occupants of low-cost housing can also spend as much as 20% of their income on heating in winter and inappropriate heating methods can lead to suspended particulates being well over World Health Organisation health guidelines.

15.8% of South African households had a sub-standard toilet facility.

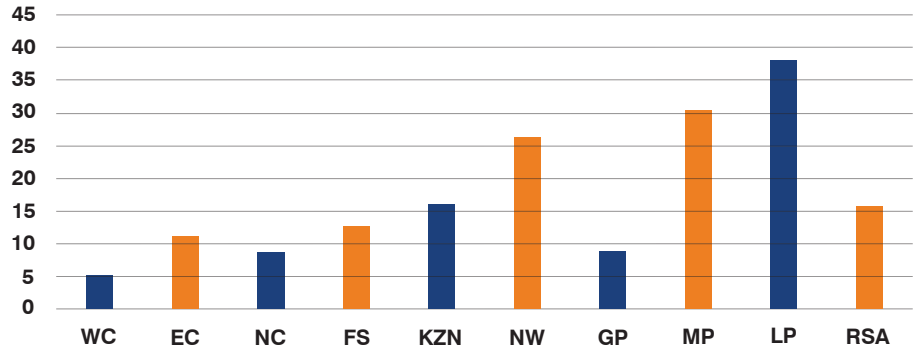


Figure 5: Percentage of households in South Africa with substandard toilet facility (https://sdg-tracker.org/water-and-sanitation)

5.1.4. Electricity

A total of 16% of South African households do not have an electricity connection. In South Africa, human settlements are associated with significant carbon emissions and residential buildings consume 13% of South Africa's energy and generate 25 million tons of carbon dioxide emissions per year. The manufacture of building materials and components, much of it used in new housing, consumes another 5% of South Africa's energy.

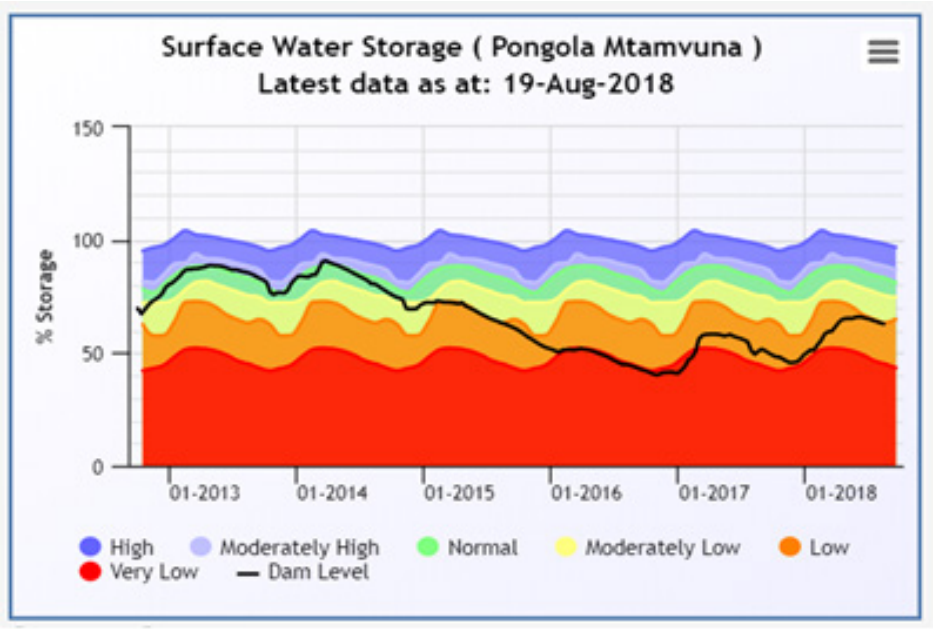
5.1.5. Climate Change

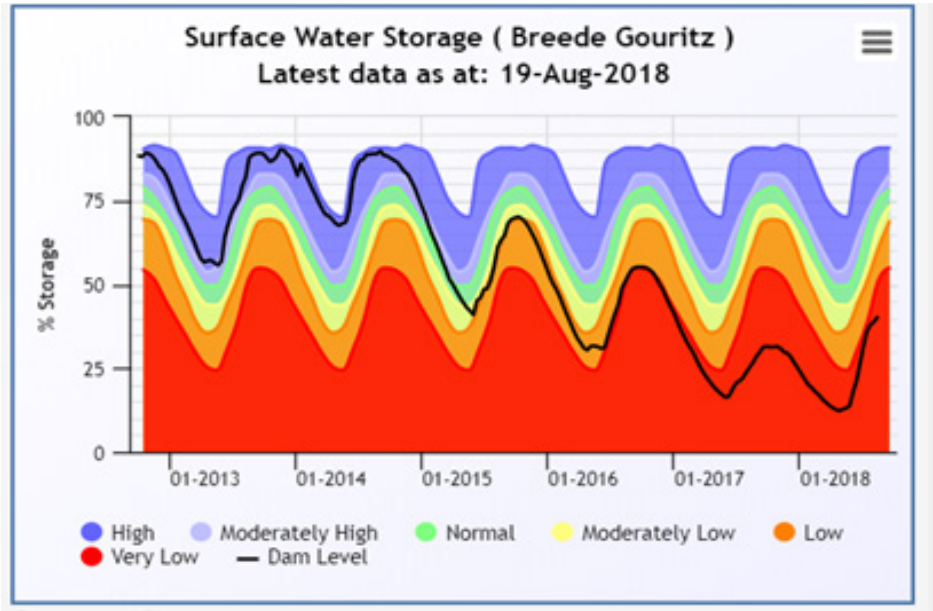
South African human settlements are also vulnerable to climate change. The Department of Water and Sanitation's Water Reconciliation All Town study indicates that water resources in 30% of South Africa's towns are already in deficit. It suggests that water shortages are expected in at least another 15% of South Africa's towns in the next five years, with an additional 12% of towns also suffering shortages in the five years following this, as shown in Figure 4.

5.1.6. *Housing Demand*

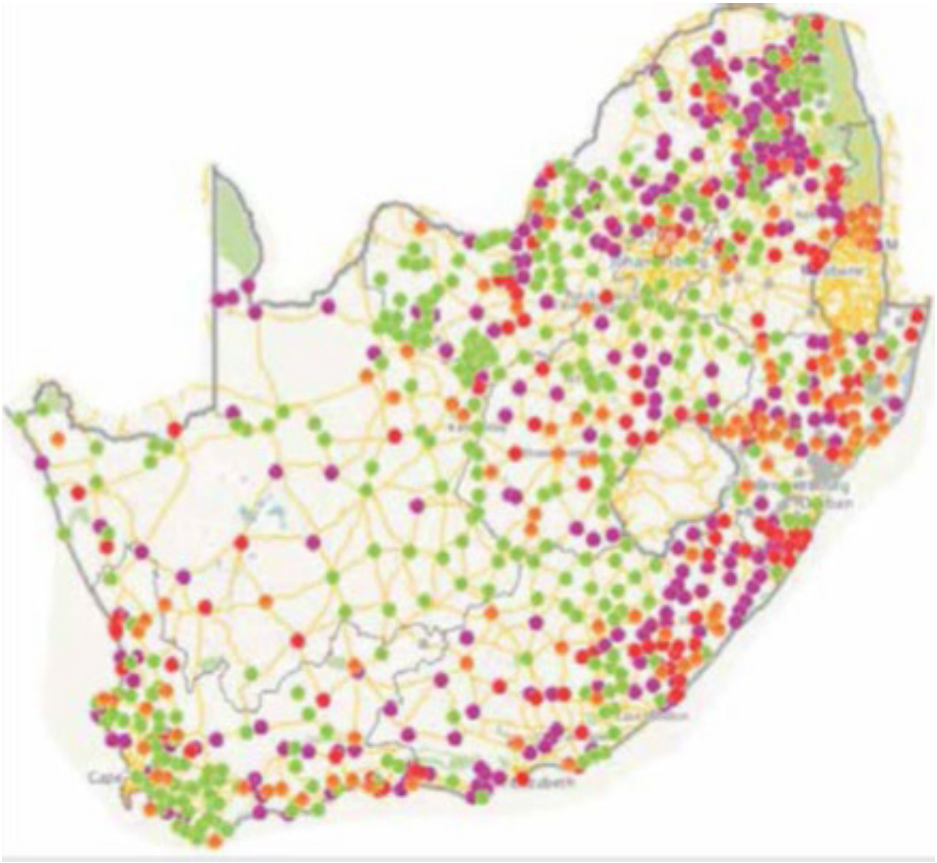
Demand for government-sponsored housing provision in South Africa is increasing. In 1994, backlogs were estimated to be 1.5 million, in 2011, 1.9 million and by 2017, 2.3 million. Yet 4.76 million housing opportunities have been created in the 25 years since the dawn of democracy (DPME 25-year Review, 2019). The cost of addressing housing backlogs by 2020 was estimated to be R800 billion, while the annual budget for 2018/19 for human settlements, including electrification and water programmes, was R56.5 billion. Scaling up programmes to construct housing within budgeted timeframes can also be problematic and in 2018, R600 million made available for new housing went unspent because of delays.

There are, therefore, significant challenges facing human settlements and housing in South Africa. In addressing these challenges, it is important to identify key targets, such as the Sustainable Development Goals, that should be addressed and acknowledge emerging risks, such as climate change. A good understanding of the challenges, goals and risks in South African human settlements can be used to identify appropriate innovative technologies and approaches that may be applied to help address backlogs more rapidly and develop more sustainable human settlements.





LEGEND			
Category		**Count of Towns**	**% of Towns**
	No shortage>10 yrs	334	37%
	Water resource shortage 5-10 yrs	113	12%
	Water resource shortage 1-5 yrs	120	13%
	Water resource current deficit	273	30%
	Unknown	65	7%
	Grand Total	**905**	**100%**



ALL TOWN STUDY	
	Town will be in deficit after 10 years or more
	Town will be in deficit in 5 to 10 years
	Town will be in deficit within 5 years
	Town is currently in deficit
	No data

Figure 6: Water reconciliation across all South African towns

5.2. Status Quo, Mega-trends and Key Drivers for Technology and Innovation Deployment in Sustainable Human Settlements

5.2.1. Introduction

Mega-trends as well as local trends shape the ecosystem of science, technology and innovation in the human settlements sector, and act as barriers or drivers for their mainstreaming. Desktop research identified a set of international mega-trends and local status which characterise current development and influences future trajectories. An electronic survey was performed to determine trends amongst key stakeholders to identify trends, drivers, barriers, gaps and opportunities experienced in the application of STI for sustainable human settlements. Below is a summary of some of these findings.

5.2.2. Mega-trends

Rapid urbanisation: Internationally and locally there are growing city populations, as shown in Figure 7, leading to infrastructure strain, hollowing rural areas and deepening vulnerabilities.

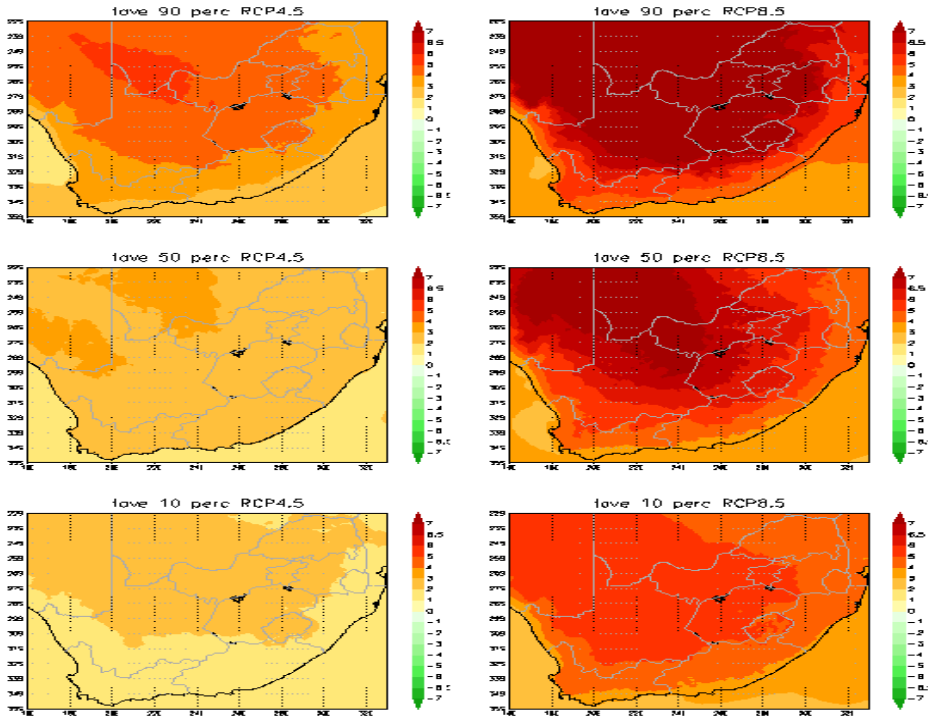


Figure 7: South Africa's climate futures (Englebrecht, 2017)

Climate change and resource scarcity: International pressure to meet commitments, emerging threats to water and food security creates imperatives to build resilience.

Economic shifts: Globalisation and competition for resources.

Demographic and social change: Growth in emerging population, falling fertility rates and rapid increase in ageing populations.

Technology: Generally there is rapid, disruptive technological change with an uneven uptake, new business models and new skills. However, internationally the built environment generally and the residential sectors in particular are slow to adopt new technology. There is a prevalent conservatism in the human settlements sector.

5.2.3. Status Quo of Sustainable Human Settlements

Human settlements planning: Inflexible approaches to housing and neighbourhood development, with a limited responsiveness to achieving enhanced living benefits through innovation.

Housing development processes: Delivery chain inefficiencies as these are paper based not digital, and high dependence on state or subsidy.

Affordability: Slow growth, increasing burden of household costs and continued inequality.

Climate change: Adaptation and mitigation targets and efforts are ill-defined and poorly enforced. The sector is not fully equipped to adjust to climate change disasters.

Alignment with commitments and goals: The Sustainable Development Goals (SDGs), New Urban Agenda (NUA), Integrated Urban Development Framework (IUDF) and National Development Plan (NDP) provide clear measures for making cities and human settlements inclusive, safe, resilient and sustainable by 2030, and are used as a reference in the Roadmap.

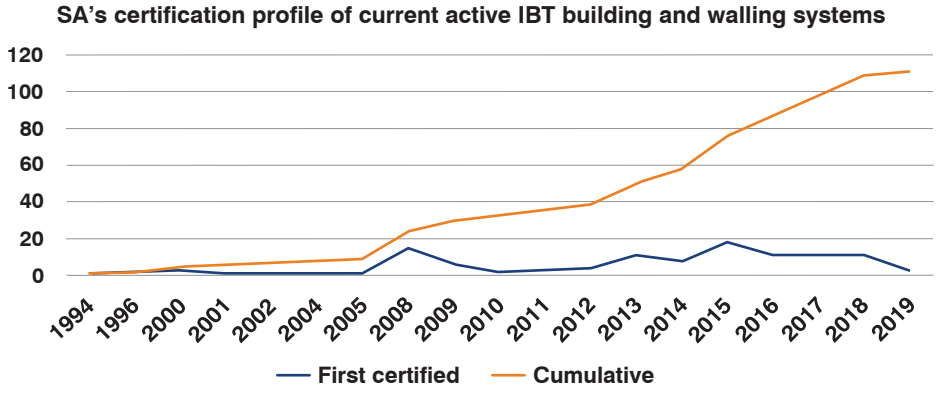


Figure 8: Profile of IBTs and walling systems in SA

5.2.4. State of Maturity of Innovation Patents in Human Settlements

The uptake of innovation in South Africa's human settlement sector appears to be slow, although more complete information is required. Figure 8 above shows the number of Agrément certified (IBT) building and wall systems in the past 25 years. Growth is as a result of accumulation of certificate-holders in the market, rather than an accelerating rate of certification. Furthermore the pipeline of innovation is weak, with high market exit rates (as indicated by certification lapse rates in excess of 30% and very low local patent registration).

5.2.5. Barriers for Innovation Uptake in the Human Settlements Sector

A number of barriers and capabilities and enablers were identified through desktop research and confirmed and ranked by means of an electronic survey. Herewith is a summary of the findings:

- **Skills and knowledge:** Specifiers and end-users may not know what the technology offers, or may not have the skills (or confidence) needed to specify or implement it.
- **Policy and regulatory framework:** A new technology may not fit with existing regulations and policies; policies can be a disincentive to investment in new technology.
- **Infrastructure and maintenance factors:** The infrastructure for delivering the product and/or spare parts is inadequate; or a maintenance network does not exist.
- **Investment factors:** Lack of access to capital, market uncertainty and risk aversion can lead to underinvestment in production capacity and scale up, so the technology cannot benefit from economies of scale and therefore cannot compete.
- **Undesirable social and/or environmental effects:** Technologies intended to solve one problem may introduce new ones.
- **Technological factors:** The technology performs poorly, is unproven, or lacks complementary technologies needed to make it effective.
- **Cultural and perception factors:** End-users may reject technologies perceived to undermine values and preferences.

5.2.6. Policy and Regulatory Environment

The institutional and policy environment that governs the regulation of new built environment technologies in South Africa is strong. State financing and procurement models for housing delivery are based on single storey, free-hold, brick and mortar typology. Access to financial and technical support may be limited for some innovators, and is a barrier to upscaling. There is generally poor awareness and low confidence in utilisation of innovative technologies in housing and human settlements in private sector, government and recipient communities and consequently uptake is constrained.

5.2.7. Human Capital Development (HCD)

The current landscape of investment and research interest in human capacity development (HCD) mapping shows a major gap and underinvestment in HCD activities focussed on science, technology and engineering for human settlements.

6. Strategic Objectives of the Roadmap

The following three strategic objectives underpin thie Science, Technology and Innovation for Sustainable Human Settlements Roadmap:

(1) To help stimulate and guide investments on the STI initiatives and innovations and technology products for the South African human settlements sector in a manner that unlocks and support SMME opportunities in the sector, through the participation of academia, research institutions, business and government departments;

(2) to facilitate a significant increase in STI investments towards smart and green human settlements and the uptake of innovative technologies for the sector; and

(3) to provide a framework for informed decision-making with respect to choices of strategic and thematic niches and initiatives for the human settlements sector transition to smart settlements and identify associated and required investments in innovation and technology product development and deployment.

The successful definition of the STI for Sustainable Human Settlements Roadmap was gained through an extensive consultation process with the human settlements sector stakeholders. Upon delivery of the STI4SHS Roadmap, key innovation priorities and strategic niches that have a direct impact in transforming the sustainable human settlements socio-technical system were identified and would be considered for funding for the implementation through multi-stakeholder investment effort and co-ordination with relevant sector stakeholders. These include in particular the Department of Science and Innovation and the National Department of Human Settlements; the provincial implementing departments, municipalities and sector entities; the business sector; regulatory bodies; NGOs and academic institutions as members of the smart and innovative human settlements actor network.

SECTION B:

TRANSFORMATIVE INNOVATION POLICY AND SUSTAINABLE HUMAN SETTLEMENTS

7. Transformative Innovation Policy as a Theoretical Framework Underpinning the STI4SHS Roadmap

7.1. Introduction

7.1.1. The Transformative Innovation Policy and the Multi-level Perspective

The STI4SHS Roadmap uses the Multilevel Perspective framework as a theoretical basis which acts as a lense to closely analyse and understand the nature of actor relationships within the human settlements sector.

The MLP framework is rooted in the Transformative Innovation Policy which is a theory that takes from the emerging frame of Innovation Policy for Transformative Change, also known as the Innovation Policy's Third Frame of Thinking.

The main argument of the TIP (as in the emerging frame) states the need for current socio-technical systems used for the delivery of societal services as mobility, transport, energy, healthcare, food education, housing etc., to transition to sustainability. Socio-technical systems, from the Socio-technical Theory, can be defined as an interaction between the people and technology, machines and other technical aspects. It is an approach that looks at people's interaction with complex infrastructures used for service delivery and how human behaviour has 'learnt' to interact with these.
TIP also observes that current regimes are very strong. Both the concepts of regimes and socio-technical systems are revisited and contextualised to South African human settlements as studies in the STI4SHS Roadmap.

7.2. Transformative Innovation Policy : Principles, Modes, Processes and Outcomes

The TIP is built on six principles: i) directionality, ii) societal goal, iii) system-level impact, iv) learning and reflexivity, v) conflict and consensus, and vi) inclusiveness.

Since the TIP is an exploratory concept, it encourages experimentation in the form of engagements to test the fit, consistency and validity of its work. The concept offers a summary of five modes which serve as the different forms of experimentation engagements (EPEs). The STI4SHS Roadmap, as an independent EPE fits partly as Mode 1 and Mode 4. It is not a perfect fit of either. Mode 1's focus is on formulation, calibration and the justification of policy while Mode 4 deals with supporting, connecting and the evaluation of existing societal experiments.

The current roadmap, in its fit trial for Mode 4, only packages existing niches or societal experiments to support decision making in the channeling of funds for support. It does not necessarily promote learning between experiments nor does it support the development of networks, per se, as suggested by the Mode. On the other hand, its partial fit on Mode 1 is covered by its need to influence formulation and/or calibration of policy which will support the relaxation of selection environments in the current regimes of the human settlements sector.

Further to the principles and modes, the TIP categorises the different transformative processes into three, each with four possible outcomes as seen in text illustrations below. The STI4SHS Roadmap, again, does not follow one process, as the theory assumes, but follows all three processes with selected (highlighted) anticipated outcomes, further discussed below.

Figure 9: Transformative processes and their outcomes

The STI4SHS Roadmap is itself a niche acting as a protective space which shields other niche innovations of the human settlements sector. It also broadens and deepens learning at a high level, where the Roadmap niche constructors gain in-depth knowledge of the sector's socio-technical systems, nature of regime selective environments and the shelved innovations which struggle to disrupt these current regimes (P1, Outcomes 1 and 2). The Roadmap also selects promising innovations which can be prioritised for support through funding, which would empower the innovations interaction with regimes (Process 3, Outcome 3) to possibly cause disalignment or disruptive changes in current sub-systems and regimes (Process 3, Outcome 1). The support through funding will also assist in the broadening and deepening of the upscaling of the innovation (Process 2, Outcome 1). Networks between stakeholders were also created, broadened and in some cases deepened through the stakeholder engagements, consultative workshops, academic conferences, expert consultations and technology showcases that have been held in the planning or formulation of the roadmap (Process 1: Outcome 3). Lastly, the STI4SHS Roadmap has policy implications as it seeks to enhance a culture of innovation in government departments and possibly influence policy though creating new formal and informal rules which would be institutionalised (Process 4, Outcome 4).

7.3. The Multi-level Perspective (MLP) of the Sustainable Human Settlements Sector

The MLP is a non-linear framework for the analysis of the socio-technical systems' dynamics as they transition to sustainability, at large scales and over long-term shifts (Geels, 2002; 2011). The basic components making up the multi-level framework are niches, regimes and the landscape as seen in Figure 9 with examples from the South African human settlements. The most important novel insight of MLP is that a transition of any socio-technical system results from the interaction of events at all micro-, meso- and macro-levels termed Niches, Regime and the Landscape, respectively.

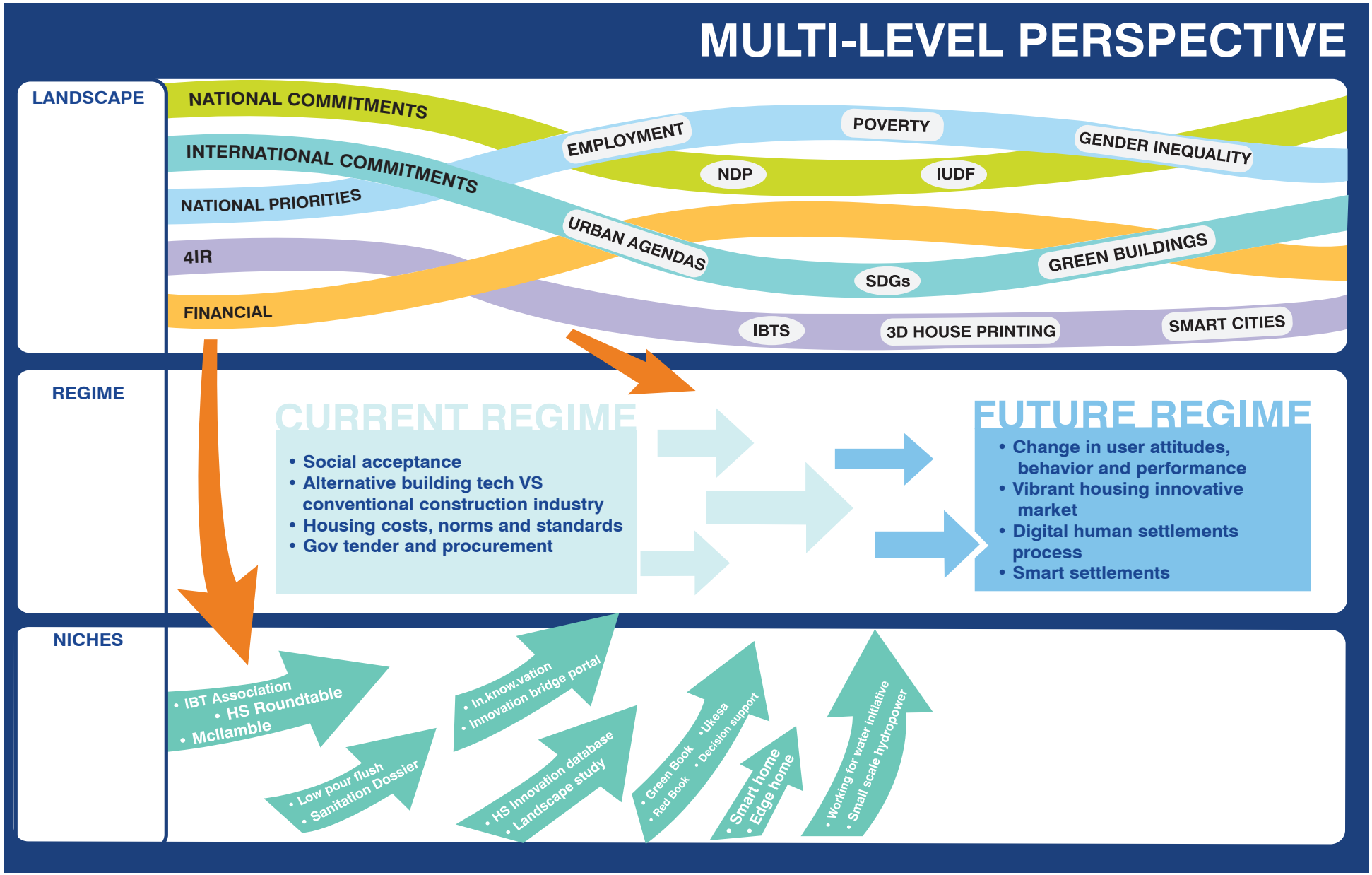


Figure 10: MLP contextualised to South African human settlements

7.4. Micro-level: Sustainable Human Settlements Niches

Niches are novelties that are outside or on the fringes of incumbent regimes. Niche technologies can be defined as 'hopeful monstrosities' (Mokyr, 1990): Promising in potential, meagre in performance i.e. technology demonstrations and various individual initiatives that seek to bring about new behaviours and practices. For this reason niche technologies often need to be protected from pressures exerted by the incumbent socio-technical regimes until they have become mature enough to enter the market. A principle adopted by the Roadmap is that various niches need to be amplified and nurtured to lead to transformative change of the sector though upscaling such niches, opening up new regime actors etc. These are influenced by landscape pressures and are the reason behind observed changes in systems. The STI4SHS Roadmap has identified over 20 niche innovations (Figure 10) within the space of human settlements in South Africa.

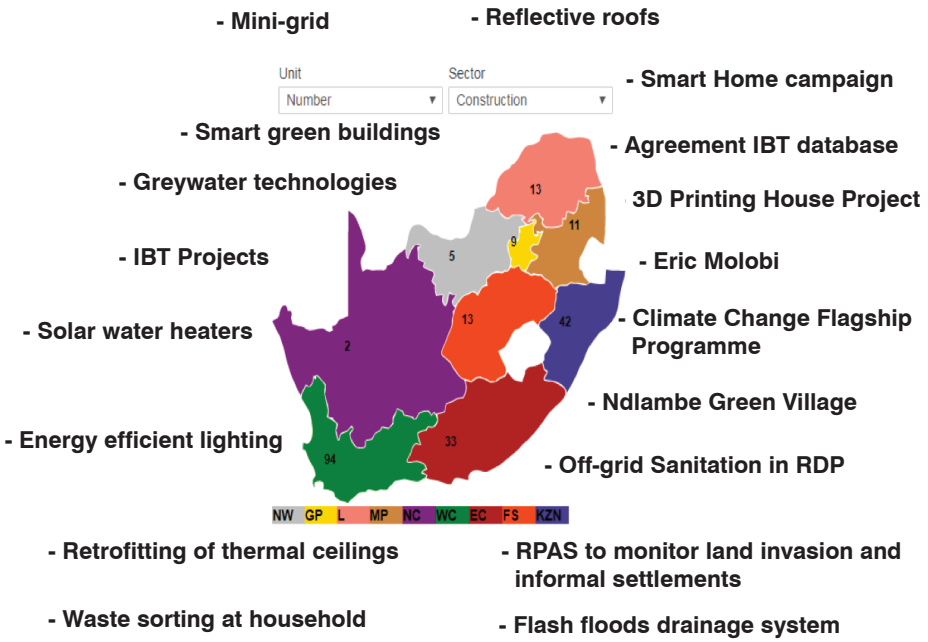


Figure 11: Some SA human settlements niche innovations

7.5. Meso-level: Sustainable Human Settlements Regimes

Regimes can be defined as shared, stable and aligned sets of rules or routines directing the behaviour of actors on how to produce, regulate and deliver human settlements and housing such as construction methods, building norms and standards, housing specification, infrastructure and services. These rules are embedded in the various elements of the sustainable human settlements socio-technical system and they shape how innovation activities are adopted and/or not adopted to transform the current system of housing delivery. Regimes are made of selection environments of policies, standards, regulations, markets, science, technology, culture and user preferences. Figure 11 depicts some of the elements that the current incumbent regimes of the South African human settlements consists of.

CURRENT REGIME	PATHWAYS	NEW REGIME/ ENVISAGED REGIME
Social acceptance and culture	Technology Pipeline	Housing technologies that are vetted
User preferences	Strategic Project; Technology Pipeline	Vibrant pipeline of technologies for smart settlements
Alternative building technologies vs conventional	Strategic Projects	Resilient human settlements
USDG allocation for innovation	Strategic Projects	Using innovation i.e. green buildings
Contractor-driven market using conventional methods	Culture of Innovation	Funding of technologies and innovations for human settlements
Government tender and procurement for housing	Culture of Innovation	Innovation buyers
National housing regulations i.e. NHBRC	Culture of Innovation	A change in user attitudes, behaviour and preferences
National housing code, norms and standards	Technology Pipeline & Technology Diffusion	Vibrant housing market
Procurement and tender specifications	Technology Diffusion	Increase in innovative building technologies in the sector
Static innovation policies	Digital Enterprise	Digitised human settlements process
Anti-innovation sector policies	Strategic Projects	Smart settlements
Monopolised housing market		

Figure 12: Figure showing current regimes, envisaged regimes and their possible pathways

Transformative change and transition for the sustainable human settlements sector through innovation is about a change of collective rules and practices embedded in the socio-technical system. The change of the human settlements socio-technical systems as advocated for in this STI4SHS Roadmap requires the configuration of actors, technologies and institutions and social attitude towards the new technologies and innovations that can improve human settlements and the living environment broadly moving from the old sustainable human settlements socio-technical regimes to the new envisaged regimes.

The STI4SHS Roadmap has not only identified the current and envisaged regimes, it has also defined the pathways most suitable for arriving at them. Figure 9 illustrates the pathways required to realise envisaged regimes. It also shows a disconnect between the envisaged new regime and the current regime which shows that the definition process of the new regime definition was non-continuous and independent.

7.6. Macro-level: Sustainable Human Settlements Landscape

The concept of landscape refers to the exogenous environment shaping both niches and regimes. Landscape pressures involve trends such as globalisation, urbanisation and climate change, but also events such as droughts, disasters, and technology mega-trends such as robotics, Fourth Industrial Revolution, and Internet of Things (IoT). This varied set of factors can be combined in a single 'landscape' category, because they form an external context that niche and regime actors cannot influence – at least in the short run. The Roadmap in context has listed landscape pressures as the NDP, urban agenda, poverty, smart cities and lack of funds as some which appear at various categories of the landscape as seen in the SA Human Settlements MLP (Figure 7).

7.7. Multi-level Perspective Transitions Phases

A transition typically proceeds in three phases. In the first, start-up phase, landscape pressures may exacerbate the internal problems of the regime thus creating a window of opportunity for niche technologies. For example, in the second half of the nineteenth century, increasing urbanisation intensified the problems with the horse-drawn carriage regime, including the high cost and low speed of horses or the amount of manure in the streets, facilitating the emergence of niche technologies such as bicycles, trams and automobiles.

In the second, acceleration phase, niches expand, attract more users and become mainstream, and markets start to compete with the incumbent regime and other niches for dominance. As new technologies diffuse the accompanying rule-sets are redefined. In the case of urban transport transition horse-drawn carriages, bicycles, electric trams, steam trams, electric cars, steam cars and gasoline cars all came to compete against each other for decades until the automobile regime finally established itself as the dominant one.

In the third, stabilisation phase, the number of actors is high, the technology itself matures and the guiding rules are relatively stable, meaning that the former niche has established itself as a new regime. This allows for a sharp increase in adoption as the regime now provides a ready-made 'template' for largely routinised user behaviour. For example, the dominant practices of car use in the USA had been defined by interwar users whereas the post-war adoption, while much more extensive in terms of the number of adopters, was largely based on imitative learning.

One of the key findings of MLP is that transitions can occur through various pathways, depending on the intensity of landscape pressure, the resilience of the dominant regime and the maturity of the niches (Geels and Schot, 2010). For example, if the landscape pressure is relatively intense whereas the niche technologies have not matured enough, intense competition between various solutions follows – this is what happened in the case of US urban transport transition. However, if niche technologies are mature a relatively quick technological substitution might follow as evidenced in the shift from sailing ships to steamers (Geels, 2002). Conversely, the lack of sufficient landscape pressure or a high degree of regime resilience may result in no transition or a failed transition (Geels and Schot, 2007, 2010; Wells and Nieuwenhuis, 2012). The MLP thus provides a nuanced analytical vocabulary for explaining not only whether transitions occur but how they do so in individual socio-technical systems.

The resulting additions to MLP have made it clear that the process of transition is far from a moderate and rational consensus-oriented debate about best solutions to clearly defined problems; instead it is rife with struggles between regime-actors and niche-actors with conflicting interests, differing time- scales, problem definitions and perceived best courses of action.

7.8. Sustainable Human Settlements: Socio-technical Systems

Sustainable human settlements is a multi-disciplinary sector that is not limited to the scale of households and neighbourhoods, whilst recognising the multi-sectoral and transdisciplinary nature of the sector. When defining sustainable human settlements, there is a variety of other socio-technical systems that may be interrelated but all feed into sustainable human settlements which can be categorised as environment, services, livelihoods etc.

This sector includes the provision of housing, water, electricity, sanitation, safe and reliable public transport, quality education and skills development, safety and security, quality health care, social protection, employment, recreation and leisure, clean environment, and adequate nutrition. In this context the sustainable human settlements socio-technical systems as depicted in Figure 12 below is influenced by other socio-technical systems and regimes. Some socio-technical systems that impact on the sustainable human settlements sector as depicted below, are not exhaustive.

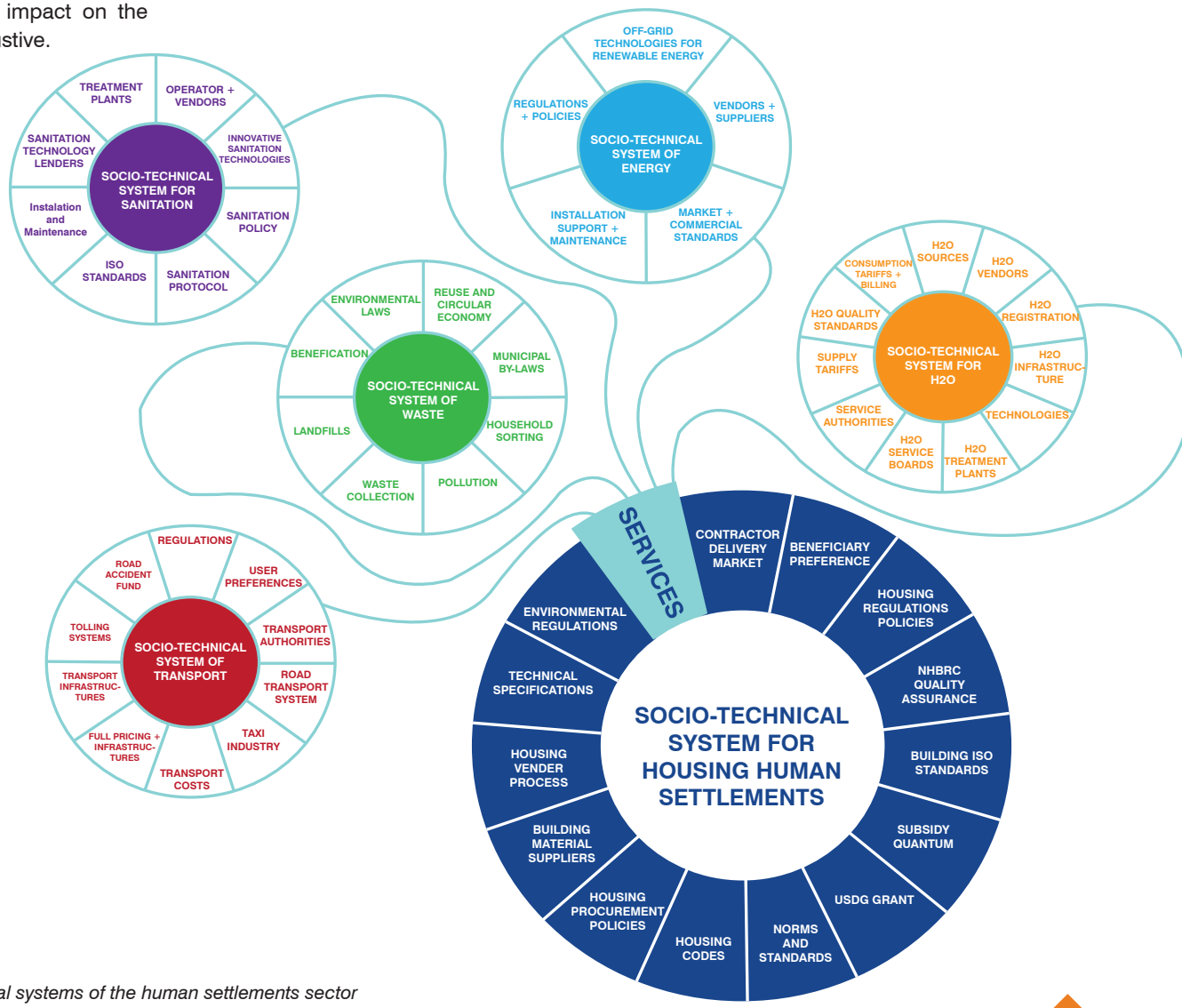


Figure 13: Socio-technical systems of the human settlements sector

Transformative change and transition for the sustainable human settlements sector through innovation is about a change of collective rules and practices embedded in the socio-technical system. The change of the human settlements socio-technical systems as advocated for in the STI4SHS Roadmap requires the configuration of actors, technologies and institutions, and social attitude towards the new technologies and innovations that can improve human settlements and the living environment by broadly moving from the old sustainable human settlements socio-technical systems to the new-socio technical system.

SECTION C:

METHODOLOGY AND APPROACH

Below is a cartoon diagram of the STI4SHS Roadmap definition process, activities, tasks and work packages showing the process followed and interdependencies of various activities/ tasks and underlying in particular the fact that some core activities like stakeholder consultative workshops to gather information and the design reports that were used to gather information required for the development of Roadmap. In each activity, feedback and input gathered were compiled into reports which were later validated by the Roadmap Steering Committee prior to such reports being consolidated into the Roadmap and released in the data repository platform.

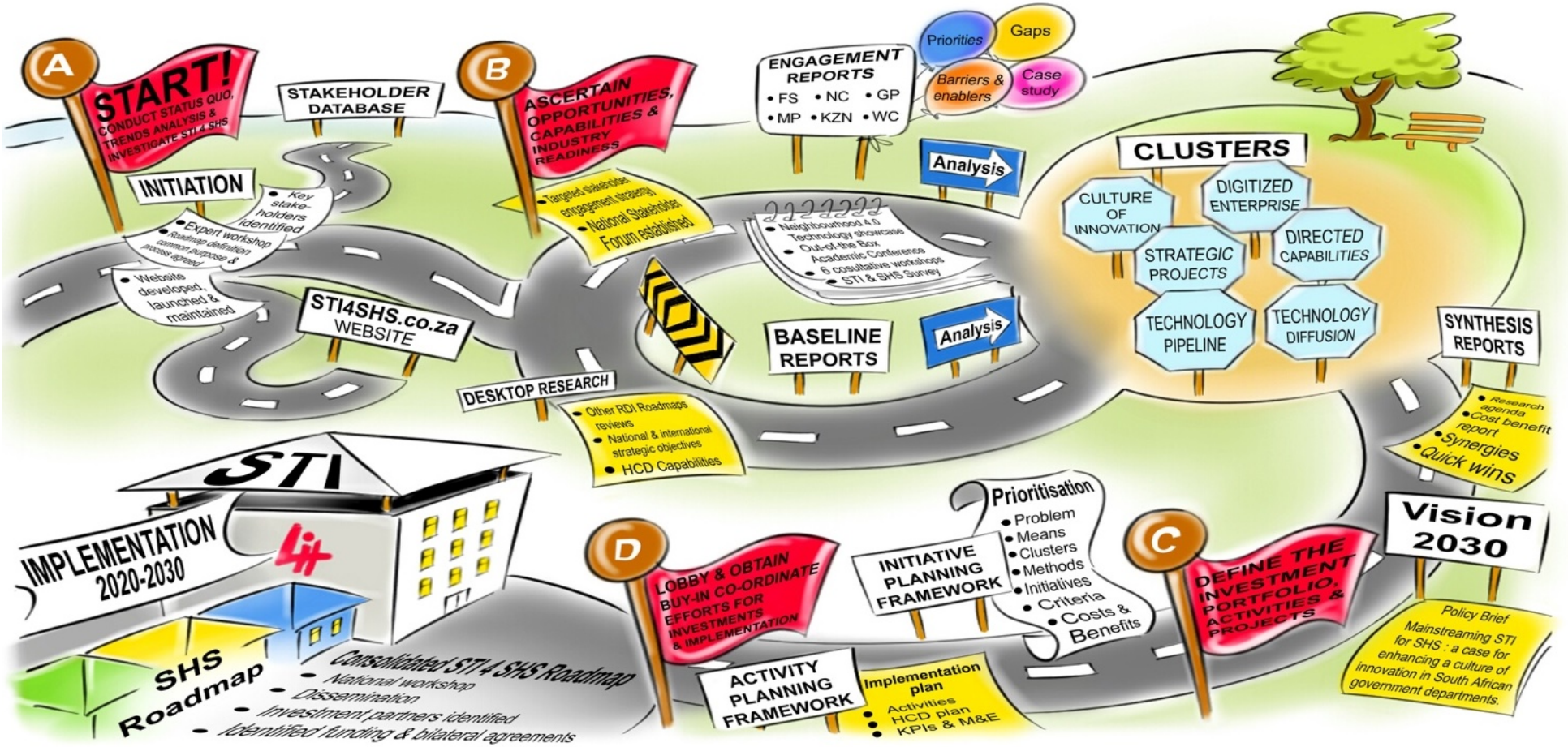


Figure 14: Pictorial summary of the Roadmap

8. The Roadmapping Process

8.1. STI4SHS Roadmap: Deliverables During the Road Mapping Process

Deliverables of the Roadmap definition process are briefly described below. The process of the Roadmap definition was through a wide stakeholder consultation process and various iterative processes which involved desktop research, compilation of databases, consultative workshops and administering of survey questionnaires to collect data. Furthermore, a review of other existing Roadmaps and processes followed in defining other roadmaps provided lessons learnt for the STI4SHS road mapping experience. Amongst the many activities undertaken the following milestones were important building blocks in the definition of the STI4SHS Roadmap:

1) Website and data repository;
2) Desktop and trends analysis;
3) Roadmap reviews;
4) Survey questionnaires;
5) Status quo report;
6) Stakeholder consultative workshops;
7) Human capital development and
8) Cost benefit assessment etc.
9) Synthesis Report
10) STI4SHS Forum

Each of the important building blocks for the STI4SHS Roadmap us defined briefly in the diagrams below:

1. WEBSITE AND DATA RESPOSITORY

PURPOSE:
To establish a web-presence and a platform for data respository.

HIGHLIGHTS:
- National STI4SHS Forum established
- Roadmap events
- Registration handled online
- Many roadmap documents shared online

WEBSITE:
A STI4SHS Roadmap website was established in July 2018, as a temporary collaboration site for the Roadmap definition phase. It has been updated and maintained continuously since.

The website was established to:
- Host the National STI4SHS Forum
- Established a platform for stakeholder registration
- Allow collaboration between project partners
- Provide a platform for engagement for the duration of the Roadmap definition
- Update key stakeholders on progress of the Roadmap
- Publish selected Roadmap outputs
- Advertise public events

OUTPUTS: www.sti4shs.co.za | Website traffic report

2. DESKTOP REVIEW AND TRENDS ANALYSIS

PURPOSE:
To assess and review local and international technology trends in human settlements.

HIGHLIGHTS:
- Patent Landscape on Energy
- Patent Landscape on Waste
- Patent Landscape on Water
- Patent Landscape on Buildings

DESKTOP REVIEW TRENDS REPORT:
Mega-trends as well as local trends shape the ecosystem of science, technology and innovation in the human settlements sector, and act as barriers or drivers for their mainstreaming were analysed.

A rapid desktop review was undertaken of innovation trends, and national and international strategic objectives Key findings:
- **Rapid urbanisation:** Internationally and locally there are growing city populations, leading to infrastructure strain, hollowing rural areas and deepening vulnerabilities.
- **Climate change and resource scarcity:** International pressure to meet commitments, emerging threats to water and food security, imperatives to build resilience.
- **Economic shifts:** Globalization and competition for resources.
- **Demographic and social change:** Growth in emerging population, falling fertility rates and rapid increase in ageing population.
- Technology: Generally there is rapid, disruptive technological change with an uneven uptake, new business models and new skills. However, internationally the built environment generally and the residential sectors in particular are slow to adopy new technology. There is a prevalent conservatism in the human settlement sector.

3. ROADMAP REVIEWS

PURPOSE:
To extract lessons from preceding Research, Development and Innovation (RDI) Roadmaps.

Roadmaps reviewed:
- National Water RDI Roadmap
- Solar Energy Technology Roadmap
- ICT RDI Roadmap
- Waste RDI Roadmaps

ROADMAP REVIEW REPORT:
Technology roadmaps are artefacts - generally graphical representations - summarising entire strategies, underpinned by various supporting activities, analyses and documentation, which are created as technology to market planning tools.

Technology roadmapping refers to one of a number of systematic techniques developed for the purpose of assessing the current state of a technology (or need), envisioning a future preferred state, and identifying the technologies, innovations and capabilities and the necessary “ingredient” to reach that state over time. A desktop and key informant interview study was made of precedent Roadmaps. A descriptive and compartive report was prepared discussing key findings in terms of :

- Theoretical concepts
- Strategic intent
- Methodology
- Stakeholders
- Process
- Implementation

4. SURVEY QUESTIONNAIRE

PURPOSE:
Voice of the Stakeholders and Industry players

PARTICIPATION:
Number of users (population size): N=292
Number of responses: N=51
Response rate=17%

Sector representation:

- Industry (12%)
- Academia (10%)
- Local government (6%)
- Other/ unclassified (59%)

SURVEY QUESTIONNAIRE:
Stakeholders involved or interested in STI in the human settlements sector, were invited to participated in a voluntary electronic survey. The data gathered was anaylsed to determine trends and drivers, barriers, gaps and opportunities experienced in the application of STI for SHS.

The following is a summary of the barriers found ranked from most to least:

- Skills and knowledge
- Policy and regulatory framework
- Infrastructure and maintenance factors
- Investment factors
- Undesirable social and/or environmental effects
- Technological factors
- Cultural and perception factors

5. STATUS QUO REPORT

PURPOSE:
To document the baseline condition and identity opportunities for innovation.

PROBLEM STATEMENT:

- **Housing backlogs** of 2.3 million units and growing
- Apartheid spatial legacy, settlement quality and rising utility costs **erode quality of life**
- Lack of **investment** in innovation
- Conservative and silo approach to human settlements
- Lack of a credible **evidence-based** to support decision making

STATUS QUO REPORT:
A Status Quo Report was prepared to describe the South African context within which human settlements must be delivered. This specifically focusses on pain points and an analysis if existing systems, regulations, drivers of innovation uptake.
Key findings:

- Steady increases in IP investment in all sub-sectors reviewed, with a major increase in waste sector.
- High withdrawal rates (abandonment, lapse and/or expiration of patents) especially houses/homes.
- No patented R&D located in the sub-Saharan African in energy sub-sector, very low in other sub-sectors.
- Very low rates of patent protection in sub-Saharan African for all sub-sectors.

6. STAKEHOLDER CONSULTATIVE WORKSHOPS

PURPOSE:
Voice of the Customer.

HIGHLIGHTS:
- Industry-meets-science-meets-government
- Satellite sessions with academia at SASUF, and
- Out-of-the-Box Conference

CONSULTATIVE WORKSHOPS:
The purpose of the workshops was to reflect on the current state of technology in human settlements, envision a future preferred state, and identify the technologies, innovations and capabilities and the necessary "ingredients"to reach that state over time. Numerous engagements were held to ensure that a diversity of views were considered.
Reports are available for Consultative Workshops:

- Free State
- Gauteng
- KwaZulu-Natal
- Mpumalanga
- Northern Cape
- Western Cape
- National Expert Workshop
- Mainstreaming STI in residential buildings in SA - Case Study

Industry was engaged at a showcase event titled *"NEIGHBOURHOOD 4.0; Off-the-wall* Technology Showcase.

Academia was engaged at the Out-of-the-box Academic Conference. All power point presentations are from the website. (Also see dissemination...for formal proceedings.

7. HCD ASSESSMENT

PURPOSE:
Assess and review existing human captial development baseline and priorities.

TAKEN INTO ACCOUNT:
- National Skills Development Plan
- DSTs White Paper on STI
- Input by Academic Advisory panel
- Input by Ministerial Academic Chairs in Human Settlements

HCD AND STI PRIORITIES REPORT:
A mapping exercise was undertaken to determine current capabilities of South African universities, science councils and agencies regarding Science, Technology and Innovation (STI) which can be applied in the field of, and in pursuit of sustainable human settlements (SHS). The report reflects on the Human Capital Development (HCD) and STI priorities for SHS, current capacity, and maturity.

From the analysis of international and local trends and needs, the report proposes a draft research agenda in order to structure, coordinate and orientate local, regional, and global research activities and mobilise partnerships. The research agenda proposes 8 key themes, and a number of priority and emerging topics as follows:
- Environmental sustainability
- The fourth industruil revolution
- Innovative building technologies and constructuing methods
- Improved living and health conditions in a household
- Smart ICT
- Culture, social acceptances and community involvement
- Models and policy innovation
- Preparing the next generation of STI4SHS researches and entrepreneurs.

8. COST-BENEFIT ASSESSMENT

PURPOSE:
To provide a transparant, systematic approach to evaluating elements of an investment or initiative.

HIGHLIGHTS:
Template allows the user to record risk mitigation and appetite.

COST-BENEFIT ANALYSIS:
“Cost-benefit analysis” is defined as any quantitative analysis performed to establish whether the present value of benefits of a given project exceeds the present value of costs. In the context of the STI4SHS Roadmap, the purpose of a cost-benefit anaylsis is evaluate the proposed initiatives and activities to satisfy the roadmap implementers and it’s stakeholders that a net positive effect is capable of being achieved, that the costs associated are acceptable and can be accommodated and that it justifies the proposed investment.

A cost benefit anaylsis report and template have been prepared, describing the criteria and approach taken, with the following structure:

- Economic benefits and costs
- Environmental harms
- Social benefits and costs

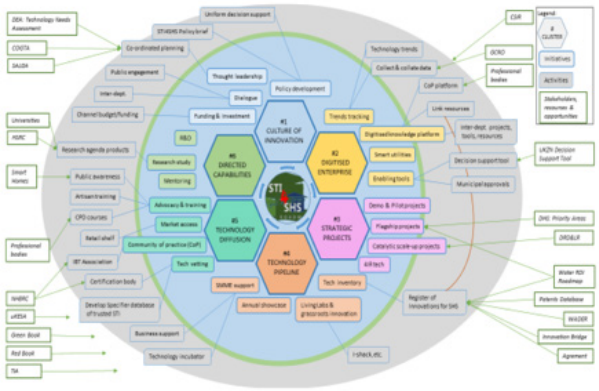
9. SYNTHESIS REPORT

PURPOSE:
To establish and document opportunities and synergies for the implementation phase of the Roadmap.

TAKES INTO ACCOUNT:

- Multi-stakeholder input
- The innovation and Transformative Framework for the Human Settlements Sector
- Priority Housing Development Areas
- Innovations Roundtable
- Quick wins

SYNTHESIS REPORT:
A mapping excercise was undertaken to reflect on commitments, priorities and opportunities which can be leveraged through the STI4SHS Roadmap, and to identify potential synergies and procedures for the Roadmap to align with pre-existing initiatives, activities, resources and opportunities as well as priorities and commitments.



10. STI4SHS

PURPOSE:
To stimulate participation

CHALLENGES:
- Low participation and response rates at “ground level”.
- Challenges in coordinating schedules of key players.

HOWEVER:
Generous and constructive input and meaningful engagements over 500 stakeholders contributed to the Roadmap definition.

ESTABLISH AN STI4SHS FORUM:
To ensure meaningful participation by a representative range of stakeholders in the Roadmap definition and establish lasting partnerships for implementation an STI4SHS Forum was setup.

Terms of reference were prepared to provide guidelines for the functioning of National stakeholder Forum for STI4SHS and it’s Steering Committee, set out roles and responsibilities and matters attendant thereto. Agendas, minutes, and attendance registers have been maintained for:

- Steering Committee meetings (x2)
- Monthly Planning Committee meetings (x11)
- Intensive engagement at numerous working group and expert focus group meetings
- Additional ad-hoc meetings with overlapping agendas with key stakeholders such as:
  - 25 year review (DPME)
  - DHS Innovation Roundtable
  - DEA Flagship
  - DHS Community of Practice
  - SASUF
- And inputs from academia via a modified Delphi method

SECTION D:

THE TEN-YEAR STI4SHS ROADMAP PORTFOLIO OF CLUSTERS, INITIATIVES AND ACTIVITIES

9. Introduction

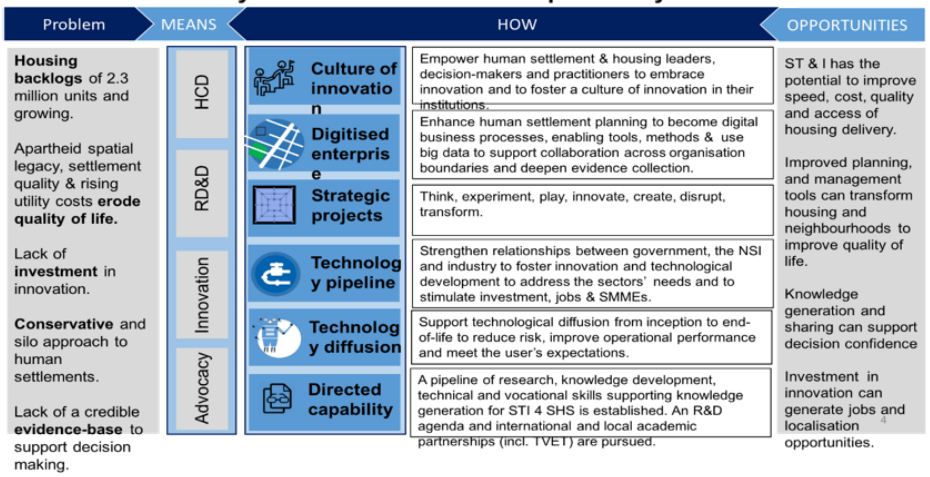
An extensive desktop status quo and trends research, and key inputs from intensive stakeholder engagement and expert consultation, resulted in a scoping and topical prioritisation for work that should be carried out in the next ten years to drive technology and innovation uptake in human settlements. This process identified niches that should be supported, nurtured and exploited and resulted in the definition of six pathways/ clusters for transition shown in the pictorial summary of the Roadmap (Figure 14) below.

A sequence of initiatives within each pathway was identified and has been defined in terms of short-, medium- and long-term goals supported by a series of activities/ projects with associated KPIs.

- **Priority interventions** identified at the consultative workshops were validated by experts at a national workshop.
- **Pathways/clusters** for uptake of STI in SHS describes the elements in the lifecycle value chain represented as a sequential flow from the culture of innovation, digitised enterprise, strategic projects, technology pipeline, technology diffusion and directed capability.
- **Initiatives:** For each of the pathways/clusters, a set of three to five key initiatives were identified, which included a range of activities/projects. Each initiative was tested against the three primary Roadmap objectives viz. to overcome conservatism, stimulate investment and provide decision support.
- **Projects/activities:** Existing activities and new projects or activities that should be carried out to support the realisation of the Roadmap objectives were considered for each of the initiatives.
- **Output indicators:** A set of output indicators for each identified pathway/ cluster, initiative and project activity has been defined.

Each cluster and associated initiatives as well as the possible activities for implementation under each cluster in the next ten years are defined broadly and unpacked visually in the narrative below.

Pictorial summary of the STI 4 SHS Roadmap Pathways / clusters



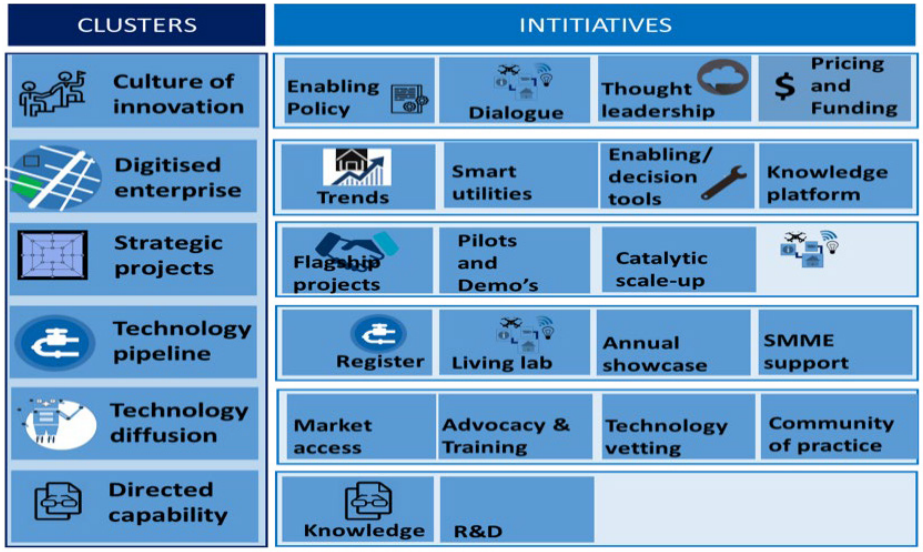
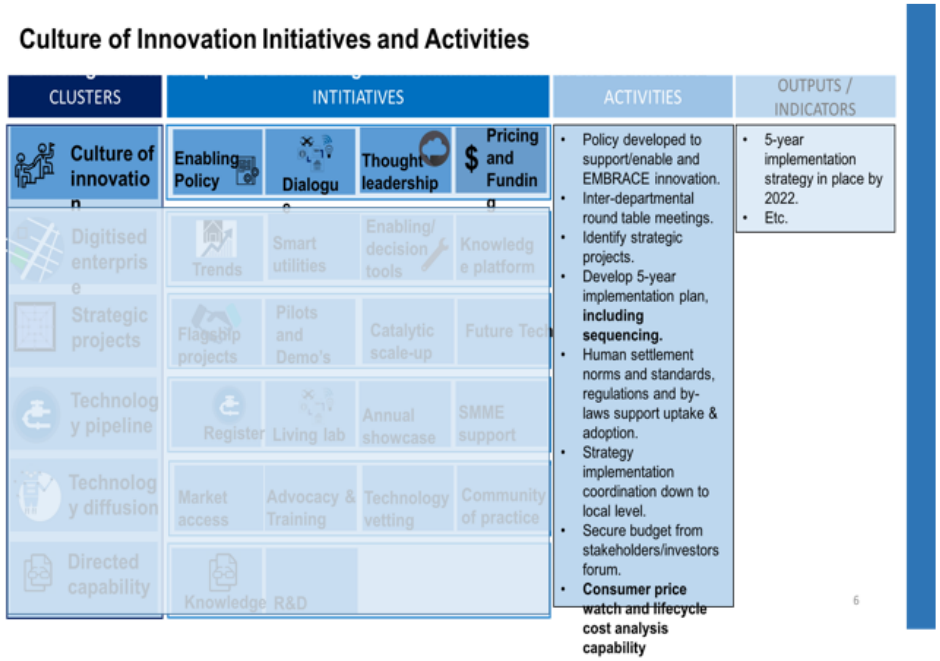


Figure 15:Roadmap clusters

9.1. Culture of Innovation Pathway



Status quo
Mature, entrenched human settlement delivery model machinery in place,
Risk aversion
Lack of investment

Drivers
Population growth;
Urbanisation;
Burgeoning demand and state dependency;
Resource scarcity

To foster a culture of innovation towards the progessive transformation of the human settlements sector STI practices.

1 A CULTURE OF INNOVATION

Human settlement and housing practitioners are empowered to work collaboratively across organizational boundaries. There is an expand mind-set, with increased experimentation, controlled risk taking, and an agile response to new challenges.[1]

Initiatives

- THOUGHT LEADERSHIP - A multi-stakeholder development policy and finance innovation technical think-tank is established to spear-head delivery model innovation and diversification.
  - **Innovation champions** are trained in Design Thinking.
  - A **national technology needs assessment** for the sector is realised.
  - A **scaling roadmap** is drafted, and implemented.
  - **Strategic projects** are identified and implemented.
  - Learning between DST Roadmap initiatives is shared via an Roadmap Community of Practice.
- CONDUCTIVE ENIRONMENT - Innovation champions create an environment conducive to embracing appropriate innvation within the human settlements and housing sector delivery chain.
- DEDICATED INNOVATION BUDGETS - Ring-fencing of atleast 2.5% of HSDG for innovation is reinstated and sustained.[2]
- INVESTORS FORUM - An investors forum is stablished and nurtured.

1. https://www.informationweek.com/strategic-circle/expanding-a-culture-of-innovation-in-government-/a/d-id/1328588

2. DoRa 2018, pg 167, subsequently discountinued.

While having innovation capabilities does not guarantee that innovation will occur, without it innovation is unlikely. A culture of innovation entails leaders who understand and promote innovation. While innovation capabilities are often found in creative individuals who question the status quo, innovative capabilities can be fostered through routines, processes and practices. Four initiatives, discussed below, are to underpin the Culture of Innovation, namely: Enabling policy, dialogue, thought leadership, and pricing and funding.

9.1.1. Enabling Policy

South Africa has a wide range of national and local policies, guidelines, norms and standards and legislation applicable to the public and private provision of housing and neighbourhoods. On occasion, these instruments do not pro-actively accommodate or promote innovation. The enabling policy initiative will provide a formal route for citizens to articulate policy ideas or frustrations to key decision makers with a view to remedying policy gaps, and reviewing and amending existing policy to support, enable and embrace innovation in the human settlements sector, where this is compatible with public interest.

9.1.1.1. Actions

a. Conduct a survey through the National STI4SHS Forum, to identify specific policies to be considered and influenced.
b. Create an electronic policy feedback and suggestion form and host it online for anytime submission.
c. Establish enabling policies to be a standing item on the quarterly Roadmap Implementing Committee agenda.
d. Convene focus groups and expert task teams through round table discussions and policy dialogues from time-to-time as needed to review and draft recommendations for enabling policy, and advocate until adopted.

9.1.1.2. Initial Focus Areas

The following policies were identified for priority attention during the Roadmap definition phase via consultation:

9.1.1.3. Actions

a. DHSWS innovation policy document led by National DHSWS
b. Green building policy
c. Policy and incentives for the promotion of low water and no water sanitation
d. Grey-water recycling
e. Policy on mini-grids for energy generation
f. Feed-in tariffs for renewables
g. Innovative financing guidance to be developed with National Treasury input for:
   - impact fees
   - special assessments
   - exactions
   - incentives.

9.1.1.4. Partners and Institutional Arrangements

These include the Roadmap Implementing Committee, National STI4SHS Forum, focus groups and policy expert task teams.

INTERVENTION FOR IMPACT

Aim: Support domestic technology development, research and innovation by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities. **Five enabling policy issues have been addressed for verified priority technologies.**

2020/21: Research and best practice identification

2021/22: Draft policies

2023-30: Policies ratified and adopted

Indicative budget: R7.5 M

NDP alignment: Establish a competitive base of infrastructure, human resources and regulatory frameworks

SDG Goal: 9

9.1.2. Dialogue

There are currently a variety of actors in the human settlements sector, in the public and private sectors, from government, business, industry, academia and civic organisations which play critical roles in providing support to promising emerging technology, and sometimes play a role in discouraging competition, innovation and/or in maintaining the prevailing regime.

Public sector departments in all spheres of government as well as business, industry, academia and civic organisations are frequently accused of behaving in siloes. The dialogue initiative is a structured engagement series to share feedback and insight, and encourage participation, collaboration and co-ordination of activities.

9.1.2.1. Actions

a. All project partners and collaborators are encouraged to actively recruit any interested stakeholder to register with the National STI4SHS Forum (see also Knowledge Platform, section 9.2.4).
b. Establish the Forum blogsite as an open public feedback mechanism. (See Knowledge Platform, section 9.2.4).
c. All-government Innovation Roundtable event to be hosted in each province annually (self-funded).

d. RIC to host half-day annual engagements (or as the need arises) with representatives of key stakeholder groups, including:
   - IBT Association (at Annual Showcase)
   - Academic Advisory Board (participating universities to host on rotational basis)
   - Black Business Council.
e. Advocacy and networking events to be held at district level.

9.1.2.2. Initial Focus Area

The initial focus will be to establish a Project Management Office (PMO) for stakeholder co-ordination for roadmap implementation and a Roadmap Implementation Committee, and to focus on PHDAs.

9.1.2.3. Partners and Institutional Arrangements

Partners would include DHSWS, DSI, human settlements departments entities, SALGA, IBT Association, and the Academic Advisory Board.

INTERVENTION FOR IMPACT

Indicative budget: R1.2 M

Support existing technology roundtable/forum co-ordinated by the NDoHS.

Host and organise policy dialogues for innovation uptake;

Organise and establish provincial innovative an dtransformative technology forums;

Supporting effort for technology uptake by various lobby and professional groups i.e. Green and Climate Change groups, IBT Assosiation

NDP alignment: Steps by the state to professionalise the public service, strengthen accountability, and improve co-ordination

SDG Goal: 11

9.1.3. Thought Leadership

Twenty-five years since the dawn of democracy, South Africa is facing persistent and growing challenges in achieving its constitutional imperative of progressively achieving access to adequate housing for all. Decisive and transformative leadership is needed to advance the objective of accelerating access to adequate housing, crafting neighbourhoods and smart cities of the future and manifesting human settlements in both rural and urban settings which are sustainable, and which unlock a good quality of life. The current situation and trajectory in the human settlements sector enjoins stakeholders to take a fresh look at how innovation can be leveraged to improve the productivity and competitiveness of the sector. The **thought leadership initiative** is proposed to stimulate creative thinking to design and implement innovative approaches to the activities of government. This is needed in order to promote an institutional environment which proactively identifies, enables and embraces innovation where it is of value to do so.

9.1.3.1. Actions

a. Participate in quarterly interdepartmental Innovation Roundtable meetings to share best practice and progress to be led by the DHSWS.
b. Lead and co-ordinate in strategy implementation to the applicable level of implementation and impact (household and neighbourhood).

c. Review and act on feedback from the National STI4SHS Forum (see Enabling Policy, section 9.1.1. and Dialogue, 9.1.2, Innovation Roundtable meetings and Community of Practices.
d. Liaise with the Cost Commission and exercise leadership to secure financial support and good governance for Roadmap activities.
e. Develop and agree to a five-year implementation strategy, and select and invest in strategic projects, with sequencing and funding for 2025-2030.

9.1.3.2. Initial Focus Area

Initially the focus will be to convene a Roadmap Implementing Committee (RIC) charged with providing strategic leadership for the Roadmap implementation, consisting of representatives from government, industry, and academia.

9.1.3.3. Partners and Institutional Arrangements

Partners will include DSI, DHSWS, SALGA, DEA, NHBRC, TIA, Agrément SA, the Academic Advisory Board, the CSIR, Chairpersons of the Cost Commissions and PMO and others as identified.

INTERVENTION FOR IMPACT

Aim: Leadership training for well-placed, early career professionals (targeting gender equity from academia, government and civil society).

2020-23: Approval of the SITT4SHS Roadmap at an executive level and adoption by the sector stakeholders and forums of the sustainable human settlements sector as a whole. Allocation of budgets by human settlement departments to support the implementation of the Roadmap;

Provincial SITT4SHS Roadmap budget set aside;

Establishment of the STII4SHS agenda by implementing entities budgets through innovation budget coordination at an NSI level.

Appointment of the provincial departments SITT4SHS Roadmap coordinators, training and research facilitators

2023/30: 15 scholarships for PhD's of which 5 international exchange student arrangements in the field of innovation in human settlements.

Indicative budget: R110 M

NDP alignment: Increase the number of Masters and PhD students

SDG Goal: 4

9.1.4. Pricing and Funding

There is high competition and very limited funding available for STI4SHS, and, indications are that there is poor follow-through, meaning that promising technologies are not supported through the technology readiness level (TRL) to reach market. Nearly 70% of start-ups fail due to being unable to successfully scale their efforts. Mainstreaming is success in diffusion (supply) and adoption (demand) processes. A critical success factor for the STI4SHS Roadmap implementation will be to ensure both are effective. The implications of this is that adequate business, technical and financial support is required throughout the value chain. Affordability and user needs are a critical element to be considered in STI prioritisation. The **pricing and funding initiative** is proposed to ensure that the very limited funding is applied to achieve best benefit, considers risks and that additional funding sources are actively sought, secured and invested.

9.1.4.1. Actions

a. Establish a Cost Commission to prepare business cases for selected investment options to guide strategies of the RIC.
b. Contract professional service providers as required on an ad hoc basis to provide independent research or technical input on matters related to pricing and funding.
c. Advocate for 30% innovation reservation for human settlements to be formalised in the Division of Revenue Act No. 4 of 2020 (DoRA), and maintained.
d. Identify and actively pursue funding opportunities.
e. Annual Investment Forum to be hosted by TIA and DSI.
f. Actively engage with potential funders and investors, and seek to identify and remove barriers to investment.
g. Make inputs into system architectures for all clusters to ensure Roadmap implementation expenditure and costs are collected, analysed and managed.
h. Consumer price watch and life cycle cost analysis is to be integrated into all cluster activities.
i. Roadmap implementation cost, expenditure and risk reporting.

9.1.4.2. Initial Focus Area

The initial focus is for the PMO to draft terms of reference for the Cost Commission.

- Review budget allocation for innovation by provincial implementing entities.
- Encourage allocation of innovation and technology as part of the subsidy quantum.
- Encourage funding for innovative projects by human settlements development funding institutions.
- Establish mechanisms for a budget coordination or technology initiative between DSI and the NDoHS.
- Provincial implementing partners including municipalities will target 10% of alternative innovative tech utilization annually.

9.1.4.3. Partners and Institutional Arrangements

The pricing and funding initiative is to be the overall responsibility of the PMO, with oversight by the Cost Commission (which has multi-stakeholder representation) reporting to RIC, with paid and contracted expertise for specialised inputs, by agreement of RIC.

INTERVENTION FOR IMPACT

Cost Commission and annual investment forum. At least 2 % of the Human Settlements Development Grant (HSDG) was be allocated to programmes and projects for the implementation of innovative building technologies in the human settlements implementation delivery chain.

Indicative budget: R 7.5 M

NDP alignment: Expand science, technology and innovation outputs by increasing research and development spending by government and through encouraging industry to do so.

SDG Goal: 17

9.2. Digitised Enterprise Pathway

Figure 16: Roadmap Cluster 1, Digitised Enterprise

9.2.1. Digitised Enterprise

The Digital Revolution — also called the Third Industrial Revolution — is a global trend characterised by the shift away from mechanical and analogue electronic to digital electronic technology, resulting in the proliferation of computing and digital record keeping, and the networks and infrastructures which have spawned the Information Age. South Africa has begun to embrace this revolution, and the technologies, infrastructures and capabilities which underpin the Third Industrial Revolution have proliferated exponentially, albeit it unevenly, across all socio-economic spheres. A range of innovative digital technologies have emerged over the last 75 years which are applicable in the human settlements sector, and which can be applied to improve housing delivery and access, competiveness, and quality, if appropriately selected, and effectively mainstreamed. Opportunities for digitising the human settlements enterprise emerged as a priority during consultation.

Four initiatives, discussed below, are proposed for the Digitised Enterprise cluster, namely: Trends, smart utilities, decision tools and platform.

9.2.1.1. Trends

a. Establishment of means to collect relevant data of satisfactory quality, at reasonable efficiency and cost, at the district level.
b. Collate data centrally.
c. Visualise, analyse and report on data in an ethical manner, and utilise the data to adjust Roadmap implementation plans, replicate successes and provide feedback to implementers as appropriate.

9.2.1.2. Actions

a. Annual review of national and international trends in STI in the human settlements sector.
b. Track and report on attainment of Roadmap targets set in the annual targeted KPIs (derived from Key Performance Indicators), both directly and indirectly attributable to the Roadmap.
c. Identification, elaboration and advocacy of success stories.
d. Tracking of NDP and SDG goals achieved in PHDAs.

9.2.1.3. Initial Focus Areas

a. Review of Global Survey 2018: Smart Building Technology, Budgets, Priorities and Preferences
b. Present SA trends at appropriate international conferences intermittently.

9.2.1.4. Partners and Institutional Arrangements

a. Data collection networks are to be established on a voluntary basis by district partners.
b. Defined contributions will be made by Agrément (eco-labelling and licencing) and IBT Association.
c. Co-ordination will be run by RICs, and collation, analysis and verification by Agrément, NHBRC and the PMO (with inputs by specialist consultants).
d. Verification will be handled by DPME. DTI will be responsible for export support.
e. International partnerships will be fostered.

INTERVENTION FOR IMPACT

2020/30: Annual STI4SHS popular publication

2020 & 24 & 28: International trends of technologies that can benefit sustainable human settlements sector

2021-2025: Digital workflows for SHS for contractors, beneficiaries, single integrated database

National digital beneficiary register;

Concept for SHS System of systems

Indicative budget: R6 M

NDP alignment: Understanding and responding appropriately to complex global challenges is the first task of planning.

SDG Goal: 17

9.2.2. Smart Utilities

New and existing hardware and software IoT, networked to promote efficiency, can yield near real-time quality data. Data can be linked to users, service providers and local authorities to enhance the capability to respond, as well as improving quality of life in homes and neighbourhoods. Smart utilities can include:

a. **Water:** Water consumption tracking, leakage detection and control, smart irrigation, and water quality monitoring.
b. **Mobility:** Real-time public transit information; congestion pricing; multi-modal, demand-based and integrated transit, car-pooling/ride share/e-hailing; bike sharing; and autonomous vehicles.
c. **Digitised security:** RFID tagging for construction material management, predictive policing, real-time crime-mapping, community gun-shot detection, emergency response optimisation, home security systems, neighbourhood surveillance, neighbourhood fire detection and early warning systems.
d. **Real estate management:** Land identification and use-optimisation; lease management; predictive infrastructure maintenance and management; reactive maintenance; data-driven building inspections; regulation of home construction; construction management; advanced materials and systems manufacturing (robotics); and BIM.
e. **Energy and indoor quality management:** Building automation, home energy consumption, dynamic energy pricing, and distribution automation systems.
f. **Service delivery applications:** Citizens to monitor use, track billing, and lodge and track compliments and complaints.

9.2.2.1. Actions

a. Systematically identify, record and map existing instances of hardware, software and networks implemented at ward or district scale for smart utilities listed above. Critically review and identify success stories and replicate.
b. Identify market gaps or opportunities and propose demonstrations where funded and feasible.

9.2.2.2. Initial Focus Areas

a. The Roadmap consultation process identified water as the most pressing need for smart utility STI. Maturity/readiness assessments should be conducted for PHDAs to retrofit water leak, water quality and consumption technology.
b. Review of existing case studies, identification of pilot sites, and review of analogue, digital, legacy and new devices as well as digital infrastructure for pilot districts.
c. Prioritisation, system design and implementation for digital transformation, integration, interconnectivity and intelligence.

d. Initial focus areas in PHDAs where budgets are available and stakeholder buy-in is high:
   - Local skills development for equipment installation and management.
e. Ongoing organisational change management support is needed in implementation sites.

9.2.2.3. Partners and Institutional Arrangements

PHDAs and implementation partners from the private sector will be gained via open tender processes. Oversight will be carried out by district project management or PMO (determined on a case-by-case basis).

INTERVENTION FOR IMPACT

New household plumbing installations fitted with water leak detection, quality and consumption monitoring for data-led decision-making. **Target 1500 households in 58 PHDAs for access to potable water.**

Smart utilities and the use of smart ICT at household level installed for water, energy, sanitation and waste management.

Sensors and other related technologies to be deployed for household efficiency and reduction of C02.

SMME's smart sensors and utilities / products deployed.
Exploit the tools like the Technology Acquisition and Deployment Fund (TADF) to deploy these technologies.

2020/21: detailed plan and pilot site selection

2021/22: 1 x pilot site, 100 youth trained in equipment installation

2023-30: 8 PHDAs p.a.

Indicative budget: R6 M

NDP alignment: Employment, access to clean potable water, reduction in water use

SDG Goals: 6 & 8

9.2.3. Decision Support Tools

The decision support tool is to provide a digital overview (dashboard) of the human settlements enterprise. In order to be cost effective and least disruptive it will include integration of both old and new technology, equipment and processes where possible in order to draw insight from the data. We define "decision support tool" in the context of the STI4SHS Roadmap implementation as a single software tool which seeks to collate data from multiple sources (acquired in the normal course of business), and apply data analytics and visualisation at both the household and neighbourhood level. The decision support tool will be for the purpose of providing public sector actors (from a variety of departments) with relevant business intelligence for progressively improving an evidence base to underpin decisions and to support reporting confidence. Life cycle cost, quality, and efficiency should be recorded and distinguishable for both conventional and innovative applications. Data should be handled in an ethical manner and be available at all levels for decision support for:

- Day-to-day operations and SHS-related service delivery
- Trends over time
- M&E and governance
- Feedback for policy and regulatory purposes.

Data integrity and acceptable costs are key elements.

9.2.3.1. Actions

a. Interoperable technology agnostic data integration platform to be procured and implemented in volunteering districts, with preference to co-ordination with smart utility initiative.
b. Organisational change support to be provided.
c. Data from a variety of convenient sources to be integrated into the system.
d. District data to be aggregated (potential integration in national observatory for spatial data and analysis envisaged in the NDP).

e. As successfully demonstrated and mature, integration with SANSA satellite data for human settlements monitoring and evaluation (see Strategic Projects: Pilots and demonstrations).
f. Integration with directed capability cluster to enhance data analytics through digital twinning, AI, and machine learning.

9.2.3.2. Initial Focus Areas

a. Satellite technology applications to provide near real-time mapping of human settlements, informal settlements, project monitoring, planning under leadership of the South African National Space Agency (SANSA). (Refer also to Digitised enterprise: Decision support tools.)
b. Digitised land registry.
c. Initial recommended dataset should be described for priority thematic areas of water and sanitation, mobility and transport, materials and methods for the provision of housing, and energy.
d. PHDAs, especially with current challenges in collecting, reporting and acting on credible data should be prioritised.
e. Big data applications in human settlements.

9.2.3.3. Partners and Institutional Arrangements

Partners will include DSI, DHSWS, PMO, private sector providers on open call and all government departments in volunteering districts.

INTERVENTION FOR IMPACT

2020/21: Target 58 PHDAs for implementation of Satellite technology in 58 PHDAs and one national digital land registry.

2020/21: Decision support tools integration platform.

2021/22: National level real time monitoring of informal settlements and land invasion.

2023/30: Single Decision support tools integrated reporting dashboard for human settlements.

SHS policy data observatory for evidence based policy and decision making in the sector.

Digital databases and registers of decision support tools for the sector.

Budget: R8 M

NDP alignment: Capable state

SDG Goal: 16

9.2.4. Knowledge Platform

The **knowledge platform** is to be an electronic platform which serves as a repository for credible open-source publications, for professional stakeholders to keep abreast of trends and developments in the field of STI4SHS, (including all Roadmap implementation activities) and which hosts an interest group blogsite to stimulate engagement and discussion between all stakeholders.

9.2.4.1. *Actions*

a. Migration of electronic forum from www.sti4shs.co.za to uKESA.
b. Establishment of a peer review mechanism to oversee content quality.
c. Advocacy, content solicitation, curation and maintenance.
d. Quarterly digital newsletter to be prepared by the PMO and distributed e lectronically to National STI4SHS Forum members.

9.2.4.2. *Initial Focus Area*

a. Existing National STI4SHS Forum platform to be transitioned to uKESA.
b. STI4SHS blog to be established and hosted by uKESA.
c. Niche forum to be maintained and strengthened by the PMO.
d. Establish strong academic partnerships and advocate participation amongst students and graduates.

9.2.4.3. *Partners and Institutional Arrangements*

Partners will include the PMO, SALGA, Academic Advisory Board and the national STI4SHS Forum.

INTERVENTION FOR IMPACT

Innovation networks and lifelong learning for a target of 500 registered, active STI 4 SHS National Forum members.

4 moderated articles.

SITT4SHS Community of practice network established.

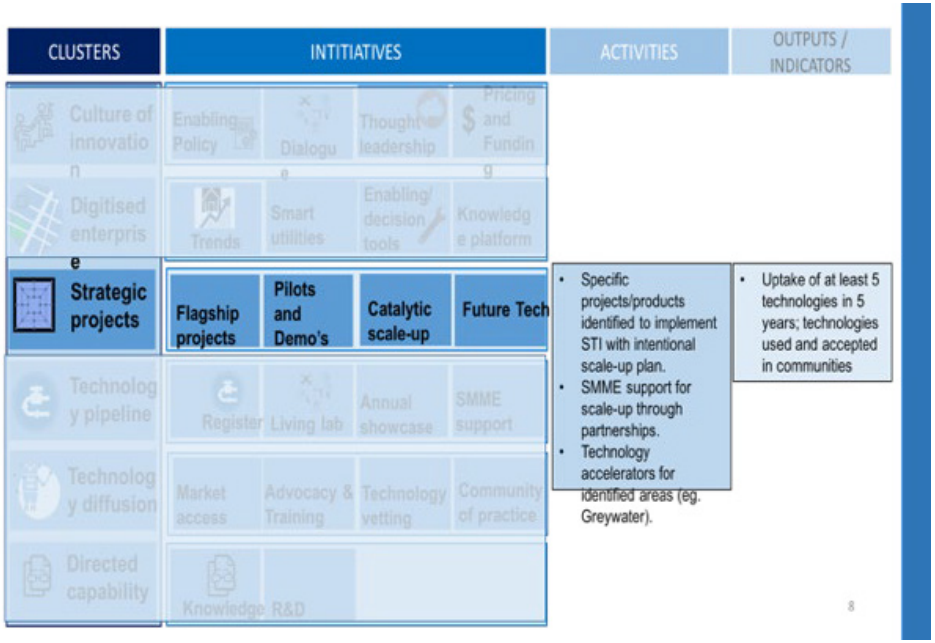
Tracking of STI related research publications in the established knowledge platforms.

Indicative budget: R12 M

NDP alignment: Steps by the state to professionalise the public service, strengthen accountability, improve co-ordination

SDG Goal: 11

9.3. Strategic Projects Pathway



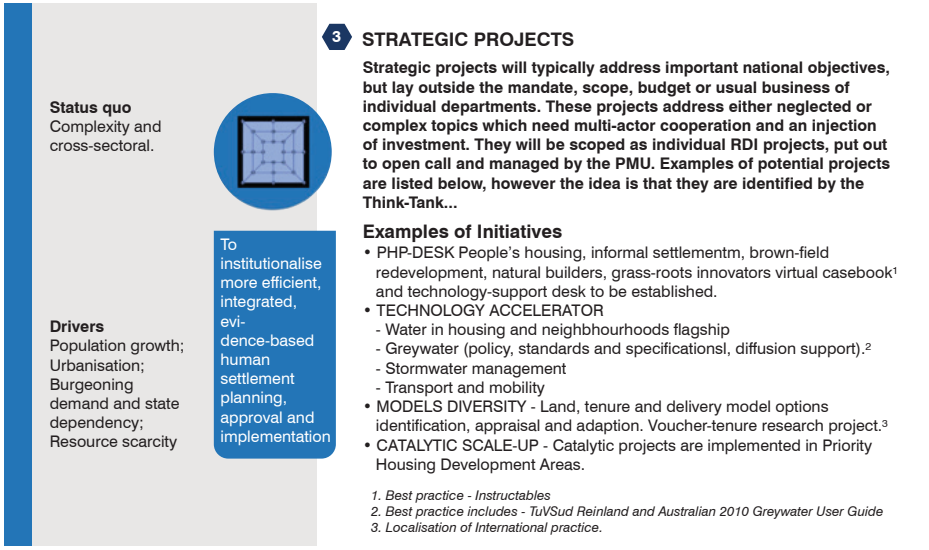


Figure 17: Roadmap Cluster 2, Strategic Projects

9.3.1. Strategic Projects

Strategic projects are multi-year initiatives where substantial public-sector investment is made in the expectation of achieving transformative innovation and/or in securing supplementary funding from external investors. These projects (or programmes) rely on co-ordinated multi-stakeholder co-operation for their successful integration into the mainstream. Strategic projects are categorised as flagship projects, pilot and demonstrations, catalytic scale-up, and future technology. Initiatives in the strategic projects cluster already have been (or can be) initiated and led by an identified RIC lead partner, with participation of multiple stakeholders.

9.3.1.1. Flagship Projects

Flagship projects are initiatives aligned with international commitments i.e. climate change programme of Sustainable Development Goals.

9.3.1.2. Initial Focus Area

DEFF and DSI lead in collaboration with various partners on climate change near-term priority flagship programmes:

a. Renewable Energy focussing on distribution scale renewable energy, and hydrogen and fuel cell technologies as enablers for scaling up renewable energy.
b. Development of a renewable energy funding proposal for submission to the Green Climate Fund.
c. Waste management flagship programme. (DEFF has secured grant funding.)
d. Water conservation and demand management flagship programme.
e. Low carbon, climate-resilient built environment, communities, and human settlements flagship programme.
f. Development and maintenance of the climate change monitoring and evaluation system focussing particularly on the adaptation components and alignment with the South African Risk and Vulnerability Atlas.
g. Reinvent the toilet revolution and offgrid community level modular sanitation technologies.
h. Alternative building materials and technologies for sustainable human settlements.

9.3.1.3. Partners and Institutional Arrangements

Partners are to lend technical assistance in line with the mandate, skills and availability, when agreed.

Initiatives are to be documented and learning to be shared, as appropriate, with stakeholders (See Dialogue under section 9.1.2. and Knowledge Platform, under 9.2.4.).

INTERVENTION FOR IMPACT

Aim: Catalysing economy-wide investment and articulating the investment case for large-scale climate action.

2020-27: One bankable business case per annum to scale-up each flag-ship project
2022-30: Scale-up funding secured and scale-up programmes being implemented

Indicative budget: R60 M

NDP alignment: Transition to an environmentally sustainable, climate-change resilient, low-carbon economy and just society

SDG Goal: 13

9.3.2. Pilots and Demonstrations

Pilots and demonstrations are experiments or prototypes undertaken in controlled laboratory or real-world settings, focussing on a single technology or innovation in isolation. (Compare and contrast Living Lab, section 9.4.2.). This category includes sandbox virtual testing environments.

9.3.2.1. Initial Focus Area

a. Additive manufacturing of 3D printed houses.

9.3.2.2. Partners and Institutional Arrangements

Human settlements are to be demonstrated by University of Johannesburg in the Western Cape, under sponsorship of the DSI. Partners are to lend technical assistance in line with the mandate, skills and availability when requested.

Initiatives are to be documented and learning is to be shared, as appropriate, with stakeholders (see Dialogue, section 9.1.2. and Knowledge Platform, 9.2.4.).

INTERVENTION FOR IMPACT

2019/20: Technology demonstrated for one house

2020-22: Equipment design refinement and testing at village scale

2022-2030: Scale up in SA, investigate AfCFTA and SADC market potential

Indicative budget: R50 M

NDP alignment: The development and marketing of niche products and services, coupled with mutually beneficial partnerships with neighbouring countries, create jobs in domestic manufacturing of renewable energy technologies

SDG Goal: 9

9.3.3. Catalytic Scale-up

Catalytic scale-up projects are large scale interventions targeting impact at scale through spatial and economic restructuring.

9.3.3.1. Initial Focus Area

Review catalytic projects in the human settlements portfolio and identify opportunities for STI to reduce inequality focussing on:

a. Investment and funding models (cross-reference Culture of Innovation: Finance and costing), and
b. Spatial transformation (e.g. extra-ordinary high density sectional title developments [WCDHS priority catalytic project]).
c. Big strategic human settlements projects that can show case at a large scale the impact, benefits for technology and innovations for the sector i.e. green settlements / off-grid settlements.

9.3.3.2 Partners and Institutional Arrangements

Partners are to lend technical assistance in line with the mandate, skills and availability when requested.

Initiatives are to be documented and learning is to be shared, as appropriate, with stakeholders (see Dialogue, and Knowledge Platform sections).

INTERVENTION FOR IMPACT

Opportunities for STI application in catalytic projects.

2020-30: Off grid settlements technologies;

Catalytic Alternative building and materials technologies;

Catalytic energy technologies at a settlement level

Catalytic sanitation technologies at settlements level.

Catalytic energy technologies at settlement level.

Catalytic designs in transport, water management, sensors, smart designs and landscaping.

Indicative budget: R10 M

NDP alignment: Promoting an inclusive society and economy through tackling the factors that sustain inequality of opportunity and outcomes by building capabilities and redressing the wrongs of the past

SDG Goal: 10

9.3.4. *Future Technology*

Future technology initiatives are challenge-led RDI endeavours. These initiatives are fostered through an accelerated development pathway through a package of support. Items are to be added as the needs emerge and opportunities become present.

Future technologies that aspires and drive society 5.0.

9.3.4.1. Initial Focus Area

Review catalytic projects in the human settlements portfolio and identify opportunities for STI to reduce inequality focussing on:

a. Human settlements future: Low carbon emission house five-year plan led by DEFF.
b. User-friendly government housing application by the WCDHS through the Home-Wise youth competition: Developments to be followed.
c. Geo-spatial IBT database (NHBRC and CSIR): Potential for integration in digitised enterprise; decision support.
d. WCDHS to investigate manufacturing of houses in factories.
e. Nelson Mandela Bay housing waiting list smartphone application.
f. Robortics, Artifical intelligence, Internet of Things, Blockchain applications and futuristic technologies.

9.3.4.2. Partners and Institutional Arrangements

Partners are to lend technical assistance in line with the mandate, skills and availability when requested.

Initiatives are to be documented and learning is to be shared, as appropriate, with stakeholders (dialogue, Knowledge Platform). The Innovation Hub is to be utilised.

INTERVENTION FOR IMPACT

Partners to sponsoring prizes to solve challenges through STI solutions using futuristic technologies, in hosted Hackathon-style event. Technology accelerator through TRL progression.

2020/30: 1 breakthrough technology per year

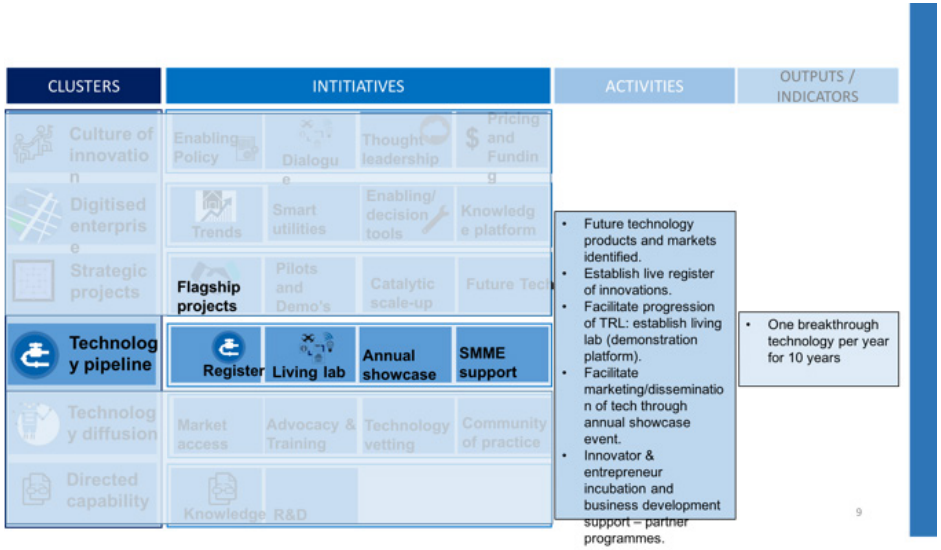
Use of robotics, artificial intelligence, nano technologies, additive materials, blockchain, Internet of Things and futuristic technologies that can help the transition to society 5.0 and the homes of the future.

Indicative budget: R5 M

NDP alignment: Building active citizenry and leadership

SDG Goal: 9

9.4. Technology Pipeline Pathway



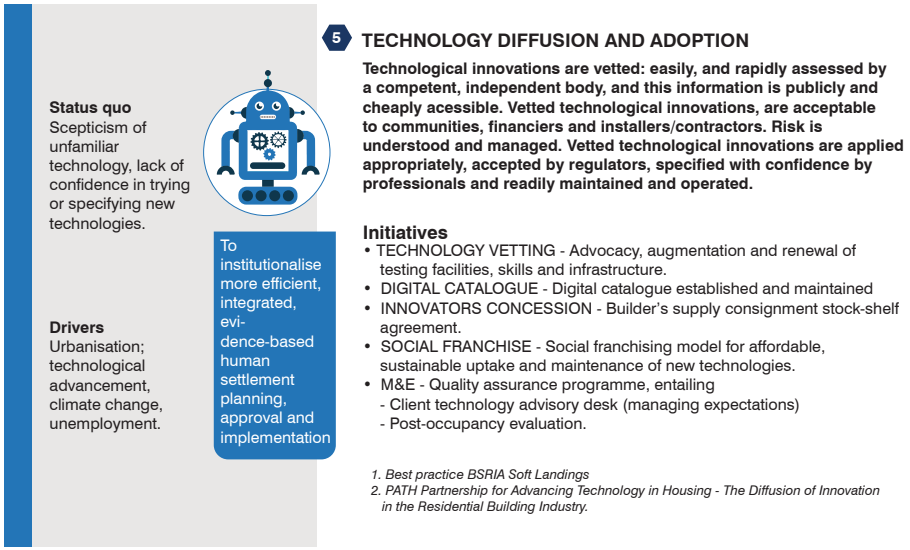


Figure 18: Roadmap Cluster 3, Technology Pipeline

Strengthening relationships between government, the National System of Innovation (NSI) and industry will foster innovation and technological development to address the sector's needs and to stimulate investment, jobs and SMMEs.

- To help strengthen the pipeline of technologies and innovations relevant to the human settlements sector the following initiatives will be supported: a technology register, living lab, annual technology showcase and SMME support.

9.4.1. Technology Register

A register listing innovative technologies that are applicable to the human settlements sector will be established. This is to be a source of reference for investors and specifiers who are seeking products to invest in to upscale or products to be applied in human settlements projects.

9.4.1.1. Actions

a. Identify technologies: This will initially be a manual process. This is to be an electronic database that is searchable with filters for sector, technology readiness level (TRL), business readiness level (BRL), market readiness level (MRL), etc.
b. Establish an open and live online database that automatically draws relevant technologies from existing databases (such as the Innovation Bridge Portal), thus ensuring that the database is always up to date with the latest available or emerging technologies.

9.4.1.2. Initial Focus Area

a. Stimulate interest amongst innovators through a call to have their innovations listed.
b. Establish formalised arrangements for the hosting of the online register (possibly uKESA or SITT4SHS platform).

9.4.1.3. Partners and Institutional Arrangements

Partnerships with hosts of other technology lists, such as the Innovation Hub, Water RDI roadmap, technology transfer offices of universities and the Climate Change Technology Needs Assessment for the human settlements sector coordinators at DEA.

INTERVENTION FOR IMPACT

2019/20: At least 250 innovations registered on the Technology register of promising technologies across the five key human settlements sectors (water, mobility, energy, shelter/construction, governance).

2020-22: Accessible, searchable online database of technologies established

2022-2030: 10 patents registered/ commercially available technology register

Indicative budget: R3 M

NDP alignment: The adoption of innovation and technologies leads to economic growth and improved quality of life.

SDG Goal: 9

9.4.2. Living Lab

The LL concept provides an environment in which innovations, which have been proven in prototype demonstrations, can be developed and tested in a real-life situation, with the input of multiple stakeholders including the end users. Multiple technologies are tested/demonstrated simultaneously in an operational environment. This ensures a suitable match of innovation and user needs. Monitoring and evaluation of the progress is an important component enabling learning and replication. End-user involvement has been identified as a key contributor to successful adoption of technologies developed in LLs. Stakeholders may include government, academia, industry and end users.

Focus will be on advancement of product/technology from one TRL to the next.

9.4.2.1. Actions

a. Identify product/project/community for LL (recommended: One of the PHDAs of DHS).
b. Engage with Southern Africa network of Living Labs (LLiSA).
c. Set up methodology for implementation and M&E of LL.
d. Appoint an oversight team.

9.4.2.2. Initial Focus Area

Focus will be on lessons learned from the Ndlambe Ecosun Village.

Living labs should endeavour to feature at least one technology from each priority subsector (water, energy, shelter/construction, mobility, and evidence-based integration/ governance).

9.4.2.3. Partners and Institutional Arrangements

Engage communities and industry/government stakeholders and LLiSA.

INTERVENTION FOR IMPACT

2020/30: 3 Living Lab sites with technologies rolled out through scale-up
At least 10 technology based solutions supporting living labs approach addressing various social challenges and local area needs deployed.

Indicative budget: R5 M

NDP alignment: The adoption of innovation and technologies leads to economic growth and improved quality of life.

SDG Goal: 11

9.4.3. Annual Showcase

To enable exposure to the market for innovative technologies, an annual showcase will be organised by the RIC. This will give potential investors and specifiers an opportunity to view technologies.

9.4.3.1. Actions

a. Select a suitable date and venue; cost event. Venue to rotate provinces each year.
b. Generate a call to exhibit extended to all listed on the technology register.
c. Enable virtual exhibition.

9.4.3.2. Initial Focus Area

The initiative will ‘’piggybackon the annual science forum (DSI/Innovation Hub).

9.4.3.3. Partners and Institutional Arrangements

Partners will include the Innovation Hub and DSI.

INTERVENTION FOR IMPACT

2019/20: At least 20 technologies are exposed to market and investors

2022/2030: 10 Innovative technologies supported to reach the mainstream market

Indicative budget: R5 M

NDP alignment: The adoption of innovation and technologies leads to economic growth and improved quality of life.

SDG Goal: 9

9.4.4. SMME Support

Innovator and entrepreneur incubation and business development support and partner programmes will be supported through the Roadmap.

9.4.4.1. Actions

a. Identify SMMEs from technology register/annual showcase event that are promising and require support to progress in TRL, BRL, or MRL in order to be viable for the market.
b. Business management training SMME's and support for product development and deployment.

9.4.4.2. Initial Focus Area

a. Greywater re-use technology supported through employment, training and mentorship towards business ownership.
b. Smart water meter technology supported through employment, training and mentorship towards business ownership.
c. Smart sensors and utilities for green and smart settlements and applications for off-grid tech and smart living in the hands of SMME's to be supported.

9.4.4.3. Partners and Institutional Arrangements

The Innovation Hub will be the partner for this initiative.

INTERVENTION FOR IMPACT

2019/20: 20 SMME's provided with business, financial and entrepreneurship mentoring support for green household and settlements products deployment

2022-2030: Intelligent settlement and home of the future
SMME technology applications for smart living and smart settlements / households

SMME activities RDI activities for Society 5.0 and related tehcnologies

Indicative budget: R10 M

NDP alignment: Economic growth through business development; deracialising ownership and control of the economy.

SDG Goal: 8

9.5. Technology Diffusion Pathway

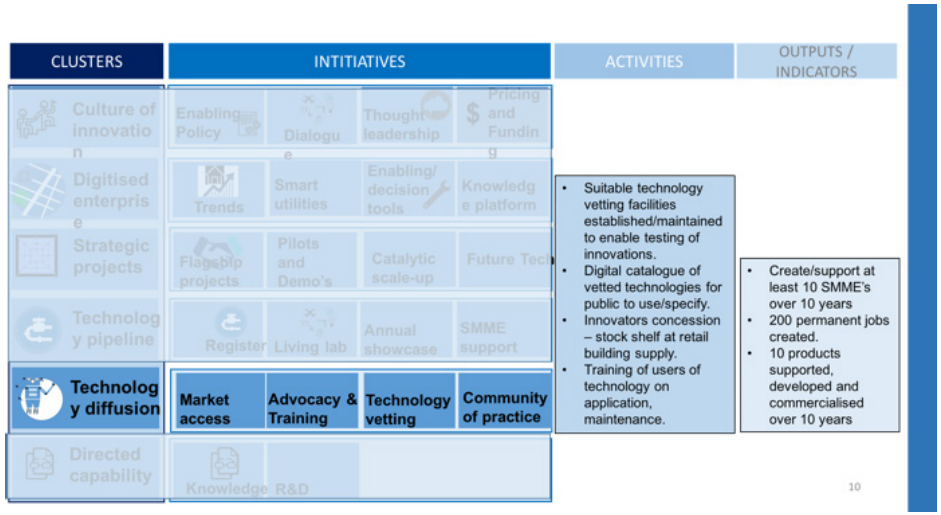


Figure 19: Roadmap Cluster 4, Technology Diffusion

9.5.1. *Technology Diffusion*

Supporting technological diffusion from inception to end-of-life reduces risk, improves operational performance and meets the user's expectations.

Technology diffusion is achieved through improved market access, advocacy and training, technology vetting (or certification), and a community of practice.

9.5.1.1. Market Access

Once a technology is market-ready, lack of access to the market can be a hindrance. Retailers are reluctant to stock products that are unknown.

9.5.1.2. Actions

a. Establish an innovators concession with popular retailers (e.g. Builders Warehouse) to stock new technologies without bearing any risk (sponsored stock).
b. Provide training (see Advocacy and Training, section 9.5.2) for how to use the sponsored technologies.

c. Develop marketing platform for the home grown SMME technologies for the sustainable human settlements sector based on the registry/ database and industry show case events.
d. Exploit the Technology Acquisition and Deployment (TADF) as an instrument to support first time purchase and deployment of locally developed technologies and innovations for the sector.

9.5.1.3. Initial Focus Area

A number of Agrément certified IBTs and light steel frame (LSF) systems will be selected for the innovators concession.

DSI and NDoHS to ensure budget coordination for as a instrument for dedeicated budgeting to support the innovations for deployment in the human settlements to support the sector including contractors, developers, SMME's and housholds.

SHS bank to provide funding packages that are designed and dedicated to upascale the upatake of technology and innovations.

9.5.1.4. Partners and Institutional Arrangements

Builders Warehouse, Chamberlains or other national hardware retailer are to be brought on board. IBT Association and the Light Steel Frame Association are also potential partners.

INTERVENTION FOR IMPACT

2019/20: 2 technologies gain market access

2020-22: Growth of industry monitored.

2022-2030: 10 innovative technologies reach the mainstream market

Indicative budget: R6 M

NDP alignment: Economic growth through business development

SDG Goal: 8

9.5.2. *Advocacy and Training*

New technologies are often not adopted by the market because users do not know how to use/install/maintain the products.

9.5.2.1. Actions

a. Sponsored training at retailers (video/pamphlet/in-person).
b. CPD training for professionals on how to specify and design with products (this relates to the Directed Capability cluster).

9.5.2.2. *Initial Focus Area*

a. Provide video training on how to use IBTss for installers, designers and municipal building control officers.
b. Smart Home Campaign (DEA/GIZ).
c. First order and second order learning networks established.

9.5.2.3. *Partners and Institutional Arrangements*

Partners will include the IBT Association, Gauteng Institute for Architecture, DEA and the GIZ (Smart Home Campaign).

INTERVENTION FOR IMPACT

2019/20: 50 End-users/installers develop capacity to use IBT's.

2020/22: Approved IBT procurement and implementation guidelines; Organise learning forums for technology and innovations in the sector.

2022/2030: IBT's reach the mainstream market; Review of SHS practices based on the first order and second order learning activities by SHS stakeholder network.

Indicative budget: R5 M

NDP alignment: Economic growth through business development.

SDG Goal: 8

9.5.3. *Technology Vetting*

An absence of local certification systems for new technologies is a stumbling block in moving an innovation to the market, which demands reputable evidence that the technology is fit for purpose. While SABS and Agrément fulfil this requirement in some areas, it is lacking in others forcing innovators to seek costly international certification.

Through the Roadmap, suitable vetting mechanisms will be sought or established. This may be by re-directing innovators to existing certification bodies, seeking financial aid to assist in obtaining international certification, or initiating a new certification system.

9.5.3.1. *Actions*

a. Establish a mechanism/forum through which innovators and entrepreneurs can request assistance with technology vetting.
b. Engage with Agrément/DTI regarding extending the scope of Agrément.

9.5.3.2. *Initial Focus Area*

a. Cool roof coating, which has the potential to significantly improve the indoor climate in houses, cannot be certified through a local mechanism. The needs for certification (in terms of laboratory equipment, costs and performance requirements) are well-established. A funding/business model is required to establish a test facility in South Africa.
b. IBT quality assurance.

9.5.3.3. *Partners and Institutional Arrangements*

NMISA, SABS, Agrément and IBT Association.

INTERVENTION FOR IMPACT

2019/20: Promote uptake and usage of innovation technology through quality assurance in the built environment

2020-22: Eco-labelling for 200 materials/products

Indicative budget: R7 M

NDP alignment: Economic growth through business development.

SDG Goal: 11

9.5.4. *Community of Practice*

Even once a technology is certified as fit for purpose, the market is often not ready to adopt it and is conservative. Additionally, the market does not necessarily know where to turn to find new and trustworthy products.

A community of practice that enables the sharing of information will help overcome these barriers and open the market for mainstreaming innovative technologies.

9.5.4.1. Activities

a. Establish a specifier's database of technologies from the innovation register that are vetted and market-ready. This will be hosted by the RIC.

9.5.4.2. Initial Focus Area

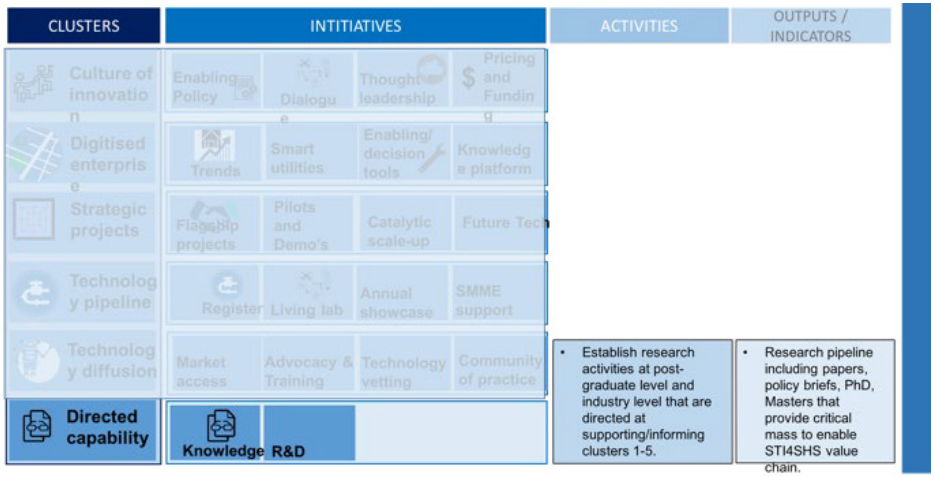
a. Establish a community of practice of vendors and suppliers who are active in new technologies for human settlements.

b. Organise events for a market community for promotion of new smart and environmentally friendly technologies.

9.5.4.3. Partners and Institutional Arrangements

Partners could include international universities involved in new products, and suppliers and commercial companies introducing to the market new technology products for smart homes and settlements.

9.6. Directed Capability Pathway



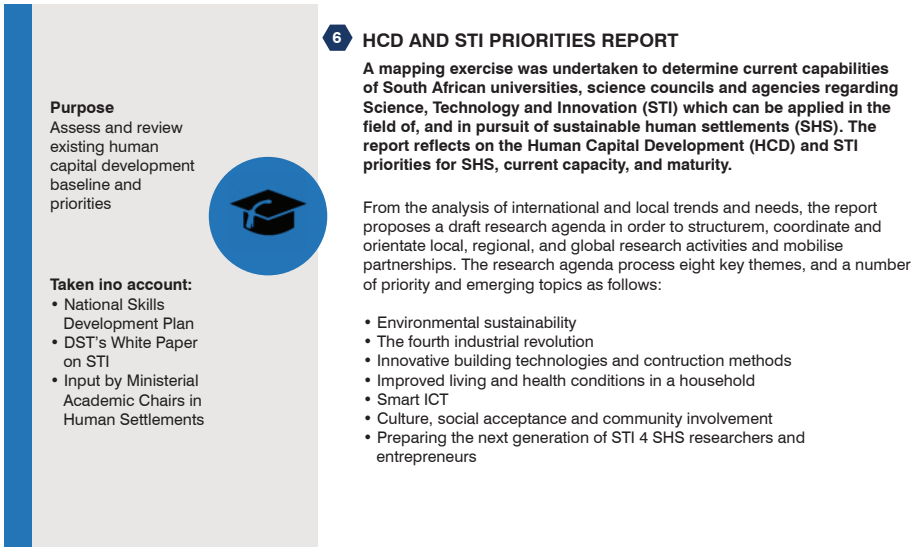


Figure 20: Roadmap Cluster 5, Directed Capability

9.6.1. *Directed Capability*

A pipeline of research, knowledge development, technical and vocational skills supporting knowledge generation for STI4SHS is established. A research and development agenda and international and local academic partnerships (including TVET colleges) are pursued.

In the context of the STI4SHS Roadmap, the value of HCD should be evident in improved uptake of innovation in the human settlements sector, technologies of the future, preparing the youth for new professions, and setting the technology agenda.

The building of capability is necessary in both the academic realm and at industry level.

9.7.1. Research and Development (R&D)

Research and development of technologies is necessary to further the impact of innovations.

9.7.1.1. Activities

a. Create a call for researchers to submit post-graduate proposals to be supported financially through the Roadmap. This is done each year. The call is to be aligned with the research agenda.
b. Identify suitable candidates to be supported.
c. Provide support (financial and possibly supervisory) for relevant post-graduate research to further the impact of innovation in human settlements.

d. Research agenda to be reviewed annually by Roadmap Implementing Committee.
e. Innovative technologies for SHS introduced as a module in the academic instititutions.
f. Advocate and support one of the existing research chairs to focus and champion a research agenda for society 5.0

9.7.1.2. Research Agenda

The draft research agenda was prepared in order to structure, co-ordinate and orientate local, regional, and global research activities and mobilise partnerships. The objectives of the research agenda are to:

a. Articulate and communicate common research interests for the pursuit of STI4SHS Roadmap objectives to stakeholders.
b. Signal areas of investment needed to funding and academic partners.
c. Guide resource allocation for key departments.
d. Inform R&D grant call formulation.
e. Inform bursary and scholarship formulation.
f. Influence researchers, research organisations, and students in South African academic institutions and NSI in planning for academic and research activities.
g. Facilitate research partnerships and collaboration with the private sector.
h. Prepare young people to succeed in the innovation economy.
i. Discover and invent the future, and support South Africa's global competitiveness.

Key themes identified for the research agenda are:
a) Environmental sustainability
b) Fourth Industrial Revolution (4IR)
c) Innovative building technologies and construction methods
d) Improved living and health conditions in a household
e) Smart Information Communication Technology (ICT)
f) Culture, social acceptance and community involvement
g) Models and policy innovation
h) Preparing the next generation.
i) Building information management
j) Society 5.0

The key themes, their rationale, examples, priority and sundry research topics are provided in the inset boxes of the next few pages.

Rationale: Sustainable development is dependent on lowering ecological footprint and particularly on lowering CO2 emissions to mitigate climate change effects. Lowering ecological footprint entails preservation of natural habitats; restoring biodiversity (with reference to the indigenous); protecting the soil, air and water from pollution and other harm. Maintaining ecological goods and services is necessary for sustainable development, and can contribute to water and food security and climate resilience. The theme aligns with the NSDP goal of taking advantage of new opportunities in the knowledge and green economies, which improve capacity to meet the SDG, and NDC commitments.

Examples: reduced ecological footprints (for example through densification), circular economy, renewables, carbon neutral, net zero energy, carbon positive, energy plus, waste reduction, restoring and managing ecological goods and services, avoiding or recycling construction waste, reuse of waste water grey-water recycling, household water leak detection, bio waste to energy, organic waste to compost and organic material reuse, e-waste recycling, net zero waste, urban food production.

Priority research topics:

1. Future mobility for reduced CO2
   a. Mobility as a service
   b. Multi-modal transport
   c. Super-efficient technologies
2. Mechanisms for achieving settlement densification and improved logistic efficiency (and thereby reduce emissions, improve access and reduced resource use)
3. Critical review and replication potential appraisals of pilots for:
   a. Grey-water recycling and unlocking other alternative sources of water
   b. storm-water management
   c. Water Sensitive Design and efficiency interventions
   d. renewable energy mini-grids
   e. biogas to energy
   f. off-grid solutions (waste, energy, water and sanitation)
   g. Social innovations

Key theme 1 Priority research topics continued…:

4. Green villages
5. Storm-water harvesting for water security
6. Incentives innovation to enhance partnerships toward an integrated housing economy
7. Net zero and energy plus – optimisation and redistribution solutions

Other:

8. Grey-water recycling, alternative sources and water efficiency technologies, standards, policies and skills development
9. Storm-water retention technologies and application decision support
10. Research on application of green approaches in the public sector
11. Circular economy potential in repurposing of inner city buildings at scale
12. Local e-waste management opportunities

Rationale: The Fourth Industrial Revolution (4IR) is an unprecedented global phenomenon featuring rapid and fundamental technological transformation precipitated by the convergence of digital, physical and biological technologies. 4IR is widely viewed as a disruptor of existing industries, production and consumption of goods and services, which, if embraced and harnessed, holds keys to delivering us from some of our most intractable problems, for example by improving productivity, and enhancing global competitiveness. However, attention must be paid to mitigating real and perceived negative effects, such as the threats of machines taking over human's work and 4IR widening the inequality gap.

Examples: Cybernetics. Artificial Intelligence (AI), big data and machine learning. Robotics. Internet of things (IoT). Information Communication Technologies (ICT): Internet, gadgets and apps. Home automation: security, connectedness of home appliances and home data to a mobile app, home computer box, home help, iRobot, home medical applications, independent living applications. Additive manufacturing (3D printing). Virtual reality.

Priority research topics:

1. South African visions for the "smart (intelligent?) city" – and the role of STI and SHS
2. Safety and security in the home and neighbourhood using IoT and AI
3. Augmented and virtual reality, and new data-driven (smart) technologies for houses and neighbourhoods: hope or hype?
4. Next generation disaster detection and response
5. IOT, AI and machine learning for environmental Life Cycle Assessment (LCA) and economical Life Cycle Costing (LLC)

Other:

6. 4th Industrial Revolution: Future Technologies for human settlements
7. 4th Industrial Revolution: Economic Opportunities in human settlements
8. 3D printed built environment
9. Sentient buildings
10. Biofilia
    a. Bio- facades using smart bricks embedded with microbes that generate electricity
    b. Chemo luminescence---like the fireflies or angler fish-- for lighting without electricity
    c. Algae living walls to harvest and derive bio- gas
    d. Use of walls with artificial leaves using photosynthesis to generate hydrogen
11. Built environment curriculum and the embrace of technological advancement skills

KEY THEME 3: INNOVATIVE BUILDING TECHNOLOGIES AND CONSTRUCTION METHODS

Rationale: Advanced materials and manufacturing can potentially impact on improving access to decent jobs, improved cost, quality and speed of delivery of housing and neighbourhoods of the future, with reduced ecological cost.

Examples: Innovation Building Technologies (IBT): Building Methods, Building Analysis and Building Material Capability IBTs, cement from plastic, phase change materials, modulated alternative methods, methods to assembly houses like car, insulated concrete forms, precast technology, interlocking brick technology, phase change materials, permeable pavements, heat reflective roofs.

Priority research topics:

1. Affordable alternative materials with acceptable performance parameters) and innovative models/pathways to achieve these at scale
2. Cool roofs at scale
3. De-escalating unplanned settlements: can STI satisfy the demand for managed land and self-build technology?
4. Warranties and risks assignment for IBTs – do these need strengthening in South Africa?

Other:

5. Transforming the backie builder into the purveyor of advanced building systems
6. Plastic roads case studies : policy implications
7. Role of academic institutions in promoting innovative human settlements designs through student projects

Rationale: Modern human beings spend up to 80% of their time indoors, over 90% in the built environment more broadly, and approaching 100% of their time in anthropogenic environments (landscapes changed at the hands of humans). The built environment impacts on vitality, health, wellbeing and productivity in myriad ways, with the most vulnerable often exposed to the poorest built environments conditions. Utility costs are rising, and putting pressure on households, especially the poor. Utility provision can be made more cost effective, resource efficient and smart with STI.

KEY THEME 4: IMPROVED LIVING AND HEALTH CONDITIONS IN A HOUSEHOLD

Examples: Smart and efficient household services (monitor household energy consumption, energy smart sensors, house as an independent energy unit, innovative sanitation, off grid sanitation, off-grid renewable energy, and products). Air pollutant detectors, health mirrors.

Priority research topics:

1. Innovation to reduce operational costs and improvement of efficiency for waste, energy, water and sanitation utilities for a variety of settings, such as emergency housing provision and informal settlements
2. Investigation into policy changes needed to unlock innovative utility technologies (e.g. procurement policy)
3. Alternative and affordable approaches to heating, cooling, lighting and ventilating housing for safety, health and wellbeing
4. Maximising passive design of housing according to climatic conditions
5. Architectural and engineering infrastructure development guidelines to facilitate climate responsive design and adaptation at the scale of the household and neighbourhood
6. Liveable cities through watercourses providing amenities, natural air-conditioning, support for bio-diversity etc.: the role of innovative storm-water design and engineering
7. Technologies for informal settlement upgrades

Other:

8. Innovative sanitation technologies
9. Green spaces and leisure – the role of STI
10. Decision support tools for selection of appropriate innovative technologies
11. Bioelectromagnetically friendly intelligent and responsive buildings and technologies
12. Health mirrors

Rationale: Research and Development: Smart data collection and use in the context of resource-constraints, as a tool for empowerment, decision-support and resolution of human settlements' development challenges.

Examples: Building Information Management (BIM) and Computer Aided Design: Information and Software. Observatories.

Priority research topics:

1. Smart infrastructure and technologies for near-real-time monitoring and metering for reduced resource loss, demand side management and supply side decision support for energy and water
2. Putting near real-time data on the desktops of decision-makers
   a. Case studies of current observatory models
   b. Detailed needs and opportunities
   c. Feasibility
3. Transformative decision support tools
4. Governance can be improved by ICT in the human settlements sector: how?
5. A critical review of current observatories – costs and benefits
6. A researched recommendation for the application of 3- 4- and 5-D BIM in the South African SHS context

Other:

7. Observatories for rural settlements: what is feasible?
8. Recommended data sets, interoperability, exchange and data privacy protocols and standards for observatories
9. (Semi)-automated BIM plan compliance examination software
10. Data visualisation (e.g. BIM) vs certification as incentives for green building uptake in clients
11. ICT for development, sustainability and the environment
12. ICT in support of smart settlements e.g. smart cities, e-government services, municipal smart infrastructure, e-services in education and agriculture
13. Digital inclusion in support of township and rural economies: Community wireless technolo

Priority research topics:

Transformative change in human settlements using technology and innovation
Finance innovation to improve access to adequate housing
Alternative design and delivery mechanisms
Tenure innovation to improve access to adequate housing
Innovation to eradicate housing market segregation
Spatial transformation to overcome legacy planning and realise sustainable human settlement: unpacking the role of STI?
Informal settlements upgrade models : case studies and critical review

Other:

Bullet train?
Tracking the impact of STI policy change on SHS
Research on governance and its role in promoting human settlements delivery
Infrastructure policies fragmentation and its impact on delivery
Policy development and implementation
Design and detailing for change over time

Rationale: High youth unemployment, rising unemployment amongst graduates, high student drop-out rates couple with accelerating rates of technological change necessitates a targeted approach to HCD development, a need to continuously forecast and align with changing needs (which entails life-long learning); access to opportunities for those otherwise excluded.

Examples: Curricular, new models (MOOCs, e-learning, blended learning), interdisciplinary work in support of innovation.

Priority research topics:

1. Sector skills needs and foresight
2. STI 4 SHS capacity absorption studies
3. Appropriateness of current research methods for STI 4 SHS
4. Advancing Public-Private-People Partnerships in HCD
5. Relooking models for skills capacitation for STI 4 SHS
6. Support testing and certification for quality of local developed technologies
7. Tracer studies to understand the career paths and mobility of people with STI or SHS PhDs across different sectors (such as universities, science councils and industry)

Other:

8. Innovation to improve the access to professionals for STI for SHS in affordable housing markets and informal settlements
9. Case studies of franchising of STI 4 SHS installation and maintenance
10. Harnessing social media to foster STI 4 SHS uptake in communities
11. Technology SME development as supplier to government
12. SMEs preferential accelerated patent protection system

SECTION E:

STAKEHOLDER ROLES, RESPONSIBILITIES AND INSTITUTIONAL ARRANGEMENTS

10. Institutional Arrangements

10.1. Stakeholders

The lead national government department in the SITT field is the DSI. It plays the role of enabler of innovation. In this capacity, it has redefined its principle role over time. Informed by a multi-level perspective, DSI has reframed its position from focussing on the National System of Innovation (NSI) and entrepreneurship, to mobilising the power of innovation aimed at structural change in socio-technical systems to address societal challenges.

This approach relooks the arrangement between state, the market, civil society and science. It values experimentation and societal learning and emphasises responsible R&D; and takes the position that foresight - and continuous reflexivity - should shape innovation processes.

DSI established a directorate to work with the National Department of Human Settlements, Water and Sanitation (DHSWS) and sponsored the development of this technology Roadmap, a project to define a ten year programme to coordinate activities and scale up the impact of science, technology and innovation in human settlements.

While DSI focuses on science and innovation, the DHSWS is mandated with the delivery of human settlements at scale and to quality. As early as 2009, it recognised the need to intensify innovation and has hosted a number of summits, indabas, round table events and conferences with some focus on innovation. Innovation is considered in the Medium Term Strategic Framework (MTSF) and Innovation and Transformative Technologies capability is planned as part of the DHSWS Research Directorate. DHSWS and its collaborators has embarked on a programme to strengthen innovation in its activities, culminating in its Innovation and Transformative Technologies (I&TT) Framework.

Beyond the national government, interested and affected parties extend to provincial and local government, parastatals, regulators, academia, private sector and industry, investors, civil society and communities.

It was subsequently resolved to combine the efforts of DSI & DHSWS, respectively and to extend a hand to collaborators and to craft a combined Science Innovation and Transformative Technologies Roadmap for Sustainable Human Settlements (SITT 4 SHS Roadmap).

At the the **2020 Human Settlement Indaba**, participants adopted a **declaration** on strategic partnerships to transform human settlements for spatial justice and social cohesion. This declaration included, inter alia to “ensure a systematic but progressive approach to ITT through the Science and Innovation Transformative Technologies 10 Year Road Map.”

The Indaba was attended by the Ministries of Cooperative Governance and Traditional Affairs, Public Works and Infrastructure, Agriculture, Land Reform and Rural Development, MECs of Human Settlements, Mayors, banking institutions, developers, civil society and community-based organisations. In light of the signing of the Declaration, a progressive increase in investment partners and funding can be further stimulated and brought on board over time.

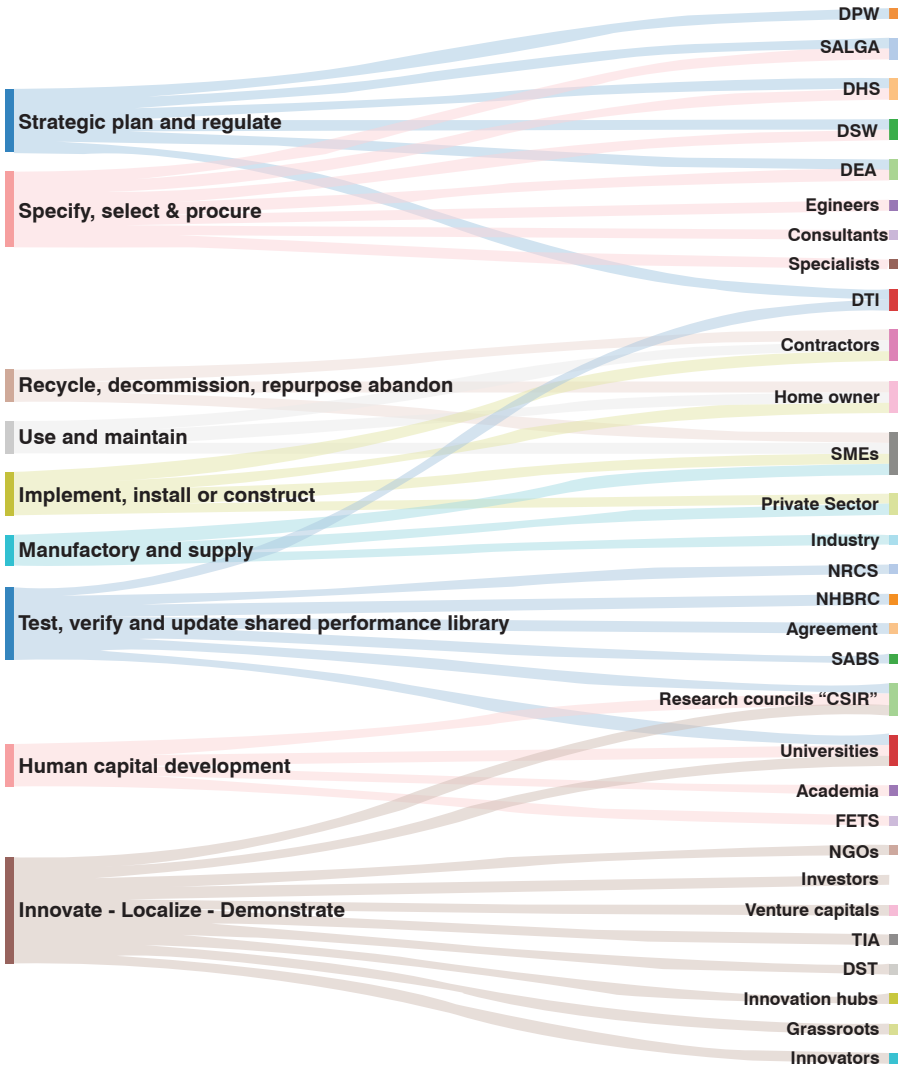
The drafting of the Roadmap involved generous contributions by various partners, recognised in the **acknowledgements** section of this document, most of whom will continue to support and participate in the implementation. For further detail on the roles and mandates of stakeholders, see the **synthesis report**.

10.2. Investment Partners

During a round table discussions convened by the National Department of Human Settlements, Water and Sanitation, stakeholders committed to formally partner, collaborate and implement their plans jointly with Government to achieve and ensure that the culture of innovation in embedded in the sector with technology diffusion over the years as well as directed human capability.

Organisations confirming commitment at the Human Settlements Roundtable for Innovative and Transformative Technologies, 11 October 2019 Soshanguve are recorded below, with funding where identified, indicated:

- Black Business Council Voluntary Association/ In-kind
- CSIR/ Under contract
- Department of Environmental Affairs, Forestry and Fisheries/ GIZ
- Department of Science and Innovation/ Treasury
- Gauteng Institute for Architects Voluntary Association/ In-kind
- IBT Association
- Mangusuthu University of Technology
- National Department of Human Settlements, Water and Sanitation
- Nelson Mandela Bay Metropolitan Municipality
- NHBRC
- University of Johannesburg
- Western Cape Department of Human Settlements Treasury/ ring-fenced



10.3. Bi-lateral Agreements

A formal Collaborative Agreement was concluded between the DSI and DHSWS for cooperation in the development and utilisation of Scientific, Technological and Innovation activities for development purposes, which makes provision for cooperation on the Roadmap and Implementation (pg 10).

Terms of Reference were prepared to provide guidelines for the functioning of the National Stakeholder Forum for SITT 4 SHS definition and it's Steering Committee, set out roles and responsibilities and matters attendant thereto. This arrangement can be renewed for the Roadmap Implementation phase for the stakeholders identified above, and additional partners as they agree to participate.

10.4. Co-operative Research Centre

In order to increase the spatial footprint of innovation in South Africa, the 2019 White Paper on Science, Technology and Innovation envisages a future through hubs of innovation expanded to enhance provincial growth and development strategies, and promote provincial technology competencies. It further envisages, cooperative research centres involving industry, science councils and higher education institutions and local innovation ecosystems will be developed, where appropriate. The Roadmap Implementation can be positioned as a cooperative research centre.

10.5. Governance and Institutional Structures

For Roadmap Implementation, which will be from 2020 to 2030, the formalised partnerships and institutional arrangements, based on extant DSI Roadmap programmes, is proposed in the roadmap implementation plan.

An essential organogram is presented in Figure 15. It is proposed that there are distinct governance, M&E, advisory, management and implementation roles, and that such roles are formalised.

10.6. Risks

Risk to successful implementation of the Roadmap could be as follows:

10.6.1. Political Factors

- Churn in government structures
- Lack of continuity or endurance of stakeholder partnerships
- Institutional rigidity
- Civil unrest stemming from discontent on service delivery

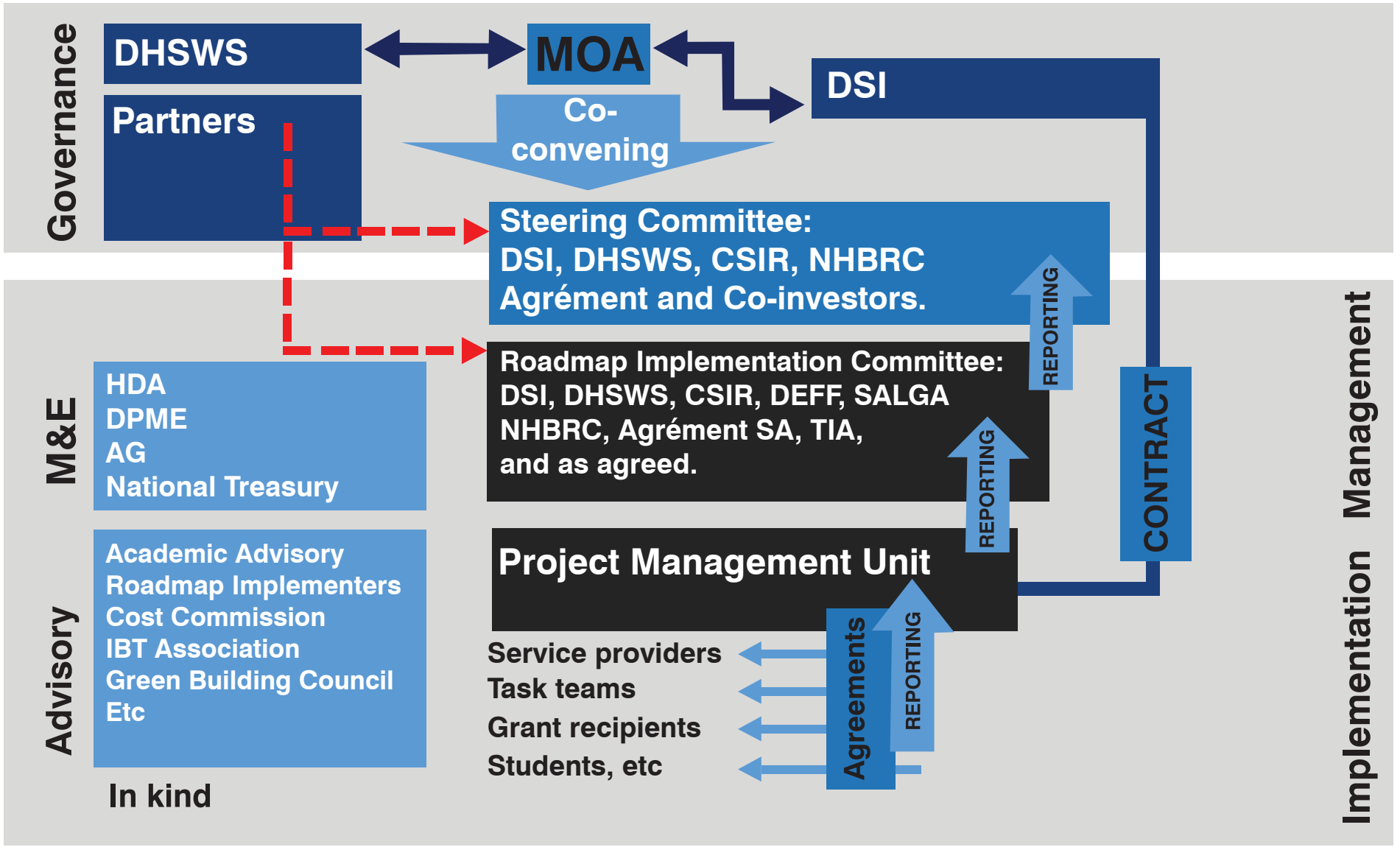


Figure 21: Proposed institutional arrangements for the SITT 4 SHS Roadmap implementation (Source: implementation plan)

10.6.2. Economic Factors

- Lack of economic growth
- Challenges in attracting investment from private public and private sector
- Funding grants and initiatives
- Disposable income of consumers
- Disposable income of businesses
- Wage rates
- Financing capabilities

10.6.3. Social Factors

- Inequality leading to social unrest
- Community resistance to innovation
- Market uptake
- Industrial reviews and consumer confidence
- Losing momentum and not achieving project goals

10.6.4. Technological Factors

- Producing goods and services
- Competitors
- Lack of technological progression
- Distributing goods and services
- Communicating with target markets

10.6.5. Environmental Factors

- Complacency or indifference
- The lack of raw materials
- Pollution and green-house gas emissions
- Climate and weather
- Environmental degradation

10.6.6. Legal Factors

- Health and safety
- Equal opportunities
- Consumer rights and laws
- Procurement challenges
- Future legislation

10.6.7. Procurement and Contracting

It is anticipated that participating entities shall generally source and fund their own participation and operate in accordance with their organisational policies. From time to time, to realise the Roadmap vision, procurement of goods and services will be required. This can be undertaken, under contract, through the PMU.

All procurement and contracting must be undertaken in accordance with the law, including the Public Finance Management Act (PFMA), Preferential Procurement Regulations, (PPPFA), Employment Equity, Treasury Regulations, and principles of good governance, as applicable. The following principles should be applied:

- Selection of service providers, suppliers, beneficiaries to be ethical, transparent and fair
- Gender, race and disability transformation targets required
- Youth targeting
- Local economic development and supply chains supported
- Record keeping standards suitable for audit

Compliance with grant and funders reporting requirements will be managed by the PMU.

SECTION F:

KEY PERFORMANCE INDICATORS

11. Background

Two target setting and performance evaluation techniques have been proposed to evaluate the performance of the Roadmap during its implementation phase. Continuous formative evaluation is proposed to assess progress in an ongoing manner, and Key Performance Indicators have been formulated with a set measurable targets, against which the success of the Roadmap Implementation can be gauged.

11.1. Formative Evaluation

Formative evaluation is designed to measure the impact of something while it is taking place and allows for incremental, nearly continuous quality improvements to be made. Formative evaluation allows for learning-in-action and reflexivity and is therefore the proposed application for the evaluation framework proposed in this Framework. Formative evaluation can be undertaken internally, by the Roadmap Implementation Committee on a regular, say quarterly, basis.

Monitoring should be an independently performed, say annually, by a trusted third party with a purpose of providing constructive feedback and to make adjustments to the Roadmap course. A summary monitoring and evaluation framework is provided in Appendix B. See full explanation in monitoring and evaluation report.

11.2. Key Performance Indicators

Key performance indicators (KPIs), which are summarised in Table 4 below were developed for the Roadmap implementation. The approach to their development is discussed in full in key performance indicators report, and the targets, aligned with project implementation plan presented earlier in this document are tabulated in Appendix A.

12. Introduction

To introduce step changes and support projects, niches and activities from a wide range of stakeholders whose effort introduces transformative change through innovation in sustainable human settlements, the STI4SHS Roadmap set out nine key specific objectives over and above the four broad objectives articulated in the background section of the document. These nine key specific objectives supports and aligns with the transformative innovation policy 12 transformative outcomes which connects to three processes of transformation: Successful niche building; niche expansion and embedding; and destabilisation and opening up of socio-technical regimes.

The nine specific STI4SHS Roadmap objectives as well as the 12 transformative outcomes are listed below and further mapped out with associated key performance indicators that should be measured and monitored in the ten year period to assess whether there is sufficient portfolio of activities that are introducing change in the sector through technology and innovation and resulting in small step changes towards achieving the vision of smart and innovative sustainable human settlements.

13. Nine Specific STI4SHS Roadmap Objectives

1. Technology demonstration and piloting
2. Learning
3. Scale-up and replication
4. Influence policy, norms and standards
5. Partnership with industry and business
6. New technology products and pipeline
7. Social behaviour change and cultural transition
8. Knowledge generation
9. Co-ordination of Actor Network

14. Twelve Transformative Innovation Policy (TIP) Outcomes

Below is a list of 12 transformative outcomes that have been adopted to support the Roadmap nine specific objectives and to frame the Roadmap key performance indicators.

14.1. Successful Niche Building

1. Shielding – broadening and deepening
2. Learning – broadening and deepening
3. Networking – broadening and deepening
4. Expectation dynamics – broadening, deepening , opening up

14.2. Niche Expansion and Embedding

5. Upscaling – increase user adoption
6. Replication – local and trans local
7. Circulation – accumulating and intermediating
8. Institutionalisation – creating formal and informal rules

14.3. Destabilisation and Opening up of Regimes

9. Destabilisation – de- aligning/disruptive change to subsystems and regimes
10. Opening-up – unlearning and deep learning of regime actors
11. Empower niches – regime interactions
12. Changing perceptions of landscape pressures

15. STI4SHS Roadmap Specific Objectives, Transformative Outcomes and Key Performance Indicators

Table 2: STI4SHS Roadmap Specific Objectives, Transformative outcomes and Key Performance Indicators

		Transformative Outcomes and Key Performance Indicators for the Roadmap			2020/21 - 2023/24		2023/24 - 2026/27		2026/27	2029/30
					Planned	Achieved	Planned	Achieved	Planned	Achieved
Roadmap 9 Objectives	**Transformative Objectives**	**Niche Construction**	**Transformative Outcome Indicator**	**Roadmap Indicator**						
Tech demonstrations and piloting 1.	Build and support innovation niches to allow certain niches to be experimented or trialed, ensure system wide learning by variours groups of actors and individuals and ensure an inclusive ecosystem of playors oriented towards distabilising teh established systems or regimes in order to achieve transformational change in the sustainable human settlements sector	Shielding - broadening and deepining of niches by providing protective space of new niches	Number of new Niches introduced; Number of existing niches supported; Number of niches mantained; Number of Number of Tech demonstrated / piloted		Introduced = 3 Supported = 6 Mantained = 3 Demonstartion pilots = 2		Introduced = 6 Supported = 12 Mantained = 6 Demonstartion pilots = 4		Introduced = 7 Supported = 13 Mantained = 7 Demonstartion pilots = 5	

		Transformative Outcomes and Key Performance Indicators for the Roadmap			2020/21 - 2023/24		2023/24 - 2026/27		2026/27	2029/30
					Planned	Achieved	Planned	Achieved	Planned	Achieved
Roadmap 9 Objectives	**Transformative Objectives**	**Niche Construction**	**Transformative Outcome Indicator**	**Roadmap Indicator**						
Learning 2.		Learning- broadening and deepening through ensuring that learning does not remain with groups involved or individulas but is system wide i.e. how failure is addressed by the system, , learning is distributed, learning is non codified	Number of learning initiatives; Number of documentatio and dissemination niches;		Learning initiaties = 3 Documentation and I dissemination niches = 2		Learning initiaties = 7 Niches documented and disseminated = 4		Learning initiaties = 8 Niches documented and disseminated = 5	
		Networking - broadening and deepening; interaction between novel actors with novel technologies with incumbent actors to enable diffucion of ideas, inclusiveness of actors involved	Number of 1st order learning platforms; Number of 2nd order learning platforms		1st order learning = 1 2nd order learning = 1		1st order learning = 2 2nd order learning = 2		1st order learning = 3 2nd order learning = 3	
		Platforms that support circulation of ideas, knowledge and sharing of resources	Number of policy dialogues		Policy dialogues = 3		Policy dialogues = 6		Policy dialogues = 7	
		Accelerating and embedding niche innovations								

		Transformative Outcomes and Key Performance Indicators for the Roadmap			2020/21 - 2023/24		2023/24 - 2026/27		2026/27	2029/30
					Planned	Achieved	Planned	Achieved	Planned	Achieved
Roadmap 9 Objectives	**Transformative Objectives**	**Niche Construction**	**Transformative Outcome Indicator**	**Roadmap Indicator**						
Scaling up and Replication 3.	Upscaling and embedding niches and innovations for STI4SHS by replicating locally and translocally and creating structures and capacity (including those that are outside of DST projects) to support and advance replication, translating learning , circulation of ideas and new knowledge through intermediary actors and setting up learning platforms, ensuring interaction of niches and enhancement of these niches to influence policy and destabilise the landscape through innovation	Upscaling - increase user adoption and embedding of technologies / innovation niches	Number of Niches Upscaled from pilot niches to large scale niches		Niches upscaled / mainstreamed = 1		Niches upscaled / mainstreamed = 2		Niches upscaled / mainstreamed = 3	
		Replication - locally and translocally; support structures that are in place to advance replication; doing the same experiments else where	Number of Niches replicated else where; Number of structures supporting niche upacaling and replication;		Niches replicated = 1		Niches replicated = 2		Niches replicated = 3	
		Circulation - accumulating and intermediating (support the flow of ideas, knowledge and resources)	Number of structures / initiatives supporting ideas circulation and learning		Niche supporting structures = 1		Niche supporting structures = 2		Niche supporting structures = 3	
		Platforms that support circulation of ideas, knowledge and sharing of resources	Number of platforms for idea circulation		Idea circulation = 2		Idea circulation = 4		Idea circulation = 3	

		Transformative Outcomes and Key Performance Indicators for the Roadmap			2020/21 - 2023/24		2023/24 - 2026/27		2026/27	2029/30
					Planned	Achieved	Planned	Achieved	Planned	Achieved
Roadmap 9 Objectives	**Transformative Objectives**	**Niche Construction**	**Transformative Outcome Indicator**	**Roadmap Indicator**						
		Platforms and decision support tools for embedding niche innovations - creating formal and informal rules	Number of Niches embedded, institutionalised and mainstreamed as part of the routines in households or in the settlement sector		Niches institutionalised = 1		Niches institutionalised = 2		Niches institutionalised = 3	
			Number of platforms and tools supporting niche institutionalisation and embedding		Niches support for institutionalisation = 1		Niches support for institutionalisation = 1		Niches support for institutionalisation = 2	
		Destabilisation, disrupting the subsystem and opening up of regimes								
Influence Policy, Norms and Standards 4.	Re-alignining and disrupting elements of the established non innovative regimes through unlearning and reflexive learning by all regime actors; empowering, nuturing and enhancing niche interaction and the actor network or ecosystem and change perceptions, change the sustainable human settlements landscape by removing negative pressures hindering transformative change through innovation	Influence on policy, standards, regulations - institutionalisation	Number of existing policies, regulation reviewed and distabilised		Policy/regulation influenced = 1		Policy/regulation influenced = 1		Policy/regulation influenced = 1	
		Destabilise and influence on procurement norms and standards	Number of niche related procurements		Procurement process influenced = 1		Procurement process influenced = 1		Procurement process influenced = 1	

		Transformative Outcomes and Key Performance Indicators for the Roadmap			2020/21 - 2023/24		2023/24 - 2026/27		2026/27	2029/30
					Planned	Achieved	Planned	Achieved	Planned	Achieved
Roadmap 9 Objectives	**Transformative Objectives**	**Niche Construction**	**Transformative Outcome Indicator**	**Roadmap Indicator**						
		Influence on service delivery options available to government/ municipalities	Openess of STDs and procurement processes		Openness of standards and norms = 1		Openness of standards and norms = 1		Openness of standards and norms = 1	
		Enabling policy instrument -uptake and acquisition support instruments	Number of policy instruments supporting uptake		Policy instrument for uptake = 1		Policy instrument for uptake = 1		Policy instrument for uptake = 1	
		Funding and budget allocations	Increase in siize of funding allocations to niches		Increased Funding for niches = 1		Increased Funding for niches = 1		Increased Funding for niches = 1	
		Vetting and certification of new products	Vetting and certification protocols		Vetting / certification protocol = 1		Vetting / certification protocol = 1		Vetting / certification protocol = 1	
		Policy briefs implemented / uptaken to influence policy	Number of policy briefs uptaken		Policy briefs = 1		Policy briefs = 2		Policy briefs = 2	
		New Support and maintenance models uptaken	Niches support and mantainance structures		Niche supporting structures = 1		Niche supporting structures = 2		Niche supporting structures = 2	

		Transformative Outcomes and Key Performance Indicators for the Roadmap			2020/21 - 2023/24		2023/24 - 2026/27		2026/27	2029/30
					Planned	Achieved	Planned	Achieved	Planned	Achieved
Roadmap 9 Objectives	**Transformative Objectives**	**Niche Construction**	**Transformative Outcome Indicator**	**Roadmap Indicator**						
		Opening up unlearning and deep learning by regime actors (policy dialogues, policy seminars)			Policy dialogues = 1		Policy dialogues = 3		Policy dialogues = 4	
		Empowering niche players, regime interaction and connections of multiple niches	Number of niches interacting, collaborating to become mega niches		Niches interacting = 2		Niches interacting = 4		Niches interacting = 5	
		Monitor changing perceptions of the landscape pressure	Number of landscape pressure changes		Landscape pressure changed = 1		Landscape pressure changed = 1		Landscape pressure changed = 1	
		Identifying and reassessing new sti4shs landscape pressures and trends - to understand the changing perceptions on landscape pressures	Number of socio-technical regimes destabilised		Socio-technical regime destabilised = 0		Socio-technical regime destabilised = 1		Socio-technical regime destabilised = 1	
		New policy or standards reconfiguration	Number of human settlements policy adjustments		Policy adjusted = 0		Policy adjusted = 1		Policy adjusted = 1	
		Deploy niche champions, innovation policy disrupters and transformative innovation orchestrators	Number of regime change actors such as orchastrators and policy transition champions		Increase policy actors = 4		Increase policy actors = 8		Increase policy actors = 10	
		New Innovative products for SHS, Business / SMME involvement, Investments and Funding								

		Transformative Outcomes and Key Performance Indicators for the Roadmap			2020/21 - 2023/24		2023/24 - 2026/27		2026/27	2029/30
					Planned	Achieved	Planned	Achieved	Planned	Achieved
Roadmap 9 Objectives	**Transformative Objectives**	**Niche Construction**	**Transformative Outcome Indicator**	**Roadmap Indicator**						
Partnership with Industry and Business 5.	To enable, to create and support STI4SHS innovation businesses / SMME's at various levels that can generate more than a large number of permanent high-level jobs and almost products that can be supported, developed and commercialized, deployed and mainstreamed into sustainable human settlements over a 10-year period;	Jobs (FTE)		Number of new job opportunities linked to niches	2		10		20	
		Start-ups/ new ventures		Number of start-up SME's linked to niches and regimes	3		8		16	
		Franchise		Number of franchise business opportunities linked to new socio-technical systems	1		1		1	
		Number of new STI 4SHS patents /IP protected		Number of IP protected / generated related to transition	2		2		6	

		Transformative Outcomes and Key Performance Indicators for the Roadmap			2020/21 - 2023/24		2023/24 - 2026/27		2026/27	2029/30
					Planned	Achieved	Planned	Achieved	Planned	Achieved
Roadmap 9 Objectives	**Transformative Objectives**	**Niche Construction**	**Transformative Outcome Indicator**	**Roadmap Indicator**						
New technology product pipeline 6.		Number of new STI 4SHS product developed for the market		Number of STI4SHS products accessing the market-market size and uptaken n the sustainable human settlements sector	3		6		9	
		SMME's		Number of SMME's and Business participating in Niches	3		9		12	
		Private sector investments / funding								
		Public sector investments / funding		Number / size of private sector investment supporting niches / funding STI 4SHS products	R200K		R400K		R600K	

		Transformative Outcomes and Key Performance Indicators for the Roadmap			2020/21 - 2023/24		2023/24 - 2026/27		2026/27	2029/30
					Planned	Achieved	Planned	Achieved	Planned	Achieved
Roadmap 9 Objectives	**Transformative Objectives**	**Niche Construction**	**Transformative Outcome Indicator**	**Roadmap Indicator**						
		Products from registers / databases		Number of products from registries and databases forming niches and uptaken as standard products in households / settlements	6		12		18	
		Technologies uptken as standard practice in the human settlement sector		Number of technologies mainsreamed in the human settlement sector	2		4		6	
		Advocacy, Perceptions, Culture Shift and Social Acceptance								
Social Behaviour Changes and Culture Transition 7.	Supporting culture transition , stimulating social acceptance, creating safe social spaces and changing established percentions, attitudes and behaviours and societal routine in order to allow upscaling	Researching culture and social perceptions of niches		Number of social acceptance and behavioral change niches	2		6		12	
		Community outreach for different niches		Number and impact of community outreach niches	1		3		7	
		Awareness campaigns niche specific		Number of User Involvement Niches	3		6		9	
		Social acceptance and impact evaluation								
		Community participation and user involvement								

		Transformative Outcomes and Key Performance Indicators for the Roadmap			2020/21 - 2023/24		2023/24 - 2026/27		2026/27	2029/30
					Planned	Achieved	Planned	Achieved	Planned	Achieved
Roadmap 9 Objectives	**Transformative Objectives**	**Niche Construction**	**Transformative Outcome Indicator**	**Roadmap Indicator**						
		Beneficiary attitudes surveys		Number of niches influencing beneficiary / user attitudes	1		2		6	
		PR exercise , communication, marketing and dissemination								
		Culture and percention change								
		User training and education		Number of community culture change niches	2		4		5	
		Peer networks and social mentorships								
		HCD and skills and knowledge products								
Knolwedge Generation 8.	Building a body of knowledge through research and development capacity building across 7 transformative outcomes of the STI4SHS roadmap and targeted outputs of the roadmap, clusters of the roadmap i.e.future technologies, culture of innovation, digitised enterprise, STI4shs throught leasdership, actors network, SMMEs, new technology product pipeline, strategic projects etc The prioritisation and development of STI partnerships with the Universities and research institutions addressing key research and development outputs and human capital development addressing STI for sustainable human settlements and smart communities.	Internships in STI 4SHS related work								

		Transformative Outcomes and Key Performance Indicators for the Roadmap			2020/21 - 2023/24		2023/24 - 2026/27		2026/27	2029/30
					Planned	Achieved	Planned	Achieved	Planned	Achieved
Roadmap 9 Objectives	**Transformative Objectives**	**Niche Construction**	**Transformative Outcome Indicator**	**Roadmap Indicator**						
		In-service (workplace-based) skills in STI4SHS related work								
		Technical and vocational training in STI4SHS field								
		Tertiary academic								
		Undergraduates Degree with modules/ degree related to the field								
		Honours with moduels / degree related to the field								
		Masters degreed with modules related to the field		Number of PhD's and Masters supported	2		2		2	
		Doctoral focusing on STI4SHS area								

		Transformative Outcomes and Key Performance Indicators for the Roadmap			2020/21 - 2023/24		2023/24 - 2026/27		2026/27	2029/30
					Planned	Achieved	Planned	Achieved	Planned	Achieved
Roadmap 9 Objectives	**Transformative Objectives**	**Niche Construction**	**Transformative Outcome Indicator**	**Roadmap Indicator**						
		Post doctoral focusing on STI4SHS								
		Research papers		Number of research papers	5		10		15	
		Publications (academic)								
		Partnerships, Actor Network Coordination (Academic Research insitituions, Business Groups, Government and NGO's)	Niche Construction							
Coordination of actor network 9.	To coordinate a wide range of actors and actor network running different niches designed to diffuse ideas that are changing the existing sustainable human settlements regime throgh innovation. To understand what each niche by different actors aim to achieve, analyse teh network and it actors, unlocking path dependencies between niches. Identify and mobilise new actors in to the actor network and coordinate the network ensure marginal "voices" or group niches are surfaced and made visible and coordinate costs and benenits between different niches, individuals and actor groups from the public and private sector.	Partnerships with local research institutions	Networking - broadening and deepening; interaction between novel actors with novel technologies with incumbent actors to enable diffucion of ideas, inclusiveness of actors involved	Number of research institutions researching on the socio-technical sysems for STI for SHS	1		3		3	

		Transformative Outcomes and Key Performance Indicators for the Roadmap			2020/21 - 2023/24		2023/24 - 2026/27		2026/27	2029/30
					Planned	Achieved	Planned	Achieved	Planned	Achieved
Roadmap 9 Objectives	**Transformative Objectives**	**Niche Construction**	**Transformative Outcome Indicator**	**Roadmap Indicator**						
		Partnerships with international research institutions	Networking - broadening and deepening; interaction between novel actors with novel technologies with incumbent actors to enable diffucion of ideas, inclusiveness of actors involved	Number of international niches supporting local transformation	1		1		1	
		Int. public/private sector new product development partnerships	Networking - broadening and deepening; interaction between novel actors with novel technologies with incumbent actors to enable diffucion of ideas, inclusiveness of actors involved	Number of public and private sector socio -technical regime change patnerships	2		3		6	
		Local public/private sector new product development partnerships	Networking - broadening and deepening; interaction between novel actors with novel technologies with incumbent actors to enable diffucion of ideas, inclusiveness of actors involved							

		Transformative Outcomes and Key Performance Indicators for the Roadmap			2020/21 - 2023/24		2023/24 - 2026/27		2026/27	2029/30
					Planned	Achieved	Planned	Achieved	Planned	Achieved
Roadmap 9 Objectives	**Transformative Objectives**	**Niche Construction**	**Transformative Outcome Indicator**	**Roadmap Indicator**						
		Municipalities	Networking - broadening and deepening; interaction between novel actors with novel technologies with incumbent actors to enable diffucion of ideas, inclusiveness of actors involved	Number of municipal partnerships	3		6		9	
		Government departments	Networking - broadening and deepening; interaction between novel actors with novel technologies with incumbent actors to enable diffucion of ideas, inclusiveness of actors involved	Number of government niches	5		7		10	
		Independent lobby groups	Networking - broadening and deepening; interaction between novel actors with novel technologies with incumbent actors to enable diffucion of ideas, inclusiveness of actors involved	Number of lobby, associate and professional groups	1		2		3	

		Transformative Outcomes and Key Performance Indicators for the Roadmap			2020/21 - 2023/24		2023/24 - 2026/27		2026/27	2029/30
					Planned	Achieved	Planned	Achieved	Planned	Achieved
Roadmap 9 Objectives	**Transformative Objectives**	**Niche Construction**	**Transformative Outcome Indicator**	**Roadmap Indicator**						
		Systematic innovation intermediaries	Networking - broadening and deepening; interaction between novel actors with novel technologies with incumbent actors to enable diffucion of ideas, inclusiveness of actors involved	Number of technology innovation intermediaries	4		4		4	
		Communities, cooperatives and user beneficiaries	Networking - broadening and deepening; interaction between novel actors with novel technologies with incumbent actors to enable diffucion of ideas, inclusiveness of actors involved	Number of NGO niches	3		6		9	
		NGO's	Networking - broadening and deepening; interaction between novel actors with novel technologies with incumbent actors to enable diffucion of ideas, inclusiveness of actors involved							

		Transformative Outcomes and Key Performance Indicators for the Roadmap			2020/21 - 2023/24		2023/24 - 2026/27		2026/27	2029/30
					Planned	Achieved	Planned	Achieved	Planned	Achieved
Roadmap 9 Objectives	**Transformative Objectives**	**Niche Construction**	**Transformative Outcome Indicator**	**Roadmap Indicator**						
		Actor network coordination forums and governance structures	Networking - broadening and deepening; interaction between novel actors with novel technologies with incumbent actors to enable diffucion of ideas, inclusiveness of actors involved	Number of actor network coordination forums	2		2		2	
		Industry - Academic Partnerships	Networking - broadening and deepening; interaction between novel actors with novel technologies with incumbent actors to enable diffucion of ideas, inclusiveness of actors involved	Number of industry niches	4		8		12	
		Marginal Voices and Lobby Groups	Networking - broadening and deepening; interaction between novel actors with novel technologies with incumbent actors to enable diffucion of ideas, inclusiveness of actors involved	Number of niches for the marginalised voices	1		1		1	

16. SITT4SHS Roadmap Clusters, Cluster objectives, Transformative outcomes and existing niches

The table below indicates how different roadmap clusters and pathways map against the 12 transformative outcomes and which existing stakeholder niches/initiatives already support a particular cluster / pathway objectives. The table should be used for progress reporting and also cataloguing existing projects and how such projects supports Roadmap clusters and their initiatives. The mapping below also provides a good indication of gaps in terms of niches/ initiatives where there is no effort or where there is high concentration of stakeholder interventions and where new niches/ initiatives should be introduced and supported in order to achieve the envisaged step changes and transformative impact.

Table 3: STI4SHS Roadmap Clusters, Cluster objectives, Transformative outcomes and existing niches

Clusters / Pathways	Cluster / Pathway objective	Initiatives	Roadmap Objective Number Addressed	Transformative Outcome Addressed	Current Niches	
Culture of Innovation 1.	Creating an institutional culture of innovation and an enabling policy environment	Enabling policy environment for innovation uptake in human settlements sector	4.	Destabilisation, disrupting the subsystem and opening up of regimes		
		Policy dialogues	4.	Learning- broadening and deepening through ensuring that learning does not remain with groups involved or individulas but is system wide i.e. how failure is addressed by the system, , learning is distributed, learning is non codified	ITT policy and programme established (NDoHS)	ITT framework approved (NDoHS)

Clusters / Pathways	Cluster / Pathway objective	Initiatives	Roadmap Objective Number Addressed	Transformative Outcome Addressed	Current Niches										
		Strong guiding coalition through thought leadership	9.	Networking - broadening and deepening; interaction between novel actors with novel technologies with incumbent actors to enable diffucion of ideas, inclusiveness of actors involved		ITT Social Contract with stakeholders (NDoHS)		IBT Association	ITT Roundtable Discussions (NDoHS)						
		Procurement and funding													
			4.	Destabilisation, disrupting the subsystem and opening up of regimes	Investors Forum for Innovations in Human Settlements (NDoHS)	Approved IBT Implementation Guidelines (NHBRC)									
Digitised Enterprise 2.	Digitalised human settlements business processes and environment	Analyse technology trends	8.												
		Smart utilities	6.												
		Enabling decision support tools and evidence based policy			Approved IBT Implementation Guidelines (NHBRC)	Review of IBT Database (NHBRC)		Green Rating Tool for Human Settlements / Residential sector (DEA)	RedBook and the Green Book (CSIR)						
		Knowledge platforms	8.												
		Digital business processes	4.												
		Data Science and big Data	4.												
Clusters / Pathways	Cluster / Pathway objective	Initiatives	Roadmap Objective Number Addressed	Transformative Outcome Addressed	Current Niches										

Clusters / Pathways	Cluster / Pathway objective	Initiatives	Roadmap Objective Number Addressed	Transformative Outcome Addressed	Current Niches										
Strategic projects 3.	Priority strategic interventions and projects	Climate change flagship projects	3.		Energy efficient Retrofiting (Municipalities)	Flashloods Rain Water Harvesting (DEA)									
		Technology pilots and demonstration projects	3.		50 3D printed houses (DSI / UJ)	Green First, ZERO energy model house (NHBRC)		Innovation Based Housing Typologies (GI of Architecture)	Green First, ZERO energy model village (NHBRC)	Hydrogen Fuel Cell in Human Settlements (DSI)	Ndlambe Green Village (CSIR)	Kwamadiba Small Scale hydropower Mini-grid (DSI)	Eric Molobi ABT Centre (NHBRC)		
		Catalytic and scaling up initiatives	3.		IBT Subsidy Housing projects (Provincial HS)										
		Future and Frontier Technologies (4th IR, Convergence, IoT, AI, Blockchain)	6.		Green Utilities Managament for the Bulding Sector (DEA)	Smart Geyser and Smart Sensors (CSIR)		Off-grid Sanitation Technologies (WRC)							
Technology pipeline 4.	Identify and support human settlements technology pipeline	Sector technology registers and databases	6.		Agrement IBT Database	Human Settlements Technology Needs Assessment (DEA / CSIR)		Water innovations, waste, sanitation database (DSI Roadmaps)							
		STI4SHS Technology Database	6.												
		Living labs with social applications	1.												
		Annual showcases of new products	6.												
		SMME product development support	6.												

Clusters / Pathways	Cluster / Pathway objective	Initiatives	Roadmap Objective Number Addressed	Transformative Outcome Addressed	Current Niches										
Tecnology Diffusion 5.	Support the difussion and uptake of technological innovations in the human settlements sector and by the society	Market access	3.	Upscaling - increase user adoption and embedding of technologies / innovation niches	SMME for House Manufacturing Machine (WC Province)	Innovation and Smart Home Market Report (NHBRC)									
		Advocacy and training	7.	Opening up-ulearning and deep learning of regimes											
		Technology vetting	7.	Institutionalise - create formal and informal rules											
		Community of practice	7.												
		Community of Users	7.	Replication - locally and translocally; support structures that are in place to advance replication; doing the same experiments else where											
		Social acceptance evaluations	7.		Smart Home Awareness Campaign (DEA - GIZ)	Household Waste Management and Sorting (DEA)		Home Owner Educational Programme (NDoHS)							
Directed Capability 6.	Develop capable human capital development through R&D	Knowledge generation products	8.	Opening up-ulearning and deep learning of regimes											
		Human capital development	8.	Opening up-ulearning and deep learning of regimes	Construction and manufacturing capacity development plan (Black Business Council)	Training Academy for Innovation Building Technologies (NDoHS)									
		Research and Development	8.	Opening up-ulearning and deep learning of regimes	Innovations, Infrastructure and services research (NDoHS -MUT)										

SECTION G:

INVESTMENT PLAN

Table 4: Budget summary

STI4SHS ROADMAP TEN YEAR BUDGET (2020 - 2030)									
PATHWAYS/ CLUSTERS	**INITIATIVES**				**TOTAL**				**CUMMULATIVE**
Culture of Innovation	**Enabling Policy**	**Dialogues**	**Thought Leadership**	**Pricing and Funding**		**Short Term (2020 - 2022)**	**Short Term (2023 - 2025)**	**Short Term (2026 - 2030)**	
	R7.5m	R1.2m	R10m	R7.5m	R26.2m	R6.2m	R10m	R10m	R26.2m
Digitised Enterprise	**Trends**	**Smart Utilities**	**Enabling Decision Tools**	**Knowledge Platform**					
	R6m	R6m	R8m	R12m	R32m	R3.5m	R14.25m	R14.25m	R32m
Strategic Projects	**Flagship Projects**	**Pilots and Demos**	**Catalytic Scale-up**	**Futuristic Technologies**					
	R60m	R20m	R10m	R5m	R95m	R20m	R30m	R45m	R95m
Technology Pipeline	**Technology Register**	**Living Labs**	**Annual Showcase**	**SMME Support**					
	R3m	R5m	R5m	R10m	R23m	R3m	R10m	R10m	R23m
Technology Defusion	**Market Access**	**Advocay and Training**	**Technology Vetting**	**Community of Practice**					
	R6m	R5m	R7m	R6m	R24m	R4m	R10m	R10m	R24m
Directed Capability	**Knowledge Generation**	**R&D**							
	R12m	R12m			R24m	R4m	R10m	R10m	R24m
					R224.2m			**TOTAL**	**R224.2m**

SECTION H:

SITT4SHS TECHNOLOGY DATABASE / REGISTER

17. Introduction

The Department of Science and Technology (DST) is one of the key department's that plays a role in supporting mature technologies. Within the department, the Science and Technology for Sustainable Human Settlements (S&T for SHS) unit specifically supports SMMEs in the human settlements domain. As a result, the unit is frequency approached by innovators requesting some form of support to help increase the adoption and use of their technologies that have the potential to contribute toward the creation of more sustainable human settlements in South Africa.

The problem, however, is that the frequency of these SMME walk-ins has not only grown, but it has become increasingly complex over time as more and more technologies are introduced to the human settlement sector. This has resulted in the accumulation of disparate information that has impacted on the department's knowledge of the sector, as well as, its ability to effectively make decisions concerning how technologies are supported to widespread application and use.

In addition, to supporting mature technologies, the unit is mandated to gather knowledge, evidence and learning to inform and influence government's development of policies related, and selection of these technologies. Knowledge and learning gathered from and about SMMEs within human settlements will help the unit better understand the innovation sector within South African human settlements. With this improved knowledge and understanding, the unit will be better positioned to directly support new SMMEs or link them to organisations that may assist them with the further development of their innovations.

The Objective of the Sustainable Human Settlements Technology Database

With this in mind, the aim of the study was to investigate the innovation landscape within human settlements and thereafter develop a database of innovations relevant to the human settlements domain. The intention of this database was to collate information on SMMEs, their innovations and that of their potential support organisations.

- Identified innovators that are involved in creating sustainable human settlements with various STI products or practices.
- Identified support organisations, i.e. public and private sector organisations, industry, development finance institutions, development agencies and entities and private sector companies, that may provide SMMEs with support including (but not limited to), funding, technical support, entrepreneurship training, mentorship, or incubation.
- Developed an STI database of SMMEs, their innovations, and support organisations.

Figure 22 shows a screenshot of the collected information on innovators. Despite noticeable gaps in some categories, the background scans showed that energy efficiency and construction materials were the most common sectors in which innovation occurred within human settlements.

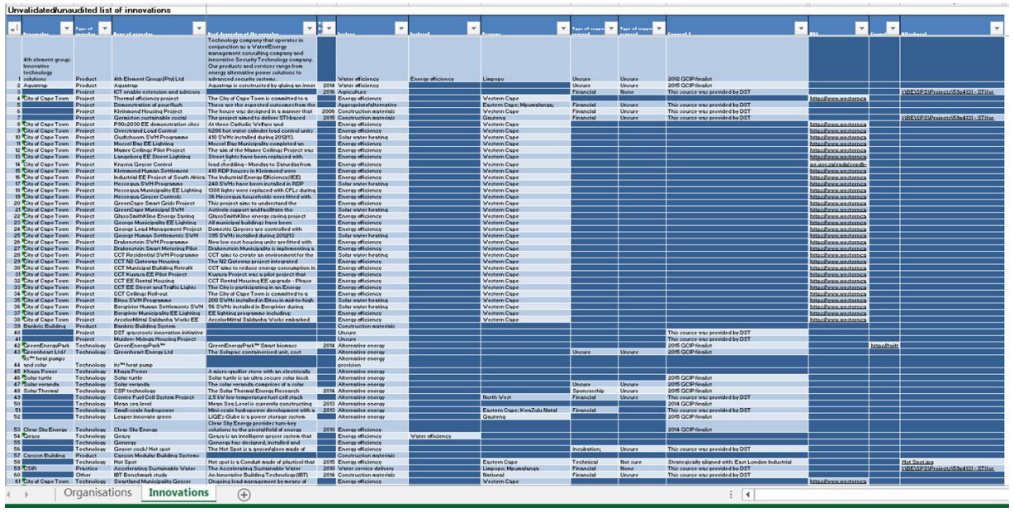


Figure 22: Screenshot of the spreadsheet with information on innovators and their innovations

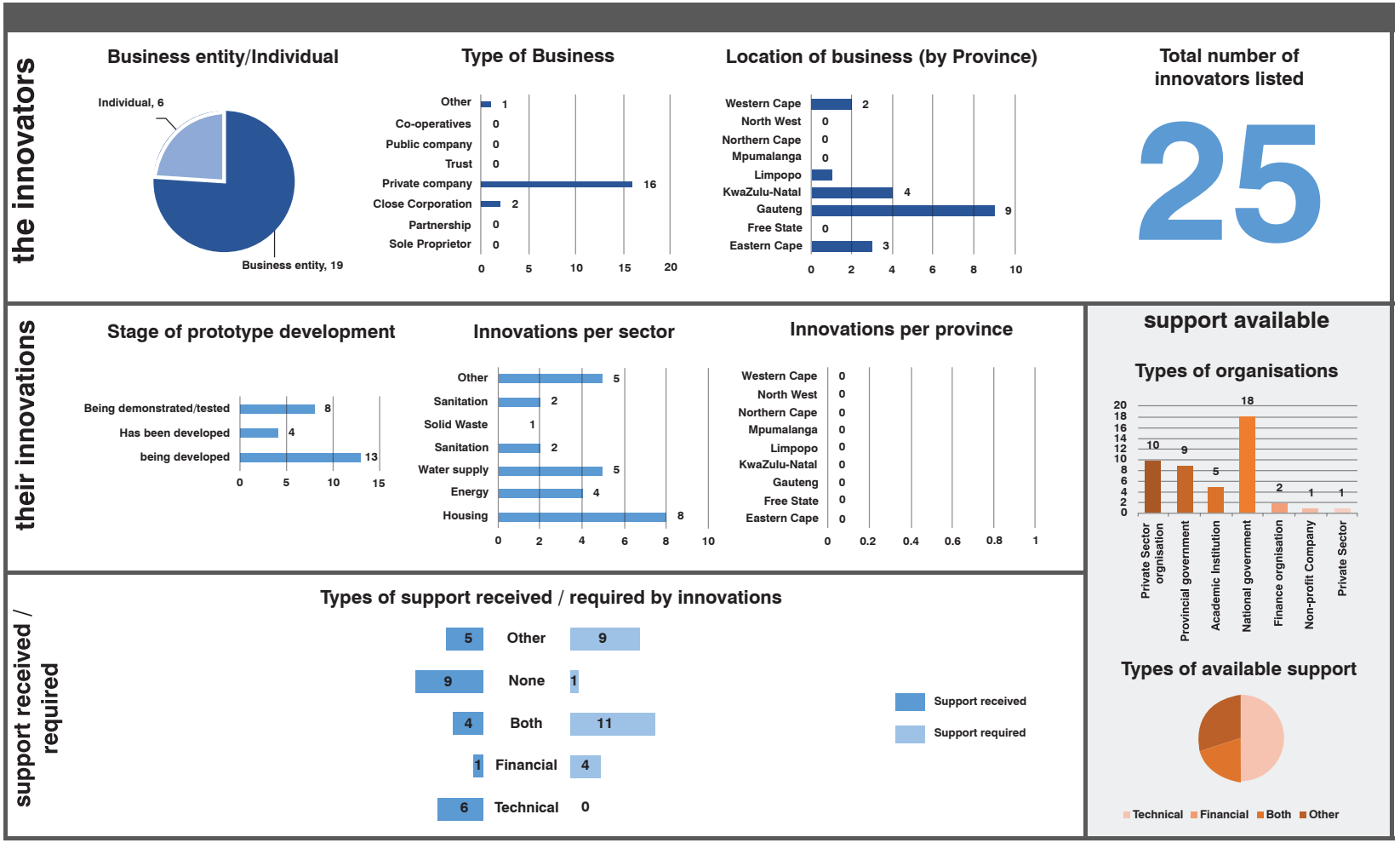


Figure 23: Screenshot of the STI4SHS Roadmap Technology dashboard

SECTION I:

IMPLEMENTATION PLAN

18. Implementation

The previous section tackled the Roadmap question "What should we do?" - lending content to the framework of the previous section. Section G tackles the Roadmap question: **"HOW SHOULD WE DO IT?"** by setting out an implementation plan.

The section sets outs funding targets, an approach to outcomes evaluation, and tabulates short, medium and long-term targets and KPIs.

Some systematic approach to prioritising investment is posited and a set of institutional arrangements to effect implementation of the Roadmap are proposed.

18.1. Section Overview

Section F of this document presented a set of initiatives, actions and initial focus areas for immediate implementation. This section reflects on funding, R&D investment portfolio can be managed over time, so that the Roadmap Implementation phase can be responsive and alive to emerging opportunity, as it presents. It discusses opportunity scouting and investment prioritisation.

18.2. Funding Targets

According to the 2019 White Paper on Science, Technology and Innovation, the government commits to increasing the levels of R&D investment in the economy so that gross expenditure on R&D (GERD) reaches 1.5 per cent of gross domestic product (GDP) in the next decade. An indicative budget of R318 M for Roadmap Implementation was identified with reference to 2 % of the current HSDG . Precedent was established in the DoRA of 2018, which ring-fenced at least 2 % of the HSDG to be allocated to programmes and projects for the implementation of innovative building technologies in the human settlements implementation delivery chain (National Treasury, 2018, p 167). Whilst this provision was not found in DoRA 2019 or 2020, it is understood that this would be an acceptable approach and was proposed at the 2nd Roadmap Steering Committee meeting.

It is anticipated that contributions in kind and through direct investment will be made by the key Roadmap Implementation Partners, as well as partners in particular initiatives. The work programme can be adapted to the actual budget availability. It should be noted that this amount reflects a core target and that the actual funds will be forthcoming also from DSI (although no firm commitment has yet been made), as well as from other partners.

[1]HSDG for 2020/21 estimated at R15 936 627' p.a based on DoRA (Treasury, 2019: p 49).

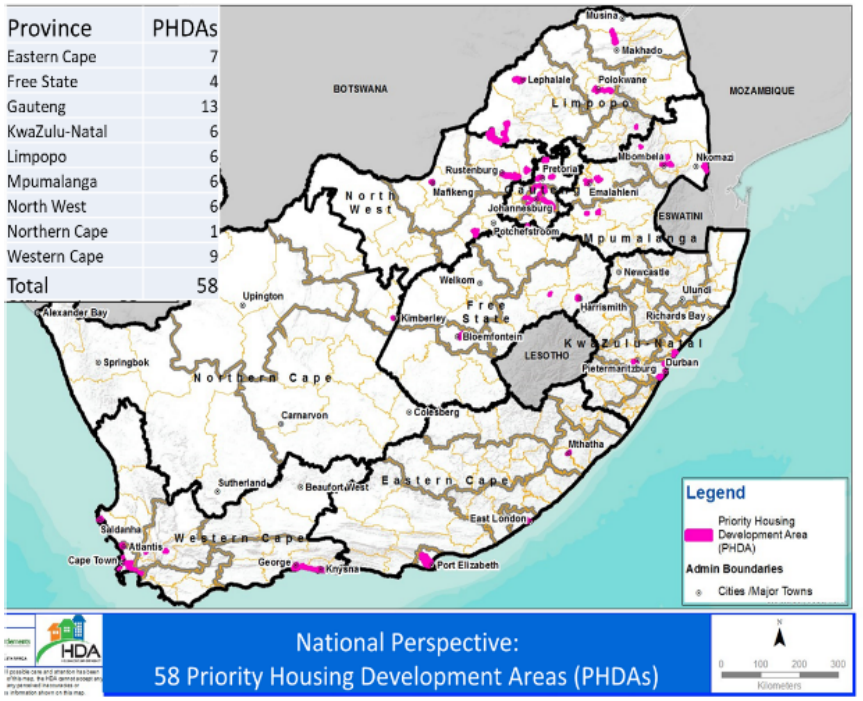


Figure 24: Priority Housing Development Areas (Source: DHSWS)

Short, medium and long term indicative budgets were presented in Table 2, per initiative, in the previous section of this Framework. A budget summary consolidated from the amounts shown in Table 2 is provided in Table 3, above.

19. Investment portfolio

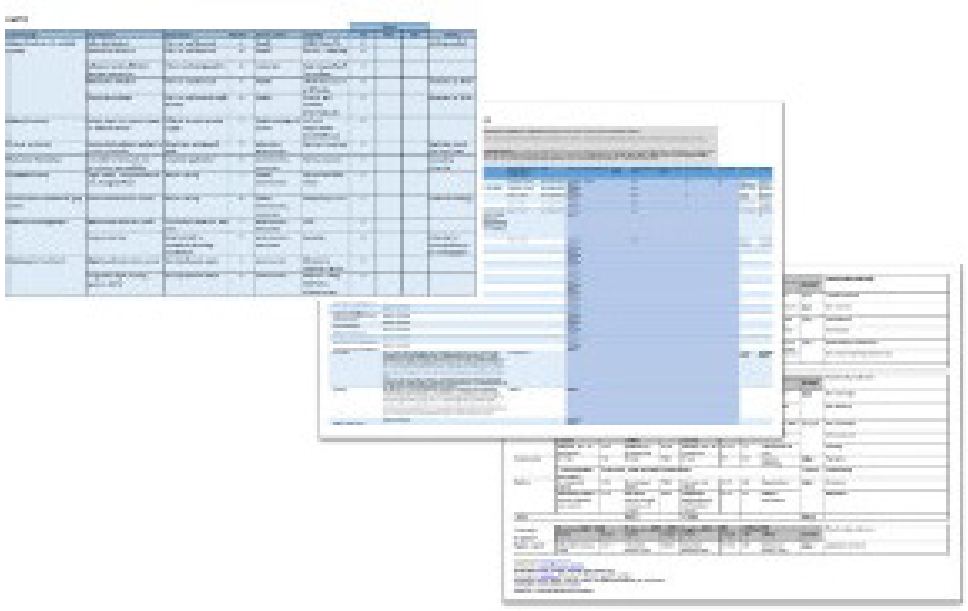
Opportunity scouting

The RIC will have the task of scouting for opportunity. Some of the planned Roadmap activities are designed to ensure that there is an ongoing surveillance of emerging trends, (to establish needs and "threats"), identification of promising SITT and a systematic review of success and failure of experiments (to replicate successes and avoid repeat mistakes). The following registers of SITT have been prepared, which will be dynamically updated, preferably automatically, throughout Roadmap Implementation.

Investment portfolio: A spreadsheet **database populated with over 250 identified emerging technologies** of relevance to the SITT and SHS markets in South Africa, gleaned from various databases and desktop research.

Technology register: A spreadsheet with **Project profiles per priority area and cluster** in each of seven priority categories. The technology register is presented in Appendix C of this document.

This approach of maintaining active registers will have the effect of ensuring there is a list of potential SITT opportunities ripe for investment.



Investment prioritisation

It is likely given competition for resources, that the budget presented in the preceding section will be partly unmet, especially in the early stages of Roadmap Implementation. It will be necessary for the PMU, under leadership of the RIC to prioritise investments. When selecting which investments to fund or to include in the portfolio of work, the following principles for RIC are proposed:

- Selections are to be made on the basis that is agreed by consensus, ethical, transparent and fair.
- Gender, race and disability transformation targets required.
- Youth targeting.
- Advancing open science, as appropriate.
- Alignment with and contribution to the human settlements sector plans.
- International commitments and national priorities should be taken into consideration, for example Priority Housing Delivery Areas (PHDAs). These are shown Figure 14.

Unsystematic or unstructured selection approaches to infrastructure investments (which is generally capital intensive), and innovation (which is generally risk intensive) are unsatisfactory. There is a requirement for evidence, comprehensiveness, value and legitimacy, especially when utilising public funds or involving third party investment. In response to an observed need for pragmatic selection processes, an initial evaluation tool has been prepared to systematically evaluate individual candidate investment opportunities. The evaluation is not limited to cost-related issues, but covers social, environmental, economic costs and benefits, as well as risks and attractiveness. This is discussed further in the cost benefit analysis report.

As discussed in the short report on investment prioritisation, project appraisal should focus on ensuring that:

- The need for the project is well justified;
- The project's objectives are clearly specified;
- Broad alternative options to meet the project's objectives are identified and comparatively examined;
- The most promising option is subject to detailed analysis;
- Project costs are fully and accurately estimated; and
- Project benefits are assessed qualitatively as likely to justify the costs.

Given South Africa's need for investment in both SITT and SHS, and its limited resources, these criteria may not be sufficient to prioritise investments. Moreover, information for comprehensive appraisal may be limited, costly to obtain and difficult to compare in a credible way (when handling cost and benefits of a non-monetary nature, for example). A set of tools has been prepared in order to systematically evaluate technologies.

The prioritisation techniques are discussed further in Appendix D of this document, and are supported by an investment prioritisation framework and video user instructions.

SECTION J:

ROADMAP IMPLEMENTATION
PROGRAMME MANAGEMENT OFFICE (PMO)

The implementation of the activities and projects of the Science, Technology and Innovations for the Sustainable Human Settlements Roadmap will be tcarried out through the establishment of the STI4SHS Roadmap Programme Management Office (PMO). The Departments of Science and Innovations and the National Department of Human Settlements will contribute funding and provide seed funding where possible to setup the operations of such a PMO.

The hosting of the PMO would ideally be hosted within one of the entities that reports to the Department of Science and Innovation. The DSI would consider carefully the project management skills necessary for the execution of the STI4SHS Roadmap projects by the PMO, in order to enable effective system level coordination , mobilisation of funds and effectine reporting lines and institutional governance arrangements for the PMO.

The STI4SHS Roadmap PMO will be required to interface with all sector stakeholders implementing different parts and interventions aligned to the STI4SHS Roadmap agenda. The PMO will be required to interact with all sector stakeholders implementing Roadma related projects, underatke monitoring and evaluation of all Roadmap activitie and projects and produce periodic progress review.

At the minimum, the STI4SHS Roadmap will require a qualified Programme Manager, Programme and project Administrator and the Transformative Innovation policy specialist. These resources will report directly to the Department of Science and Innovation and the National Department of Human Settlements.

Acknowledgements

The STI/SITT 4 SHS Roadmap was sponsored by the DSI. The project was funded by TIA as part of the South African government's initiative to promote and support innovation for inclusive development.

The SITT 4 SHS Roadmap Framework is the product of an **extensive engagement process**, which relied on the inputs, goodwill and contribution of a wide number of partners, sponsors and stakeholders.

Organisations consulted during stakeholder engagement processes are recognised in the individual reports prepared and are not repeated here. Major contributors included, but were by no means limited to those identified below.

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SITT4SHS Roadmap developed in partnership with:

Science and Technology
Human settlements
Water & sanitation
Energy
Environmental affairs

SOUTH AFRICAN LOCAL GOVERNMENT ASSOCIATION
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NELSON MANDELA UNIVERSITY

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technology innovation AGENCY

WATER RESEARCH COMMISSION

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GREEN BUILDING DESIGN GROUP.
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