GOING BEYOND THE INFRASTRUCTURE FUNDING GAP:

A SOUTH AFRICAN PERSPECTIVE

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FOREWORD

The Sustainable Development Goals (SDGs) are a bold commitment to tackle some of the more pressing challenges facing the world. South Africa's commitment to achieving the ambitions of the SDGs by 2030 is embodied in the National Development Plan Vision 2030 (NDP). Even though progress has been made thus far, South Africa has significant work ahead to achieve the SDGs. According to the *Sustainable Development Report 2022*, South Africa ranks 113 out of 161 countries in terms of its performance in the 17 SDGs. The performance highlights the urgent need to step up its efforts to meet the 2030 ambition and the social, economic, and environmental priorities it espouses.

Meeting the ambitions of the SDGs requires adequate infrastructure. High quality school and college infrastructure facilitates better instruction, improves student outcomes, reduces dropout rates, and increases teacher motivation. High quality transportation infrastructure allows people to access basic services, jobs and firms to be competitive and create more and better jobs. High quality water and sanitation infrastructure allows access to adequate, safe, and affordable water and sanitation services. Resilient infrastructure ensures sustainable progress towards the SDGs. Hence, there is a need to accelerate the provision of infrastructure. However, as a recent global report on infrastructure needs by the World Bank (*Beyond the Gap*) concluded, the focus should not be on spending more, but on spending better.

The magnitude of the challenge ahead requires a concerted effort from all stakeholders. It is for this reason that the Development Bank of Southern Africa (DBSA) and the World Bank decided to join efforts in studying the infrastructure needs in transport, water and sanitation, basic education, and technical and vocational education and training (TVET) sectors. The study, which is the first country level application of the approach employed in the *Beyond the Gap* report, goes beyond quantifying the service and funding gaps and proposes concrete actions to close them by spending better. This effort brought together sector departments and other critical stakeholders in government through working groups to ensure the relevance and usefulness of the findings and recommendations to all stakeholders. Ultimately, we hoped that the study will enable responsible investment decision-making and inform the strategic perspectives of government, our institutions, and other stakeholders on investing in the development of South Africa.

The study develops a compelling set of scenarios, with their concomitant policy trade-offs and spending requirements (including capital and operations and maintenance), for the transport, water and sanitation, basic education, and TVET sectors. The scenarios, which vary in their level of ambition of the service goals as well as the efficiency with which the goals are reached, illustrate that for South Africa to achieve the SDGs, significant spending of between R4.8 trillion and R6.2 trillion between 2022 and 2030 will be required. This is equivalent to spending between 8.7% and 11.2% of Gross Domestic Product (GDP) per year on average. A key finding of the study is that quality and management of infrastructure and services undermine the achievement of SDGs, hence, investing in infrastructure is not enough, rather properly managing and maintaining it matters. It was found that recurrent spending (including operations and maintenance and teacher salaries) makes up 74% on average of the total funding requirement across the three scenarios, with capital representing 26% on average, highlighting the point that improving services requires much more than capital expenditure. Ensuring a steady flow of resources for operations and maintenance and service delivery is a necessary condition for success.

South Africa is exposed to a range of natural hazards like floods and droughts that can damage its infrastructure assets and in turn disrupt infrastructure services, generating high losses for firms and households. It is important that the existing and new infrastructure assets are resilient to natural hazards, which are becoming more frequent and extreme because of climate change. At the same time, it is important that the investments to increase resilience are targeted to where they will have the largest impact. The study found that, based on the net benefits of avoided direct damages, the additional cost of increasing infrastructure resilience is small compared to the funding needs to achieve the SDGs.

The analysis presented in this report should help officials and policy makers in South Africa explore a variety of pathways and the reforms that are required for achieving the SDGs and the NDP in the four chosen sectors. A follow-up report by the DBSA will cover the energy, digital/ICT, health, and human settlements sectors. Regardless of the quality and quantity of services targeted, or the spending efficiency that will be achieved in reaching the goals, it is evident that closing the SDGs gap will require significant infrastructure and related spending, and that policies are urgently required that will ensure better spending and the mobilisation of additional resources. This is essential to creating an environment that is conducive to acceptable economic growth and sustainable development.

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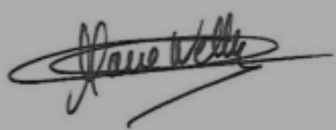

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ABBREVIATIONS AND ACRONYMS

BAU	Business as usual
BRT	Bus Rapid Transit
CES-CET	Constant Elasticity of Substitution and Transformation
CGE	Computable General Equilibrium
DBE	Department of Basic Education
DBSA	Development Bank of Southern Africa
DG	Director General
DHET	Department of Higher Education and Training
DoT	Department of Transport
DPME	Department of Planning, Monitoring and Evaluation
DWS	Department of Water and Sanitation
ECD	Early Childhood Development
ERT	Expanded Rapid Transit
FET	Further Education and Training
FSM	Faecal Sludge Management
FTE	Full-time Equivalent
GDP	Gross Domestic Product
GER	Gross Enrolment Ratio
GET	General Education and Training
GHG	Greenhouse Gas
GSM	Global Sustainable Mobility
GTF	Global Tracking Framework
IAPs	Invasive alien plants
iRAP	International Road Assessment Programme
JMP	United Nations Joint Monitoring Programme
Km	Kilometres
LRT	Light Rail Transit
LUT	Land-use and Transport Planning
MDGs	Millennium Development Goals
MMI	Modified Mercalli Index
NATED	National Accredited Technical Education Diploma
NC(V)	National Certificate (Vocational)
NDP	National Development Plan
NEIMS	National Education Infrastructure Management System
NPC	National Planning Commission
NPV	Net present value
NQF	National Qualifications Framework
NRW	Non-revenue Water
NSFAS	National Student Financial Aid Scheme
O&M	Operations and maintenance
PGA	Peak Ground Acceleration
PLP	Pre-vocational Learning Programs
PSET	Post-School Education and Training
RAI	Rural Access Index
RCP	Representative Concentration Pathways
RG	Rationalised, gravel surfaces
RS	Rationalised, sealed surfaces
RTR	Rapid Transit to Resident Ratio
SAGE	South African General Equilibrium Model
SANRAL	The South African National Roads Agency SOC Ltd
SCR	Student to Classroom Ratio
SDGs	Sustainable Development Goals
SSA	Sub-Saharan Africa
Stats SA	Statistics South Africa
STRs	Student Teacher Ratios
SuM4All	Sustainable Mobility for All
TFP	Total factor productivity
TVET	Technical and vocational education and training
UG	Unrationalised, gravel surfaces
UMIC	Upper Middle-Income Country
UN	United Nations
UNECE	United Nations Economic Commission for Europe
US	Unrationalised, sealed surfaces
USAO	Universal Service and Access Obligation
VIP	Ventilated Improved Pit latrine
VNR	Voluntary National Review
WCDM	Water Conservation and Demand Management

OVERVIEW

Introduction

The United Nations 2030 Agenda for Sustainable Development is a universal commitment to peace and prosperity while preserving the planet. South Africa is deeply committed to the Sustainable Development Goals (SDGs) that are outlined in the 2030 Agenda, coupled with the Paris Climate Agreement and the African Union's Agenda 2063 ('The Africa We Want'). This commitment is embodied in the National Development Plan Vision 2030 (NDP), which is the country's blueprint for economic growth and development to achieve a prosperous society that is based on inclusive growth and sustainable development. South Africa, however, ranks 113th out of 161 countries in terms of its performance in relation to the 17 SDGs (Sachs et al., 2022).

Infrastructure is required to support the progress towards the 2030 SDG agenda. Education, electricity, water and sanitation, and transport infrastructure are required to improve access to basic services and support inclusive economic growth. The infrastructure needs to factor in environmental considerations and climate change risks to ensure growth is sustainable. The question then arises, how much infrastructure is needed and where? The economic growth aspirations and social and environmental objectives of the country play a role in determining the infrastructure that is required to close the service gap. Understanding the service gap and the ambition of the sector plays a role in determining where investments should be made.

As Rozenberg & Fay (2019) explain, the solution is not always to spend more, but to spend better on the right objectives with the use of relevant metrics. Following this premise as well as the analytical framework put forward by Rozenberg & Fay (Figure O.1), this report quantifies the spending — including capital and operations and maintenance (O&M) — needed in education, transport, and water and sanitation to achieve the related SDGs, and highlights infrastructure cost drivers and the implications of different policy choices on the spending needed.

Figure O.1 Analytical Framework for Beyond the Gap

Analysis

The report presents sectoral analyses covering transport, water and sanitation, basic education, and technical and vocational education and training (TVET). The analysis of each sector includes a diagnostic of the sector in relation to the 2030 SDG agenda, providing the local context and the challenges the sector faces with regard to policy development and implementation, to identify the gaps in achieving the targets set for the respective SDGs. The sectoral analyses also present detailed results on the spending needs under several scenarios and recommendations to close the gap. The sectoral analyses are followed by an assessment of the exposure of infrastructure assets to natural hazards and the investment needs to increase their resilience following the methods developed for the Lifelines report (Hallegatte et al. 2019). A final macroeconomic analysis examines the growth implications of the proposed spending and the projected funding gap. This overview summarizes the main messages and recommendations coming out from the analysis.

Quality and management of infrastructure and services undermine the achievement of SDGs

A large part of the SDG gap in transport and water and sanitation is due to the poor quality and management of existing infrastructure and services, while the quality of the public schools and TVET campuses and the efficiency of the sectors undermine the achievement of SDGs.

Transport

In South Africa, there are certain areas of the transport system that operate well, while others are in severe decline or outright collapse. The weakest performance is on access, both in rural and urban areas, and safety, particularly road safety. South Africa ranks 80th out of 183 countries in terms of rural access with a Rural Access Index (RAI) score of 74% based on 2016 global data. But the 2020–21 data from South Africa shows a bleaker picture. Only 57.5% of the rural population lives within 2 kilometres (kms) of an all-weather road. South Africa has a Rapid Transit to Resident Ratio (RTR) of 3.1 km/million people, ranking 58th out of 140 countries in the world on urban access according to the Global Sustainable Mobility (GSM) index.[1] In terms of road safety, South Africa ranks 143rd out of 183 countries according to the GSM index.

The lack of adequate maintenance of rural roads is the main reason for the limited access in rural areas. Less than 10% of the unpaved rural roads, which account for 81% of the rural road network, are in good or very good condition. As a result, about three quarters of the rural road network does not qualify as all-weather roads and close to 4.5 million people in rural areas live beyond 2 kms of an all-weather road, hindering their access to economic opportunities, education, and health services.

The poor service level of urban rail, which is not at the level of mass rapid transport, is one of the main reasons for South Africa's low ranking on urban access. Service quality has been in steady decline since 2010 and collapsed entirely during the lockdowns imposed in response to the COVID-19 pandemic. The quality of rail infrastructure, including stations, is threatened by theft, vandalism, and maintenance issues. The poor interconnection of rail, bus rapid transits (BRTs), and minibus taxis (paratransit) is another important reason for only a small share of public transport users commuting by rail and BRTs, with the majority using minibus taxis. The weaknesses of rail and BRTs coupled with the high cost of minibus taxis and apartheid spatial policies have resulted in walking being the primary means of transport for the poor.

Road safety in South Africa does not have an exemplary record. In the 2010 decade, there has been a marginal reduction in the annual number of road crash fatalities from 13 967 in 2010 to 12 503 in 2019 (ITF, 2019) bringing the fatality rate to 21.3 deaths/100 000 population, but it is still above the global average. The latest available data indicates that only 15% of the high traffic roads have a 3-star rating or higher (iRAP, 2020).[2]

Water and sanitation

South Africa has a good track record of water and sanitation infrastructure delivery for new services at scale, resulting in the rapid expansion of access to water and sanitation from 1994 to 2019. However, access to services has historically been measured based on the type of service and proximity to households and not the more stringent requirements for safety and reliability provided in the SDGs. As a result, 46% of all households in the country still do not have access to a safely managed water supply and 49% of households do not have access to safely managed sanitation services (Stats SA, 2019). The largest share of the water gap, 48%, is due to quality and reliability issues and the largest sanitation gap, 44%, is due to inadequately managed faecal sludge. The remaining service challenges are concentrated in informal settlements and rural areas.

1 The GSM index is an index for sustainable mobility (SuM4All, 2020).

2 International Road Assessment Programme (iRAP) star ratings are used for road safety inspection, road safety impact assessments, and in designs. Star ratings are an objective measure of the level of safety which is 'built-in' to the road through more than 50 road attributes that influence risk for vehicle occupants, motorcyclists, bicyclists, and pedestrians. Star ratings reflect the risk as it relates to an individual road user. 1-star roads have the highest risk, and 5-Star roads have the lowest risk.

In addition to issues of access, South Africa also struggles with availability of water resources. In recent years integrated bulk water supply services have come under threat, primarily due to lack of investment in the operation of the systems, lack of attention to planning revisions and poor adaptation to changes in demand and surface water availability. There are also high levels of non-revenue water (NRW) — approximately 41% of the system input volume (DWS, 2018) — with 85% of this being due to real losses in the system, that is technical losses, including leaks and bursts. Most losses are due to poorly maintained infrastructure or slow responses to reports of leakage (McKenzie, 2014).

Basic education

There is growing evidence that high quality school infrastructure facilitates better instruction, improves student outcomes, reduces dropout rates, and increases teacher motivation, among other benefits. But evidence from South Africa shows that school infrastructure often falls short of these basic minimum requirements, and it is often the most disadvantaged students who experience these sub-optimal learning conditions.

As of 2021, the condition of the existing stock of schools in South Africa was not good and many schools did not meet the Minimum Norms and Standards for Public School Infrastructure published in 2013 by the Department of Basic Education (DBE). The government has made progress in recent years to eliminate classrooms constructed from inappropriate/non-permanent materials in South Africa, but this progress notwithstanding, there is still a considerable number of schools (mostly in Limpopo, the Eastern Cape, KwaZulu-Natal, and Mpumalanga provinces) that do not meet the minimum acceptable standards of infrastructure. Out of the almost 567 000 toilets across preschool, primary, and secondary levels of education, about 124 000 (22%) do not meet the minimum acceptable standard of ventilated improved pit latrine toilets. More than one quarter of schools do not have access to adequate water during school sessions, a situation which weighs negatively on the sanitation in affected schools and potentially affects school attendance and learning outcomes in the long run.

Aside from the existing stock of schools that need to meet these minimum standards, there is also pressure in South Africa to build more schools to accommodate a growing population, particularly in some provinces such as Gauteng, KwaZulu-Natal, Western Cape and Free State. In the Eastern Cape, even with the rationalization of small schools, a 7 to 10% growth in population will require a relook in terms of the growth in numbers of schools, particularly if the preference is for larger schools. Provinces like Limpopo, Mpumalanga, the Northern Cape and North West will have a decline in population growth so will not have to expand infrastructure for a growing population but may need to expand the number of classrooms in existing schools to address high student to classroom ratios. Assuming a 1.8% population growth rate, there will be approximately 1.2 million additional learners in the basic education system in South Africa between 2022 and 2030.

The internal efficiency of the system is low. The repetition rate for primary and upper secondary education was estimated to be about 15% and for lower secondary education 8% in 2020. Around 300 000 students drop out of public schools each year without having reached matriculation (Van der Berg et al., 2019). Spending on teachers, classrooms, textbooks, and other learning materials to accommodate repetition can generally be regarded as wasted expenditure, as repeating (especially at the higher grades) is unlikely to add to learners' educational and labour market prospects.

TVET

TVET colleges are seen as part of the solution to address the high unemployment crisis in South Africa by serving as part of the post-school education and training system (PSET) to provide youth the skills and competencies the labour market requires. Public TVET colleges are the largest providers of TVET services in South Africa and the government is targeting a significant expansion of the system by 2030.

The internal inefficiencies of TVET colleges, with high levels of repetition and dropout, mean that students do not complete programs in the expected timeframe and contribute to placing additional costs and demands on existing campus infrastructure. Some of the potential causes of repetition and dropout are the low quality of training, low availability and quality of instructional facilities, outdated programs and curricula, low private returns to TVET, and students' financial constraints. Repetition causes students to spend longer than expected on campus and places a high burden on campus infrastructure such as student accommodation, which is already in short supply.

The lack of proper expansion plans, the limited use of technology, and the funding allocation undermines efficiency of the system. The TVET sub-system has not had a planned infrastructure expansion program since the Recapitalisation Program, which ended in 2008. Since then, most infrastructure development at the college level has focused on refurbishing buildings or constructing a few extra buildings on existing campuses (DHET, 2020). The lack of information and communication technology on campuses prevents the adoption of alternate, cheaper modes of delivery. Funding allocated to the TVET colleges focuses on covering staff costs which make up 80% of expenditure (DHET, 2018), leaving very little available for quality infrastructure investment and quality improvements, which hinders the ability for colleges to become more efficient.

Efficiency is also limited by sub-optimal utilization of existing infrastructure. Space norms for the utilization of TVET campuses in South Africa (DHET, 2017) prescribe a lower utilization rate for classroom space (50%) than comparable norms in India (AICTE, 2021) and Australia (TEFMA, 2009) (70-75%). The system also lacks macro-level space norms (i.e., norms that support system-level planning by establishing broad ranges for the space required based on student headcount) and college-level space norms are outdated and do not reflect changes in pedagogy and technology use. The Department of Higher Education and Training (DHET) currently lacks a systematic process to revise norms regularly based on observed good practices in TVET colleges and the evolution of international norms and standards.

Closing the SDG gap will require significant infrastructure and related spending

South Africa needs to spend between R4.8 and R6.2 trillion on transport, water and sanitation, basic education, and TVET, including capital and O&M in 2022—30 to close the SDG gap in these sectors (Table O.1). This is equivalent to spending between 8.7% and 11.2% of Gross Domestic Product (GDP) per year on average. In the preferred scenario, the funding needs are R1.3 trillion in transport, R1.2 trillion in water and sanitation, R2.5 trillion in basic education, and R411 billion in TVET, which annualized represent 2.26%, 2.17%, 4.73%, and 0.78% of GDP in 2022—30, respectively (Table O.1). For all sectors, the difference between scenarios is driven by the ambition of the service goal and the efficiency with which the goal is reached.

Service level and access goals and the efficiency in achieving those goals are the main drivers of funding needs. The preferred scenario sets ambitious goals in terms of the service levels, such as mass rapid transit service level for public transport and safely managed drinking water services, which are significantly more expensive than the current service levels set under the minimum spending scenario. The difference in spending needs between the minimum spending and preferred scenarios do not fully reflect the higher costs of services because the latter scenario considers the use of more efficient approaches and technologies for delivering transport, water and sanitation, and education services. For example, the use of alternative technologies and water conservation measures offset most of the cost of upgrading the level of service in water and sanitation. Similarly, efficiency improvements in basic education and TVET, such as reductions in repetition rates and the use of distance education, respectively, would reduce the need for additional infrastructure and related expenses, reducing the cost per additional student in the system.

Table O.1: Cost of closing the infrastructure gap to achieve the SDGs, 2022–30

Transport		Water and sanitation		Basic education		TVET		Total
Minimum spending scenario: less ambitious goals, mostly lower efficiency								
Keep current service level of urban rail and BRTs. Invest in urban roads. Pave current rural road network. Improve road safety of high traffic roads.		Provide universal access to basic service level. Invest in alternative technologies and water demand conservation measures.		Upgrade existing schools. Keep the status quo in terms of access and efficiency.		Bring existing campuses to minimum standards. Maintain the status quo in terms of access and overall performance.		
R1000 billion	+	**R1125 billion**	+	**R2485 billion**	+	**R203 billion**	=	**R4.9 trillion**
1.68% of GDP		**1.97% of GDP**		**4.69% of GDP**		**0.38% of GDP**		**8.72% of GDP**
Preferred scenario: ambitious goals, high efficiency								
Bring urban rail and BRTs to mass rapid transit service level. Invest in urban roads. Rationalize the rural road network and pave all roads. Improve road safety of high traffic roads.		Provide universal access to SDG service level. Invest in alternative technologies and water demand conservation measures.		Upgrade existing schools. Provide universal access. Improve student to teacher and student to classroom ratios. Reduce repetition. Increase recurrent non-salary spending.		Bring existing campuses to minimum standards. Double participation rate, expand housing and welfare support. Invest in distance education. Improve teacher to student and teacher to non-teacher ratios.		
R1295 billion	+	**R1243 billion**	+	**R2505 billion**	+	**R411 billion**	=	**R5454 billion**
2.26% of GDP		**2.17% of GDP**		**4.73% of GDP**		**0.78% of GDP**		**9.94% of GDP**
Maximum spending scenario: more ambitious goals and/or lower efficiency								
Bring urban rail and BRTs to mass rapid transit service level and expand the network. Invest in urban roads. Rationalize the rural road network and pave all roads. Improve road safety of high traffic roads.		Provide universal access to SDG service level using conventional technologies.		Upgrade existing schools. Provide universal access to basic education. Improve student-teacher and student-classroom ratios.		Bring existing campuses to minimum standards. Triple participation rate and further expand housing. Invest more strongly in distance education. Further improve teacher to student ratio.		
R1456 billion	+	**R1427 billion**	+	**R2569 billion**	+	**R709 billion**	=	**R6.2 trillion**
2.54% of GDP		**2.49% of GDP**		**4.85% of GDP**		**1.34% of GDP**		**11.22% of GDP**

Note: Total cost in billion rands, average annual cost as percentage of GDP. In the maximum spending scenario for TVET some interventions increase efficiency while others decrease it relative to the preferred scenario.

Operations and maintenance (O&M) spending needs are higher than capital spending needs in all sectors (Table O.2). Investing in new infrastructure without adequate maintenance will only have a transient impact and will not allow South Africa to achieve sustainable development. The build, neglect, rebuild path costs significantly more than the build and maintain path. For example, the South African National Roads Agency SOC Ltd (SANRAL) estimated that the cost of repairing roads is 6 times the cost of preventative maintenance after three years of neglect and 18 times after five years of neglect (SANRAL, 2004). As discussed later, the rehabilitation of existing infrastructure like urban rail and water and sanitation represents a significant share of spending needs because of the lack of maintenance, vandalism, theft, and sabotage.

Table O.2: Capital and recurrent costs of closing the infrastructure gap to achieve the SDGs, 2022–30

	Total cost (billion rands)			Average annual cost (% of GDP)		
	Minimum spending scenario	Preferred scenario	Maximum spending scenario	Minimum spending scenario	Preferred scenario	Maximum spending scenario
Capital						
Transport	494	549	593	0.84	0.96	1.04
Water and sanitation	535	604	717	1.03	1.06	1.25
Basic education	144	149	200	0.27	0.28	0.38
TVET	22	90	157	0.04	0.17	0.30
Total	**1 195**	**1 392**	**1 667**	**2.18**	**2.47**	**2.97**
Recurrent/operations and maintenance						
Transport	506	746	863	0.84	1.30	1.50
Water and sanitation	590	638	710	0.93	1.11	1.24
Basic education	2 341	2 356	2 369	4.42	4.45	4.48
TVET	181	321	552	0.34	0.61	1.04
Total	**3 618**	**4 061**	**4 494**	**6.53**	**7.47**	**8.26**

Source: Authors' elaboration.
Notes: In transport and water and sanitation, recurrent spending includes only operations and maintenance of the infrastructure and services. In education, recurrent spending includes the operations and maintenance of infrastructure as well as teacher salaries.

Transport

In order to address the sustainability gap in the transport sector, a focus on improving the condition and operation of existing infrastructure is required before any expansion of the transport network. Improving the level of service of urban rail, ensuring the operation of all BRTs that have been built, strengthening urban roads, and addressing their maintenance backlogs requires R703 billion between 2022 and 2030, which represents 1.25% of GDP per year on average. This preferred scenario costs almost twice as much as the lowest cost scenario, which keeps the status quo in terms of the service levels of urban rail and BRTs and strengthens the same extent of urban roads as in the preferred scenario. The highest cost scenario proposes to expand the mass rapid transit network according to cities' plans in addition to the spending proposed in the preferred scenario, and costs R160 billion more than the latter with a limited impact on accessibility.

The restoration and improvement of rapid transport systems represents the lion's share of the funding needs. However, large infrastructure investments alone will not solve the problem of accessibility. Besides enabling people to travel to where opportunities are, opportunities should be brought close to where people live. This requires relooking, rethinking, and adopting a multi-pronged approach to address land use and transport interactions in an integrated manner.

Increasing rural access in an efficient and sustainable manner requires a long-term focus and strategic planning. Chasing overly ambitious goals in the short- to medium-term would end up costing the country a lot more than needed. Achieving an RAI score of 94% by 2051 — the highest possible without building new roads —by re-graveling roads would end up costing 25% more by 2030 than a policy of rationalizing the rural road network and paving all rural roads. The latter policy requires more time because small schools and clinics will need to be relocated, without jeopardizing access to education and health services, to reduce the extension of the road network. The preferred and maximum spending scenarios include this more efficient policy, which costs R270 billion or 0.44% of GDP on average for the 2022—30 period, while the less ambitious minimum spending scenario proposes to pave all rural roads in the current network, which cost R312 billion, or 0.46% of GDP on average, for the 2022—30 period.

It is important to allocate resources for O&M to sustain access. To ensure sustainability, cities will need to spend significantly more resources on the O&M of their public transport systems rather than on the construction of new infrastructure. O&M costs range from 80% to 89% of total funding needs across the range of policy paths considered. In the case of rural access, routine maintenance and rehabilitation costs represent 26% of costs under the policy of sealing rural roads. This contrasts with the policy to continue with gravel roads, where 100% of the costs go to rehabilitation and maintenance.

While infrastructure improvements can help South Africa improve its performance in road safety, it will not be enough to achieve the SDGs. Bringing 75% of the high traffic roads to a 3-star rating or higher by 2030 would require a total of R322 billion or 0.57% of GDP per year. In South Africa, however, speed and drunk driving are major contributors to road traffic crashes (World Bank, 2021) and such behaviour cannot be eradicated through infrastructure investments only. Policies that are discussed in the report can induce behavioural changes.

Water and sanitation

Similar to the transport sector, a focus on maintaining, operating, and renewing existing infrastructure is required to close the infrastructure gap. Spending should shift from the provision of new infrastructure to the maintenance of existing infrastructure and services though proper asset management, with a focus on the renewal backlog to restore service levels to where they should be.

The largest capital investments are required in metros and intermediate city municipalities followed by B4 rural municipalities,[3] with much of the operating expenditure necessary in urban formal areas where 62% of customers live. Rapid urbanization means that even more resources will be needed in urban areas. However, individual services, which is a requirement as per SDGs, may be unaffordable in urban informal areas given the limited space available and the potential of shared services therefore needs to be considered.

Water conservation and demand management (WCDM) measures represent a fraction of the cost of achieving the SDGs but have significant benefits. The most significant is the reduced environmental impact of the water service. The impact of WCDM measures on water resources, bulk water purchase and water treatment costs can actually reduce operating costs below what is currently being spent. Reducing NRW and improved water use efficiency has financial benefits for municipalities that can then assist in covering the increase in demand that is generated through higher levels of services.

Taking into account the constraints faced in the water and sanitation sector, coupled with providing the most cost-effective solution while achieving the SDG targets, the preferred scenario requires an expenditure of R1243 billion between 2022 and 2030, or 2.17% of GDP per year on average. This scenario provides service at SDGs levels, with alternative technologies — i.e., maximum use of onsite boreholes, pour flush toilets, next generation sanitation and decentralised wastewater treatment — and an aggressive focus on WCDM. The minimum spending scenario proposes alternative technologies and WCDM, like the preferred scenario, but sets less ambitious goals by setting the service levels at the current basic levels set out in the South African water policy (DWS, 2017) instead

3 Intermediate City Municipalities, which include secondary cities, are a grouping of 39 municipalities identified by the Department of Cooperative Governance as densifying urban settlements that do not yet have the characteristics of metros. The categories of B2—B4 municipality refer to the Development Bank of Southern Africa (DBSA) Municipal Infrastructure Investment Framework categorization of municipalities into municipalities with a large town as urban core (B2), largely urban municipalities with small towns (B3) and municipalities dominated by communal land tenure (B4).

of the SDG levels. This scenario costs R119 billion less than the preferred scenario in the 2022—30 period. The maximum spending scenario is less efficient than the preferred scenario as it proposes to achieve the SDG target level using conventional technologies in line with the status quo and is, therefore, R183 billion more expensive than the preferred scenario in the 2022—30 period.

Basic education

Upgrading existing schools requires addressing the backlog of infrastructure improvements related to access to basic services and non-permanent classrooms, and addressing the gap in access to computer rooms, libraries, laboratories, and servers. The total cost of upgrading the existing stock of schools to DBE's current minimum norms and standards amounts to R51 billion, R68 billion, and R93 billion depending on whether 50%, 70%, or 100% of the needs relating to computer rooms, libraries, laboratories, and servers are addressed. Under all these options, 100% of the 'core' needs are met for infrastructure latrines, electricity, water, and addressing non-permanent classrooms made of mud/wood/clay, as well as broken floors and ceilings. The recommended option is addressing 70% of the computer, library, laboratory and server needs, and the upgrading of the existing stock of schools needs to be completed as a matter of urgency in the next three to four years. Other infrastructure needs related to increased security in schools, in terms of fencing, and burglar bars, are not costed as part of this study but are increasingly becoming essential for schools located in areas that are insecure.

The cost of expanding the network of schools to accommodate an increase of approximately 1.2 million additional learners by 2030, comprises of the cost of infrastructure (capital costs), the cost of additional teachers and maintenance costs (both of which are recurrent costs). The cost of the expansion (both capital and recurrent) of the public basic education system is about R 2.4 trillion to R 2.5 trillion in the 2022—30 period. The costs depend on a series of policy decisions around the gross enrolment ratio (GER), grade repetition, class sizes, student teacher ratios (STRs), and the share of non-salary expenditure within the recurrent budget of the DBE.

Under the preferred scenario, the assumptions are that all students who are eligible for preschool, primary and lower secondary education, will be accommodated but there would also be efficiency gains in terms of reduced repetition in primary and upper secondary education which would reduce the need for more classrooms. This scenario would necessitate a net addition of 19 400 classrooms with 4700 at primary level and 14 800 at secondary level, which would cost approximately R81 billion. The recurrent costs associated with these additional classrooms, in terms of additional teachers (about 25 000) and maintenance costs would be about R2.36 trillion for the 2022—30 period. This scenario also assumes that more funds will be spent on non-salary items that would improve the quality of education services provided.

The preferred scenario of full access with improved efficiency will require R2.44 trillion in 2022–30 (capital and recurrent costs), which is R64 billion less than the maximum spending scenario that aims for full access but without efficiency improvements. The preferred scenario costs R20 billion more than the minimum spending scenario, which assumes a business as usual (BAU) approach in terms of access and efficiency.

The combined recurrent and capital costs of upgrading, expanding, and operating and maintaining the basic education system ranges between R2.48 trillion and R2.57 trillion, which represents 4.69% to 4.85% of GDP per year on average. It is important to note that more than half of the capital costs are for expansion and that the bulk of the total costs — 93% on average — are recurrent costs mainly to support teacher wages.

TVET

The preferred scenario requires R427 billion for the 2022—30 period or 0.76% of GDP per year on average. This scenario doubles the student participation rate by 2030, while improving the STR, improving the balance between teaching and non-teaching staff, and housing an additional 10% of students. The total funding needs in the maximum spending scenario, which accounts for the more ambitious policy that aims to triple the student participation rate, is R755 billion for the 2022—30 period, or 1.34% of GDP per year on average. In the minimum spending scenario, which maintains the status quo, the funding needed for the 2022—30 period is R212 billion, or 0.38% of GDP per year on average.

As with basic education, the bulk of the funding needs (78%—89%) are to cover non-infrastructure recurrent costs, with 90% of the recurrent costs being slated for execution at the TVET campuses. Recurrent costs cover salaries for administrators, instructors and support staff, support to student welfare financing, and operation in the TVET system. Also, the bulk of the infrastructure funding needs are for the expansion of the system and its maintenance, with only R6 billion needed for upgrading existing campuses. Infrastructure interventions include construction of additional campuses, expansion and upgrading of housing facilities and proper maintenance of facilities.

The adoption of technology and alternate modes of delivering TVET could substantially reduce costs. The preferred and maximum spending scenarios include the use of distance education (used as a proxy for the cost-saving effects of technology and alternate delivery models). While the exact efficiencies obtained through technology and alternate modes of delivery would depend on the specific technologies and modalities chosen, assuming that the recurrent per-student cost of TVET provision would be five times lower for distance education than for on-site training shows that the funding needs in the preferred and maximum spending scenarios would be 32% and 64% higher, respectively, if distance education were not considered as a delivery option.

Expansion of the TVET system is likely to be constrained by the supply of qualified and trained instructors. The increases in enrolment and improvements in STRs in the preferred and maximum spending scenarios would require approximately 20 000 and 46 000 instructors in the public TVET system respectively by 2030. This would be a large increase from the approximately 7800 teaching staff in the public TVET system (based on DHET administrative data from 2020). If the current delivery model for TVET were to continue, the number of instructors required would be much higher.

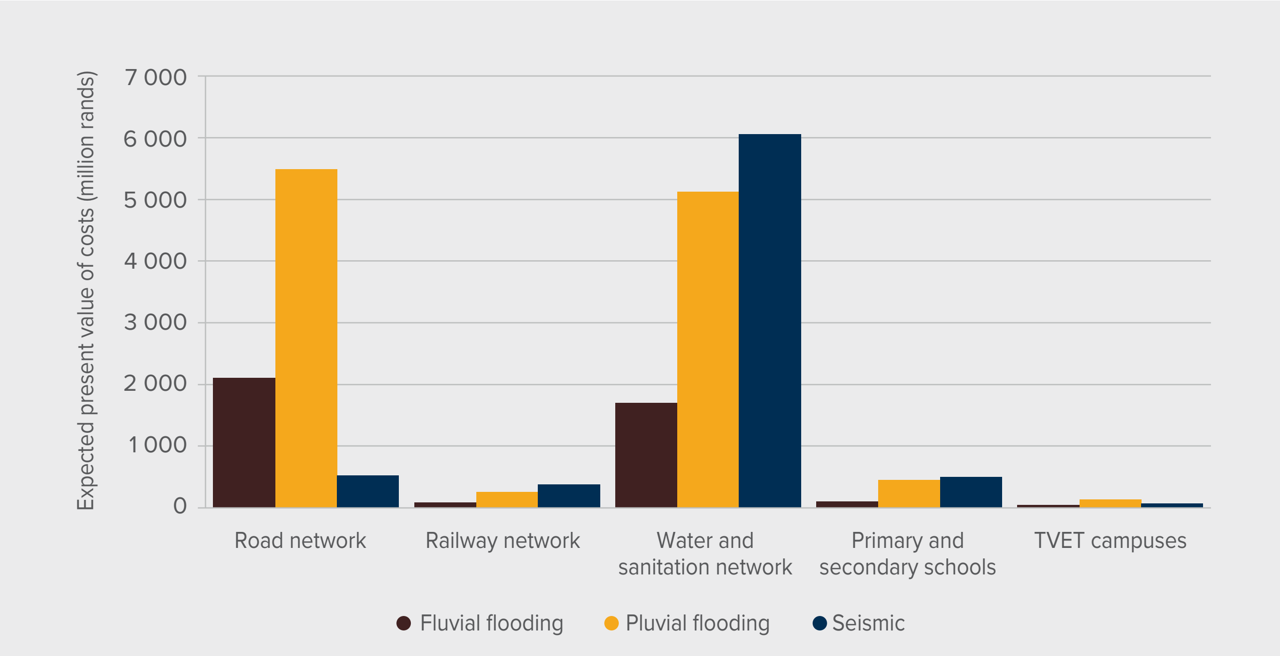
The construction of new campuses and student housing required to accommodate increased enrolment would require a many-fold increase in capital expenditure. In 2020, the government spent R393 million under the College Capital Infrastructure Efficiency Grant for the maintenance and upgrading of colleges. This would mean that the funding associated with interventions under any of the expansion scenarios would be a 6-, 26- and 44-fold increase from the 2020 levels of capital expenditure.

The cost of increasing infrastructure resilience is small compared to the funding needs to achieve the SDGs

South Africa is exposed to a range of natural hazards like floods, droughts, and seismic events that can damage its infrastructure assets and in turn disrupt infrastructure services, generating high losses for firms and households. Since floods and droughts will increase in intensity with climate change, it is important to assess the cost of these events on current infrastructure systems and to estimate the cost of making future infrastructure systems more resilient.

Flooding causes the most expensive direct damages overall, mostly due to its impact on the road network and on water and sanitation assets (Figure O.2). Seismic events are the costliest hazard for water and sanitation assets, railways, and primary and secondary schools. The total cost of seismic damages is driven by water and sanitation assets given their extensive network, while total cost is limited for schools and railways due to a smaller number of exposed assets. While the economic cost of disruptions (i.e., indirect damages) were not estimated in this report, previous global estimates suggest they can be 15 to 30 times higher than direct damages (Hallegatte et. al., 2019).

Figure O.2: Expected hazard impact for infrastructure assets



To increase the resilience of infrastructure systems, South Africa can strengthen its existing and future assets, focusing on the ones that are exposed to flooding and seismic events and that bring the highest benefits in terms of avoided direct damages. Based on a cost-benefit analysis of assets strengthening, South Africa would need to invest an additional R59 billion to R95 billion (Table O.3) to increase the resilience of education (basic and TVET), transport (road), and water and sanitation infrastructure — i.e., this spending is additional to the funding needs to achieve the SDGs in Table O.1. The investments to increase resilience represent 0.10%, 0.12%, and 0.17% of GDP per year on average in 2022–30, a small sum compared to the bulk of investments needed to reach the SDGs. These investments will increase the resilience of primary roads and water and sanitation assets to flooding, and that of primary and secondary schools and TVET campuses to flooding and seismic events. Note that rural roads would already become more resilient to flooding with the spending considered in the transport scenarios therefore there is no additional spending for the resilience of rural roads.

Overall, the additional cost of strengthening infrastructure assets is small compared to total infrastructure investment needs in South Africa and compared to the many benefits it can bring beyond avoided repairs. For example, more resilient infrastructure systems would avoid transport and supply chain disruptions, and the slowdown of production processes because of water shortages, and would minimize the learning disruptions that occur when students are not able to attend schools physically.

Table O.3: Total capital cost for infrastructure resilience, by sector and scenario

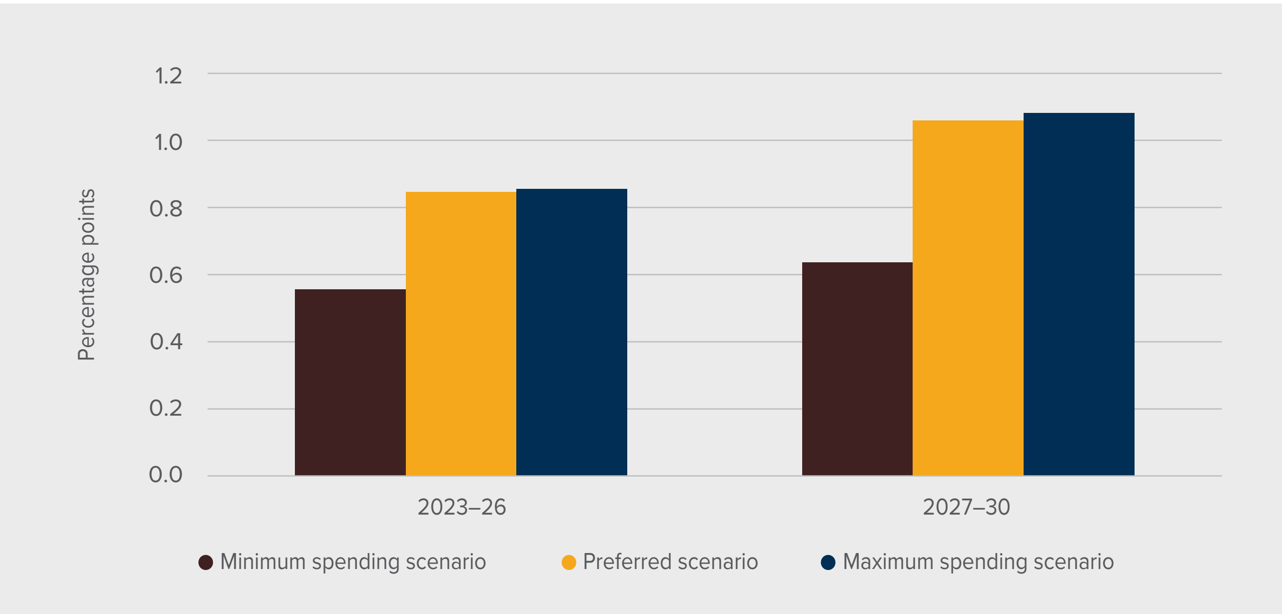
	Scenarios		
	Minimum spending	Preferred	Maximum spending
	Billion rands		
Transport (primary roads)	7	7	7
Water and sanitation	2	2	2
Basic education	41	42	45
TVET	9	18	41
Total	**59**	**69**	**95**
	% of GDP (2022—30)		
Total	**0.10**	**0.12**	**0.17**

Source: Authors' elaboration.
Note: Transport and water and sanitation only include the cost to increase resilience against flooding, while basic education and TVET also include the cost to increase resilience against earthquakes. For transport and water and sanitation the cost of resilience is focused on upgrading existing assets and is thus the same across all three spending scenarios.

The additional growth until 2030 will not be enough to fund the closing of the SDG gap

Investing, operating, and maintaining the transport, water and sanitation, basic education, and TVET infrastructure required to achieve the SDGs in these sectors will have significant impacts beyond the specific sectoral SDGs in terms of increase in labour force, reduction in unemployment, and higher GDP growth. The preferred scenario yields an annual average GDP growth rate for the 2023–30 period that is 0.95 percentage points higher than the status quo, while the minimum and maximum spending scenarios yield growth rates that are 0.52 and 0.97 percentage points higher. Growth picks up in the second half of the 2020s, particularly under the preferred and maximum spending scenarios (Figure O.3).

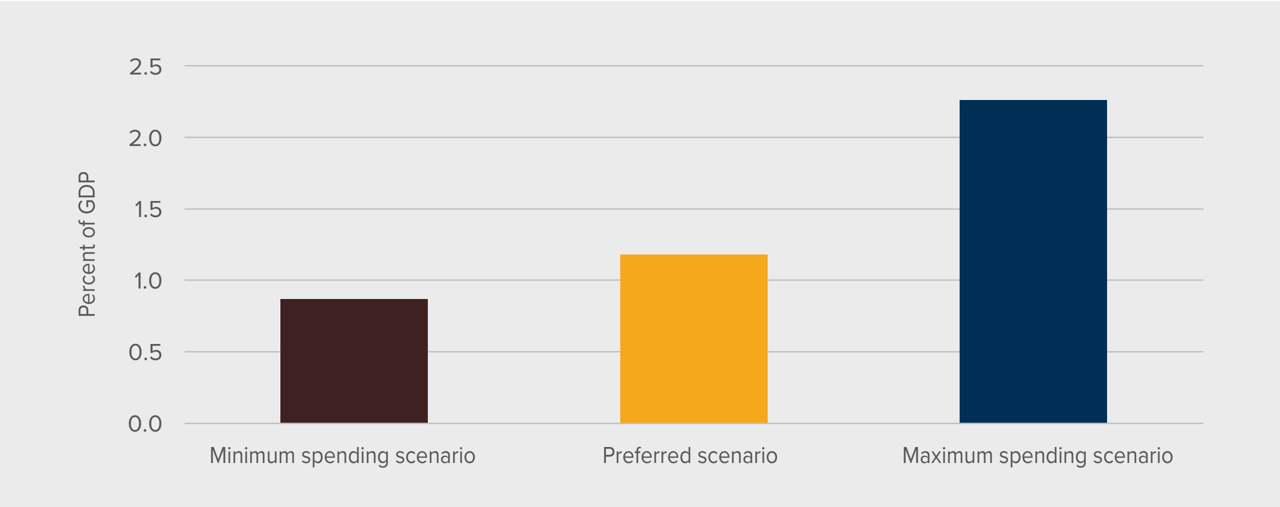
Figure O.3: Projected additional annual average GDP growth by scenario



Source: Authors' estimations.

The projected fiscal resources are not enough to cover the cost of closing the infrastructure gap to achieve the SDGs and increase infrastructure resilience. The GDP growth triggered by the additional spending in the four sectors will lead to an increase in tax revenues. If the government allocates these additional tax revenues to the four sectors, the average annual funding gap over the 2022—30 period will be 0.9%, 1.2%, and 2.3% of projected GDP in the minimum spending, preferred, and maximum spending scenarios (Figure O.4). The annual gap will be the highest in the first few years and decrease over time as GDP and tax revenues grow.

Figure O.4: Projected average annual net funding gap, by scenario



Source: Authors' estimations.

Closing the gap requires policies to spend better and mobilize additional resources

Achieving the SDGs in transport, water and sanitation, basic education, and TVET requires additional spending. However, given the limited public resources available there is a need to spend better and to mobilize additional resources. Spending better requires a set of priority policies in each of the sectors to get value for money, which are presented in this section and developed in the sectoral chapters. Additional resources could come from the private sector, however additional analysis will be needed to identify which investments generate enough direct revenues to be financially viable and therefore attract private funding in a fiscally sustainable manner.

Transport

Spending better to improve transport access and safety requires tackling the challenges of implementation, which include institutional barriers, limited intergovernmental coordination, and lack of capacity. Supporting the Passenger Rail Agency of South Africa (PRASA) to refine its recovery plan while devolving authority over public transport to metropolitan governments is the first in a series of policy initiatives that are required to restore and improve rapid transport systems to facilitate for greater urban access. This needs to be done in conjunction with updating public transport network plans that strengthen the integration between land use and transport planning, while recognising the role of the minibus taxi industry in public transport.

While additional funding will be required to arrest the decline of the rural road network, investment in better asset management systems and in the capacity of provincial road departments could help ensure that available resources are invested wisely. The latter is required to effectively implement the rationalization of the rural road network through a carefully coordinated intergovernmental process. To increase resilience and ensure longevity of road assets, road authorities should develop climate resilient standards and implement them.

Infrastructure investments to improve road safety, including the safety of pedestrians and cyclists, should be complemented with the policies that follow the principles of the safe system approach. These include the introduction of more stringent measures for drunk driving and speeding, ensuring road safety audits standards are funded and implemented, and adopting stronger vehicle safety standards.

Water and sanitation

The current performance of water services in South Africa is indicative of a decline in local government capacity to manage infrastructure assets and sustain water services. One of the issues is the lack of adequate technical skills in the public sector, and in particular the low number of engineers managing water services in municipalities (Lawless, 2016). Therefore, spending better to close the SDG gap in water and sanitation requires developing and implementing a nationally coordinated capacity building and institutional strengthening strategy. The institutional capacity building required includes building sector leadership and improved governance at the national and local spheres of government and increasing technical capacity at local government.

Stronger capacity will allow the prioritization of WCDM measures and the implementation of proper integrated asset management. The latter is key to successfully shift the spending focus from the provision of new infrastructure to the maintenance of existing infrastructure and services. Capacity building will also help municipalities better manage water resources allocation, faecal sludge management (FSM) and invasive alien plants (IAPs), which can reduce water availability.

South Africa cannot afford to achieve even the universal basic servicing targets, let alone the SDG targets by 2030, without radical revision to tariff levels and/or fiscal allocations. On the one hand, hard choices need to be made to spend on the highest impact solutions with the lowest cost. On the other hand, there is a need to improve economic regulation of water services to address chronic revenue shortages.

Basic education

While there is little that can be done to reduce the recurrent costs of the expansion of the network of schools, for example, it would not be feasible or desirable to reduce teachers' salaries or increase STR norms as there are policy choices to spend better when it comes to capital spending. Capital costs could be reduced by addressing three key areas: (i) reviewing the minimum norms and standards for school infrastructure; (ii) changing the implementation modality mix for school construction; and (iii) building better data monitoring and dissemination systems for school construction to improve accountability and sustainability.

The minimum norms and standards for school infrastructure could be reviewed by prioritizing a 'minimum' package of facilities over the 'optimum' package, adopting classroom libraries in primary schools, and digital libraries in secondary schools, and making digital connectivity a norm in schools. In South Africa, provincial school construction is dominant, accounting for 71% of the funding towards overall school construction and maintenance, but there is an opportunity to decentralize even further to the community level through community engagement for better value for money. Improving the data collection system would allow for regular and relevant analysis of the costs, effectiveness, and efficiency of the school construction program. This can be done through a regular update of the National Education Infrastructure Management System (NEIMS) and its linkage to Education Management Information Systems, and the development of a systematic process to collect data on costs of construction.

TVET

Spending better in the TVET sector can help close the infrastructure gap. This can be done by improving the internal efficiency of the TVET system — i.e., reducing repetition and dropout rates — to reduce the infrastructure needs, and developing macro-level space norms and improving the norms for space utilization. For example, increasing the expected utilization of classroom space in the space norms from the current 50% to 75% will reduce the amount of classroom space needed by 33%. The use of technology, where the necessary digital infrastructure is present, can also greatly reduce demands on physical infrastructure, particularly for space or equipment intensive activities. The success of these measures will require strengthening the DHET's capacity to develop and implement infrastructure norms and standards and to identify and procure technology-based training solutions.

In the case of TVET, there is also potential for diversifying the sources of funding to close the gap, which means public resources can be directed to where they yield the highest value for money. This can be done by creating an enabling regulatory and funding environment for private providers. In addition to crowding-in private providers of college-based TVET, there is significant potential to leverage the capacities and resources of firms through alternate training mechanisms such as workplace-based learning. Reforming the model for determining student fees and program funding from the DHET could also generate more income for higher performing colleges, where investments are most efficient. Public TVET colleges should also diversify their sources of income. There is significant potential for TVET colleges to raise revenues from direct services provided to firms, drawing on models from other countries. The use of technology in TVET can be funded by leveraging emerging business models and funding sources.

Conclusion

Investing, operating, and maintaining the transport, water and sanitation, basic education, and TVET infrastructure required to achieve the SDGs in these sectors will have impacts beyond the specific sectoral SDGs. However, significant public resources are needed to close the infrastructure gap and the projected resources are not enough. As a result, the government will need to make important decisions and will face trade-offs.

First, the government will need to decide the level of ambition and the investment and policies to achieve its goals in each sector. The government will need to decide how to close the funding gap, which can be done through additional tax revenues, revenues from user charges—including service fees—and by shifting resources from other sectors. The government will also need to prioritize among the investments in the sectors covered in the report, but also across other important sectors such as energy and health, among others. Finally, the government will have to decide how much current and future generations will contribute to closing the gap by deciding how much of the funding gap will be financed through the different options available to South Africa. These are all decisions that need to be made at the highest level of government to achieve sustainable development.

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INTRODUCTION

The United Nations 2030 Agenda for Sustainable Development is a universal commitment to peace and prosperity while preserving the planet. South Africa is deeply committed to the SDGs that are outlined in the 2030 Agenda, coupled with the Paris Climate Agreement and the African Union's Agenda 2063 ('The Africa We Want') (African Union Commission, 2015). This commitment is embodied in the NDP, which is the country's blueprint for economic growth and development to achieve a prosperous society that is based on inclusive growth and sustainable development.

In 2019, South Africa took stock of progress on the SDGs in the Voluntary National Review (DPME, 2019) and in the SDGs Country Report 2019 (Stats SA, 2019). The review indicated that there has been improvements on several fronts, but also that South Africa has fallen behind on many SDGs.

According to the review, improvement was seen on food security (SDG 2), with social assistance playing a role in reducing the share of households that are vulnerable to hunger, while health (SDG 3) improved based on the reduction of premature death rates. Improvement on electricity (SDG 7) was also noted with 95% of the population having access to electricity. Water and sanitation (SDG 6) indicated that 86% of the population had access to safely managed drinking water services and 83% had access to safely managed sanitation services. Education (SDG 7) overall demonstrated an increase in access to facilities but with the quality of education still remaining a challenge.

The areas where South Africa has fallen behind include poverty (SDG 1), with poverty rates differing greatly by groups and geographical locations. The rural population, particularly in the provinces of Limpopo and the Eastern Cape, show the highest poverty rate, while those with little or no education and black African, female-headed households also sit in the higher poverty bracket (DPME, 2019). South Africa is listed as one of the most unequal countries in the world (SDG 10) despite having an expansive social protection system that covers 30% of the population (DPME, 2019). The apartheid legacy, with its isolation of black townships and unequal distribution of land, has created structural bottlenecks in addressing inequality, poverty, and unemployment, which then impacts the social sectors of education, health, and housing (DPME, 2019).

Poor management practices in the water and sanitation sector threaten the sustainability of water resources (SDG 6), while informal settlements' lack of access to electricity and country-wide dependency on coal has an impact on energy (SDG 7). Outdated rail facilities, overburdened roads, and poorly integrated mass transit (SDG 9) coupled with inadequate services (SDG 11) threaten the sustainability of cities and impair social inclusion (DPME, 2019).

Overall, South Africa ranks 113th out of 161 countries on the Global SDG Index which tracks countries' performance in relation to the 17 SDGs (Sachs et al., 2022). There is an urgent need to accelerate progress to meet the 2030 ambition.

Infrastructure is required to support progress towards the 2030 SDG agenda and to allow for improvement in access to basic services in both urban and rural communities. A comprehensive infrastructure network including electricity, water and sanitation, transport, and education infrastructure is required to support growth and development. This network needs to factor in environmental considerations and climate change risks while ensuring economic prosperity. The question then arises, how does one determine how much and where the infrastructure is needed? The economic growth aspirations and social and environmental objectives of the country play a role in determining what infrastructure is required to close the service gap. Understanding the service gap and the ambition of the sector plays a role in determining where investments should be made. However, it should be recognised that different sectors have different goals, and while some are complementary—for example transport that supports access to work opportunities, health care, and education—other sectors may be competing—for example, affordable electricity access (SDG 7) and climate action (SDG 13). This indicates a complex relationship between determining the level of infrastructure required and the existence of trade-offs between competing goals (Rozenberg & Fay, 2019).

Objectives and scope of the report

The objectives of the report are to:

- Quantify the infrastructure funding needs on education, transport, and water and sanitation under feasible pathways to achieve the SDGs by 2030.
- Highlight infrastructure cost drivers and the implications of different policy choices.

The report determines the current status of the respective sectors in relation to the 2030 SDG agenda. It provides the local context and challenges each sector faces with regard to policy development and implementation to identify the gaps in achieving the targets set for the respective SDGs. The methodology applied, described later in this chapter, then aids in determining the infrastructure funding requirements to meet the SDG targets. The infrastructure funding needs include capital and O&M expenditures to ensure that once the targets are met, they are sustained.

Methodological approach

The Beyond the Gap report (Rozenberg & Fay, 2019) introduced a framework that focuses on spending better on the right objectives using the relevant metrics, which in turn helps decision-makers build a vision of what they want to achieve through investments. This framework is built on a body of literature that indicates that the long-term decision should be based on an agreement on the multiple objectives the decision is trying to reach, and the metrics used to measure the success, while understanding the vulnerabilities of the system under current and multiple future conditions (Brown et al., 2012; Haasnoot et al., 2013; Hallegatte, 2009; Kwakkel & Walker, 2010; Walker et al., 2013).

The Development Bank of Southern Africa (DBSA) has partnered with the World Bank to adopt a similar approach in South Africa in an effort to enable responsible investment decision making. The framework that has been applied in this report is based on the framework developed by Rozenberg & Fay (2019) which consists of the following steps (Figure I.1).

Figure I.1 Analytical framework for Beyond the Gap Analysis

i. **Identify objectives**
Public infrastructure investments have multiple economic and noneconomic objectives which include physical and social integration of a country, management of pollution, public health, and safety amongst others. Understanding the vision of what the investments are meant to achieve across the range of objectives using multiple metrics is the first step.

ii. **Identify metrics to monitor infrastructure services**
Infrastructure's ability to deliver on economic and noneconomic objectives requires that the services provided be effectively available, be of reasonable quality and reliability, be affordable, and be provided in a financially and environmentally sustainable manner. Assessing the infrastructure investment needs requires identifying relevant metrics to determine the current status of infrastructure services and monitor their evolution over time in all these dimensions.

iii. **Identify the types of options available to reach the objectives**
There are multiple options available to decision-makers to reach the objectives described above. In each sector, options include both technology and policy instruments that can influence demand and choices. Feasible options need to be considered for the analysis to be relevant.

iv. **Identify the exogenous factors that influence the cost and success of the investments**
External factors that are beyond the control of decision-makers influence the success and cost of the various options. Common uncertainties include future demand, technological disruptions, future environmental stress, financial resources, and the political environment.
Three socioeconomic pathways capturing population growth, the spatial distribution and age structure of the population, and economic growth were developed for this study (Box I.1) and used across sectors to forecast demand for infrastructure and to quantify funding needs.

Box I.1: Socioeconomic pathways

Three socioeconomic pathways were developed for scenario analysis across sectors, providing forecasts of population and GDP growth for the period 2021–2030. The three pathways are the following:

- **Baseline**. This pathway assumes population follows the long-term population growth projections for 2021–50 as released by Statistics South Africa in 2021. The average annual population growth projected for 2021–30 is 1.3%. This pathway assumes that fiscal policy through 2030 follows current National Treasury projections. The average annual GDP growth projected for the 2021–30 period is 2.21%.
- **Urban**. This pathway assumes that total population growth is the same as in the baseline pathway, but that there will be a different distribution of the population across the country due to a trend of urban-centric development and population migration towards cities. The more rapid urbanization increases the tax base, and hence fiscal revenues, but increases the stress on public services and infrastructure provision requirements, resulting in a net deterioration of the fiscal position and a lower GDP growth than in the baseline pathway. The average annual GDP growth projected for the 2021–30 period is 1.98%.
- **Rural**. This pathway assumes total population growth is the same as in the baseline pathway, but that there will be a different distribution of the population across the country due to government intervention in rural areas that makes them more attractive to people. The slower urban-to-rural migration reduces fiscal revenues and increases social transfer payment obligations, causing a slowing of GDP growth. The average annual GDP growth projected for the 2021–30 period is 1.78%.

Natural disasters, including extreme weather events caused by climate change, are an important source of risk. The exposure of infrastructure assets to such events was assessed as part of the study following Hallegatte et al. (2019).

v. **Estimate the cost of achieving the objectives under different scenarios**
The final step is to estimate the cost for different scenarios. Scenarios include varying levels of ambition for the objectives, technology and policy options, implementation timelines and the realization of uncertainty. This process promotes transparency around decision making, while helping to manage deep uncertainty regarding the future, by estimating the cost for a range of scenarios instead of estimating a single number.

Structure of the report

The report is structured with an overview that provides the key messages that have been derived from the sectoral studies. This is followed by the introduction which provides a high-level overview of the motivation and methodological approach to the study. Sectoral analyses of basic education, TVET, transport, and water and sanitation, providing diagnostics of the sectors, the scenarios applied, the funding needs, and sectoral recommendations are presented in respective chapters. The infrastructure resilience chapter follows with an assessment of the sector's exposure and an adaptation assessment that provides the additional costs of making infrastructure assets more resilient. The report concludes with an analysis of the macroeconomic implications of the sectoral investments.

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Chapter 1

TRANSPORT

Introduction

There is a clear correlation between the progress a country has made on their SDGs and the quality of their transport and mobility system[1] (Vandycke & Fabian, 2020). Countries with more resilient and sustainable transport systems in place have higher scores in relation to progress in achieving their SDGs. This highlights the need to address the fundamental weaknesses in the transport and mobility system if South Africa wishes to achieve progress on SDG targets.

While the transport sector does not have a dedicated SDG, it does have the following targets which are considered in this report:

- **SDG 3.6:** Halve the number of global deaths and injuries from road traffic accidents.
- **SDG 9.1:** Develop quality, reliable, sustainable, and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human wellbeing, with a focus on affordable and equitable access for all.
- **SDG 11.2:** Provide access to safe, affordable, accessible, and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities, and older persons.

In addition, transport serves as a contributor to a range of SDGs as mobility is at the heart of access to many essential services and opportunities. In relation to climate change action, SDG 13 on reduction of greenhouse gas (GHG) emissions cannot be realized without action taken on energy provision (SDG 7) of which transport is one of the largest consumers. Food security (SDG 2), healthcare (SDG 3), schooling (SDG 4), employment empowerment (SDG 5), access for people with disabilities and the elderly (SDG 9 and 11) all require a safe and reliable transport system to achieve the SDG targets.

As part of the analysis of the sector, the study follows the Sustainable Mobility for All (SuM4All) approach to sustainable mobility. SuM4All is a platform hosted by the World Bank for international cooperation on transport and mobility that has developed a Global Tracking Framework (GTF) for Transport (SuM4All, 2020b). Through the framework a GSM index score is derived,[2] which allows for a ranking of countries in relation to four goals that define sustainable mobility. These goals include universal access, efficiency, safety, and green mobility. The SuM4All goals together with the GTF, GSM, and the catalogue of policy actions were used to frame and develop the analysis presented in this chapter.

This chapter first presents a brief diagnostic of the transport sector in South Africa, followed by a description of the scenarios and methodology used for the study. Key messages coming out of the scenario analysis and a preferred development scenario for the sector are presented before presenting recommendations.

The transport sector in South Africa

Within South Africa there are certain areas of the transport system that operate well, often at global standards, while there are other areas that are in severe decline or in some instances outright collapse. Using the GSM index, South Africa ranks 88th relative to 183 countries. This ranking places South Africa third amongst Sub-Saharan African (SSA) countries—behind only the Small Island Developing States of Mauritius and Seychelles.

While the relevant policies do exist, except for polices on gender in transport (Box 1.1), the challenges of implementation include institutional barriers, lack of capacity, limited intergovernmental coordination, and lack

1 A mobility system is broader than the transport system, for example, the mobility system includes considerations about land planning, environment, affordability, and quality of transport options, among others, while the transport system does not.

2 The GSM index score is a composite index score for sustainable mobility which is calculated for each country in the world as the average performance scores on universal access, efficiency, safety, and green mobility. The value of the GSM index ranges between 0 and 100 (SuM4All, 2020a).

of investment. Fragmentation of sectoral mandates across rail and road with different spheres of government being responsible for oversight, planning, and implementation provides the context for why the different transport sectors have such varied performance. Some organisations are well capacitated, managed, and resourced, and provide a high standard of management of the assets under their control, while other organisations have weak systems of governance, a dearth of technical expertise, unfunded mandates, management instability, and have contributed to poor outcomes overall.

Box 1.1: Gender and transport in South Africa

Transport infrastructure and services are not gender neutral. Women have different, often overlooked, transport and mobility needs that stem from the fact that they are often primary caregivers both for the young and the elderly, and they are, unfortunately, also vulnerable. These realities impact travel choices – women often make more trips with more transfers than men, and often need to travel during interpeak times, also tending to limit their travel to daylight hours. These factors mean that transport costs tend to be higher for women, as they are often accompanied by children or elderly relatives because of their domestic or family responsibilities.

In spite of a recognition of the need for the distinction required in service provision for women, there is no specific legislation in South Africa that addresses the gendered challenges in the sector. Furthermore, there is no gender specific and gender disaggregated data to undertake a full diagnostic of access. This further entrenches existing gender inequities and hinders women's development, which in turn undermines the policy direction to empower women and girls (Jennings & Arogundade, 2020; Lucas, 2019; Porter et al., 2020).

The contrasting performance is evident in the road sector where the South African National Roads Agency SOC Ltd (SANRAL) is considered to be a global leader on pavement management systems, while roads in rural provinces are in a severe state of decline. Similarly, the freight rail sector is world known for the longest production trains in the world on the Sishen–Saldanha iron ore export line, while the passenger rail network is in a state of complete collapse.

In the case of public transport, an effective mobility solution requires a combination of modes to be able to service the variety of travel demand patterns particularly in urban centres. The current fractured nature of having the different modes of public transport under three spheres of government has resulted in an uncoordinated policy approach which affects service delivery. This is exacerbated by public transport funding provided by the fiscus which tends to be modally driven rather than overall demand/solution driven due to the lack of integration and coordination between the modes of public transport and the respective institutions that manage them.

Urban access

Access to opportunities and amenities is largely dictated by where people live and the transport services they can access. At a national level, 11% of workers live 1 km or more from the first available public transport access point. Only 40.9% of workers using train services have access within 1 km. Apartheid spatial polices, exacerbated by housing programs and market forces (Baffi et al., 2018) and a strong orientation towards private car usage has resulted in a highly dispersed urban form with which comes negative spill overs, including keeping the poorest of the urban residents on the urban periphery.

Most South African households use minibus taxis as their means of transport, suggesting that measures to improve accessibility should also address the quality of service provided by these other modes of transport. Of all public transport users, 66.5% use minibus taxis (paratransit), 23.6% use buses and 9.9% use trains.[3] Walking is the primary means of transport for the poor. Countrywide 41.7% of people walk all the way to their destination—an estimated 17.4 million South Africans.

3 Metered taxis are frequently used by middle-to-high income earners and tourists. Low-income earners use metered taxis mostly in emergency situations. Metered taxis represent 10% of the total taxi fleet.

The 2020 National Household Travel Survey (Stats SA, 2022) found that among public transport modes, minibus taxis were the most expensive mode of travel for workers with average monthly travel costs of R960, followed by buses (R745) and trains (R581) – these costs may have increased in subsequent years as a result of changes in travel demand patterns subsequent to the COVID-19 pandemic lockdowns and the decline of the commuter rail services.

South Africa has a RTR of 3.1 km/million people, ranking 58th out of 140 countries in the world according to the GSM index. South Africa's RTR is derived from the 49.2 and 31.5 kms of operational bus rapid transit routes in Gauteng (Johannesburg and Tshwane) and Cape Town, respectively. Metrorail lines do not qualify for the RTR because of the poor service levels on offer at the time of estimation. Minibus taxi (paratransit) services also do not qualify for the RTR. The RTR metric offers a snapshot of rapid transit infrastructure coverage in relation to population. To qualify for rapid transit, public transportation must meet specific criteria (Box 1.2) that aims to be a measure of transit quality but is important to the note that RTR must be considered critically in context at a city level to ensure there is an understanding of the geographical relationship between transit and population within a city.

Box 1.2: Rapid Transit to Resident Ratio (RTR)

The RTR compares the length of rapid transit lines (including rail, metro, and bus rapid transit [BRT]) with a city or country's population in cities with over 500 000 people. For a corridor to qualify as rapid transit it must meet the following criteria:

1. BRT and Light Rail Transit (LRT) must meet the 'BRT Basics' definition in the BRT Standard: A section of road, or contiguous roads at least 3 km, dedicated lanes for transit vehicles, and one or multiple routes.
2. BRT and LRT corridors must have five essential elements: Dedicated right of way, busway alignment, off-board fare collection, intersection treatments, and platform-level boarding.
3. Metro is defined as any rail-based transit mode that features grade separation, off-board fare collection, regular station spacing, frequent service, and is capacity-oriented.

The sustainability gap is derived by comparing a country's performance relative to the best performing countries or a sustainability threshold when the distribution of observations has significant outliers. In the case of the RTR, a sustainability threshold of 40 km per million people was used in lieu of the best performing country (Norway with 95.83 km/million people). The result is that South Africa achieved a score of 8% on urban access, and that is there is an urban access gap of 92%.

Rural access

The RAI measures people's transport accessibility in rural areas where the majority of the poor live and serves as indicator 9.1.1 for SDG target 9.1. It measures the share of the population who live within 2 km of an all-season road.

South Africa ranks 80th out of 183 countries in terms of rural access with an RAI score of 74% based on 2016 global data. South Africa has a 32.5% rural access gap when compared to the best performing countries which are the Czech Republic, Singapore, Barbados, and Luxembourg, but when compared to best upper middle-income country (UMIC), Lebanon, the gap is reduced to 25.8%.

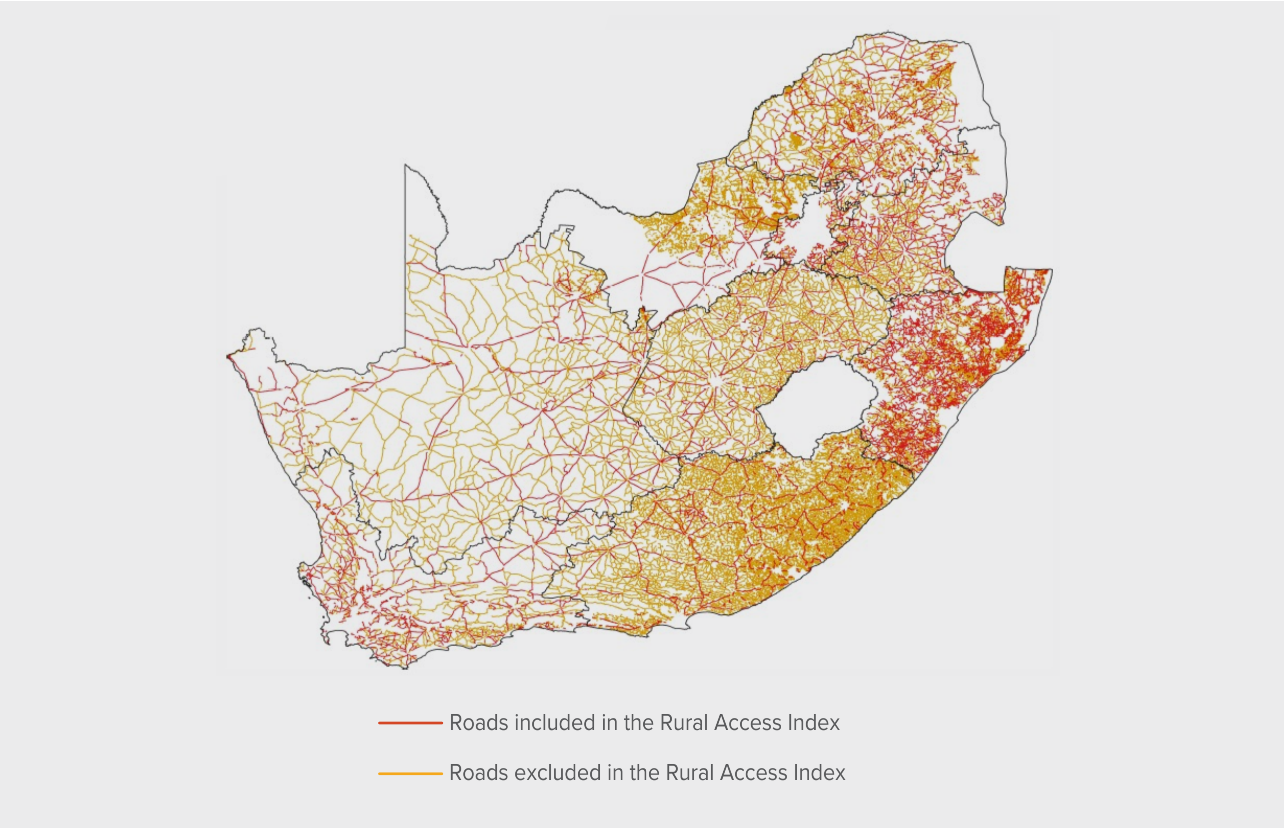
Using the latest data on the rural road network, which allows for the clarification between an all-weather and not all-weather road[4] and the latest population data, South Africa scores 57.5% on the RAI in 2020—21. This means there are approximately 6 million people living in rural areas within 2 km of an all-weather road.

4 An all-weather road is a road of sufficient construction and firmness for vehicles and equipment to traverse during normal inclement weather, including expected rain, snow, and freezing temperatures, irrespective of the season. Typically, this refers to paved or constructed unpaved roads. This is a more stringent requirement than an all-season road, which is generally defined as a classified or un-classified road that will not be closed for more than two consecutive days and not more than two weeks per year in total. All-weather roads are by default also all-season roads, but all-season roads are not necessarily also all-weather roads.

The provincial and local road network in South Africa is overall in poor condition, with the majority of maintenance concerns pertaining to the unpaved rural road network. The road network is comprised of paved and unpaved roads with paved roads making up 18.8% of the total rural road network. Of the paved network, 84.2% is in fair, good or very good condition, with only 9.7% of the unpaved network in good or very good condition. This outcome falls far short of the national Department of Transport's (DoT) chosen performance indicator, that no more than 10% of the road network should be in a poor and very poor condition (DoT, 2017).

One implication of the poor road conditions, especially that of the unpaved network, is that the majority of roads do not qualify as all-weather roads. Map 1.1 shows the roads that do qualify, which represent 24% of the rural road network, and those that do not qualify.

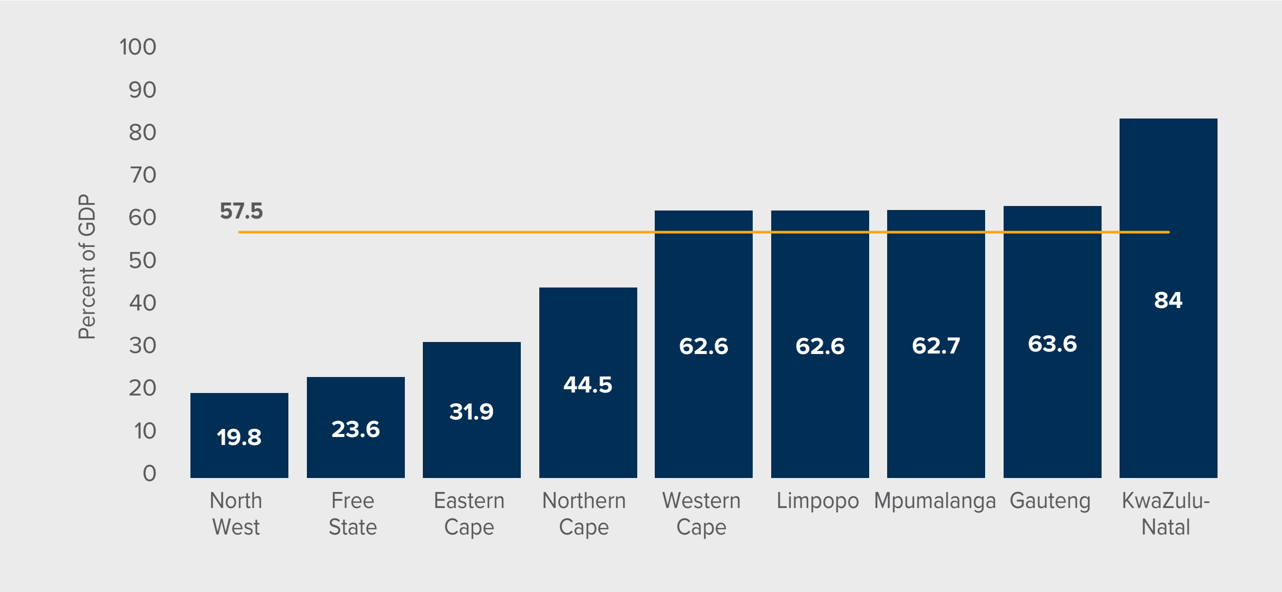
Map 1.1 All-weather roads within the rural network, 2020



Source: Authors' elaboration based on data received from the National DoT and Provincial Road Departments.

So, despite the extent of South Africa's road network on paper, many citizens do not actually enjoy adequate access because roads are not safely and effectively usable in all-weather conditions. This underlines that inadequacies in asset management are exacerbating the relatively low RAI score, as opposed to limitations in network coverage. There is significant variation in access across provinces, with KwaZulu-Natal having an RAI score of 84% and the Free State an RAI score of 23.6% (Figure 1.1).

Figure 1.1: Provincial rural access indices, 2020



Note: The North West Province was included in the analysis using limited data (the only available data for their Key Performance Indicator network), and hence the results for this province are subject to revision

Safety

South Africa has a mixed record on transportation safety with its maritime and aviation safety record being exemplary, while the same cannot be said for road and rail. In the last decade, there has been a marginal reduction in the annual number of road crash fatalities from 13 967 in 2010 to 12 503 in 2019 (ITF, 2019) bringing the fatality rate to 21.3 deaths/100 000 population, which was still above the global average. Road crash rates remain high, costing an estimated 3.5% of GDP in 2017 (ITF, 2019).

In line with SDG target 3.6, the safety policy goal aims to reduce road fatalities, injuries, and crashes. South Africa has a safety gap of 71.4% relative to the best performing country in the world (Maldives), which ranks South Africa 143rd out of 183 countries based on the GSM index.

The latest available data indicates that 85% of the high traffic road network has a star rating below three (iRAP, 2020).[5] In South Africa, however, speed and drunk driving are major contributors to road traffic crashes (World Bank, 2021). Speed limits in the country are higher than the globally recommended safe system speeds and 58% of fatalities involve a driver over the legal blood alcohol content limit. Men suffer disproportionately (77% of total fatalities are men, 83% of which are in their most productive years 15—64 years old) and pedestrians represent 39% of total fatalities.

Non-Motorized Transport infrastructure is critical to reduce the large share of pedestrian and cyclist fatalities especially in provinces with large urban populations that record the higher number of pedestrian fatalities (Arrive Alive, 2022). The International Road Assessment Programme (iRAP) found that 93% of carriageways surveyed have no adjacent footpaths or bicycle lanes, 92% have no pedestrian crossings, and 100% of undivided rural roads have vehicle speeds greater than 80 km per hour, which leads to unacceptably high risks for pedestrians (World Bank, 2021).

5 International Road Assessment Programme (iRAP) star ratings are used for road safety inspection, road safety impact assessments, and in designs. Star ratings are an objective measure of the level of safety which is 'built-in' to the road through more than 50 road attributes that influence risk for vehicle occupants, motorcyclists, bicyclists, and pedestrians. Star ratings reflect the risk as it relates to an individual road user. 1-star roads have the highest risk, and 5-Star roads have the lowest risk.

With respect to rail, the quality of South Africa's rail infrastructure, including stations, is threatened by theft, vandalism, maintenance issues and the rail environment is not safe for commuters as well as the general public in South Africa. The 2019/20 State of Safety Report highlights increasing long-term trends in both safety and security-related incidents. The report indicates that the occurrences of security-related incidents per million train km increased dramatically by 193% (compared to 106% since 2010/11). This has impacted rail infrastructure and the efficiency of freight and passenger rail.

Green Mobility

South Africa is the 14th largest emitter of GHG emissions in the world. South Africa's transport system is energy and carbon intensive, contributing 13% of GHG emissions (Climate Transparency, 2019), driven by reliance on road-based transport and spatial inefficiency.

Electrification in transport, while a world trend, will result in an increase in transport sector emissions in South Africa as long as the country relies on fossil fuels as the main source of energy. However, should the renewable sector take up the projected 40% of electricity production by 2050 (DMRE, 2019), electric mobility can play an important role in greening transport.

Efficiency of freight transport

South Africa has an overall efficiency gap of 36.6% relative to the best performing country in the world, Germany. South Africa's railroad and road infrastructure quality are rated 3.55 and 4.42, respectively, on a scale of 1 to 7. South Africa ranks better on both fronts exceeding the average scored for UMICs—3.00 and 3.73 respectively.

Freight transport in South Africa, with the exception of bulk movements is predominantly road-based. South Africa scores well in terms of the road connectivity index,[6] ranking seventh out of 141 countries. However, the quality of the road network is declining due to the variability in the management and condition of low category roads across provinces, which comprise the majority of the road network.

South Africa has the eleventh longest rail network in the world with 22 387 route km and 30 400 track km, with the heavy bulk lines of coal and iron ore realizing large economies of density. However, in spite of the ranking, the rail network fails to provide an efficient and cost-effective service. In addition to the cost, the rail system is a major concern, with frequent operational breakdowns owing to theft, vandalism, and power outages, increasing numbers of signal failures, and inadequate maintenance resulting in temporary speed restrictions, all of which consume capacity. This has been exacerbated by inadequate investment in recent years to firstly ensure the network stays at its design capacity, and secondly, extends the capacity to meet current and projected demand.

South Africa is among the top three African countries in terms of integration level in global liner shopping networks, according to the liner shipping connectivity index.[7] While South Africa is not a major player globally, it is a regional giant. Despite this, ports are comparatively expensive, inefficient, and unreliable. The spatial and operating efficiency is poor, the inter-modal connectivity and service with rail, except for the bulk movements is also poor, and there have been limitations in management, maintenance, and investment in recent years.

Transnet's unique and unusual institutional structure has contributed to a lack of competition among the ports. Whilst the private sector is involved on the bulk side, there are no specialist independent container terminal operators, operating solely or jointly, at any of the South African ports. The situation is similar for the freight rail network given that Transnet Freight Rail owns and operates the country's only long-distance rail network, and all freight locomotives and wagons. While there are no legal constraints for private operators to use the network, entry barriers are high, making third party access a challenge. Despite changes in policy, private sector operators are limited to branch line operation only as mainline operations are conducted by Transnet and any use by private

6 The road connectivity index is defined as average speed and straightness of a driving itinerary connecting the ten or more largest cities that together account for at least 15% of the economy's total population (World Economic Forum, 2019).

7 The liner shipping connectivity indicates a country's integration level into global liner shipping networks (UNCTAD 2020)

operators would be at their cost using Transnet operational staff and equipment, often making this option too costly.

Freight container constraints exist at the ports that include efficiency and scheduling reliability as well capacity constraints based on rail network condition and availability of locomotives. The Port of Durban, strategically located between the global east and west and one of the largest African ports after Morocco and Egypt, is the busiest container port in South Africa and in the Southern African Development Community region. However, according to the 2021 World Bank Container Port Performance Index the Port of Durban ranks 349th out of 351 global ports.[8]

Methodological approach and scenarios

The Beyond the Gap framework (Rozenberg & Fay, 2019) was implemented in the transport sector as follows: the primary transport sector objectives used to define the scenarios to assess the infrastructure funding needs are based on the SDG 3.6, SDG 9.1, and SDG 11.2, and the SuM4All universal access and safety goals. These goals are interpreted at a country level in the context of South African transport policy and South Africa's transportation system performance, which is weakest in the areas of urban and rural access, and road safety. The secondary objectives considered are those of efficiency and green mobility. The options available to decision-makers were identified based on the SuM4All catalogue of policy actions, South African transport plans, and through interviews with transport experts in South Africa.

The combination of the sector objectives and identified options led to four policy scenarios in urban transport, four policy scenarios in rural transport, and one policy scenario in road safety, which together yielded 16 aggregated transport scenarios.

The four policy scenarios in urban transport look at transport investment, including infrastructure, and buses and rolling stock for public transport, and O&M costs needed to increase the RTR and improve accessibility in urban areas. The scenarios are the following:

a. The business as usual (BAU) scenario assumes metropolitan and secondary cities road networks are strengthened, maintenance backlogs are addressed, and ongoing maintenance is provided to support road-based transport and minibus taxis. The extent of the strengthening is based on Kannemeyer (2016). The scenario assumes the ongoing maintenance and operation of urban rail and operational BRTs in Johannesburg (42.2 km), Tshwane (7 km), and Cape Town (31.5 km), and the maintenance of the infrastructure in place for not yet operational BRTs in Tshwane (11 km), eThekwini (31 km), and Nelson Mandela Bay (17.7 km).
b. The improved rapid transit (IRT) scenario assumes: (i) the improvement of the quality of urban rail bringing it to full capacity with 20 minutes headways and 75 km per hour of effective speed, including improvement in signalling and conditions of stations, which will improve safety conditions in the urban rail network; (ii) the start of BRT operations in Tshwane, eThekwini, and Nelson Mandela Bay; and (iii) the interventions in the metropolitan and secondary cities road networks considered in the BAU scenario.
c. The expanded rapid transit (ERT) scenario assumes a 28 km expansion of the urban rail network in Cape Town and Nelson Mandela Bay, and a 120 km expansion of the BRT network in Gauteng, eThekwini, Cape Town, and Nelson Mandela Bay, all of which are investments planned by cities and municipalities (PRASA, 2020; DoT, 2021), in addition to the interventions assumed in the IRT scenario.
d. The integrated land use and transport planning (LUT) scenario assumes that on top of the interventions assumed in the IRT scenario, a joint land use and transport policy is implemented. Such a land use intervention aims to capture the effect that 'take the opportunities to the people' may have, as opposed to 'transport the people to the opportunities.' Modelling policies that mix land use and transport instruments are challenging, partly because transit-oriented development policies typically are designed at the local level. The shortcut is to assume that 2% of the populated (1 km by 1 km) cells in an urban area receive a mixed-use facility with all

8 The Container Port Performance Index ranks ports based on total port time (World Bank 2022).

opportunity types except for a hospital, with the cells with lower accessibility having a higher probability of being selected.

The four policy scenarios in rural transport assume different policy and technology alternatives in terms of infrastructure investment and maintenance costs to increase all-weather access in rural areas. The scenarios are the following:

a. The unrationalised, gravel surfaces (UG) scenario assumes the extension of the current rural road network will remain unchanged and roads will be rehabilitated maintaining their current surfaces.
b. The unrationalised, sealed surfaces (US) scenario assumes the extension of the current rural road network will remain unchanged, and roads will be rehabilitated by sealing them.
c. The rationalised, gravel surfaces (RG) scenario assumes the rural road network is rationalised by relocating some small rural schools and clinics while ensuring no rural community is deprived of essential services access and roads will be rehabilitated maintaining their current surfaces.
d. The rationalised, sealed surfaces (RS) scenario assumes the rural road network is rationalised as in the RG scenario and roads will be rehabilitated by sealing them.

All four rural policy scenarios assume that deteriorated paved strategic roads are rehabilitated as quickly as possible and that operational resources for their subsequent on-time maintenance are committed. Strategic roads are roads that support the highest contribution to economic growth independently of fluctuations in business and commodity price cycles.

An important safety gap that is not covered in the rural and urban analysis is with regards to safety in high traffic roads, that is urban and interurban roads. A policy scenario that brings 75% of the high traffic roads to a 3-star rating is assessed. This scenario includes improvements in the road design, particularly design standards for pedestrian and cyclist infrastructure, and creation of safer environments for walking and cycling.

The urban transport, rural transport, and road safety policy scenarios were analysed assuming the three socioeconomic pathways that were developed for this study and presented in the introductory chapter. This assesses the sensitivity of the findings to exogenous factors, particularly population and GDP growth.

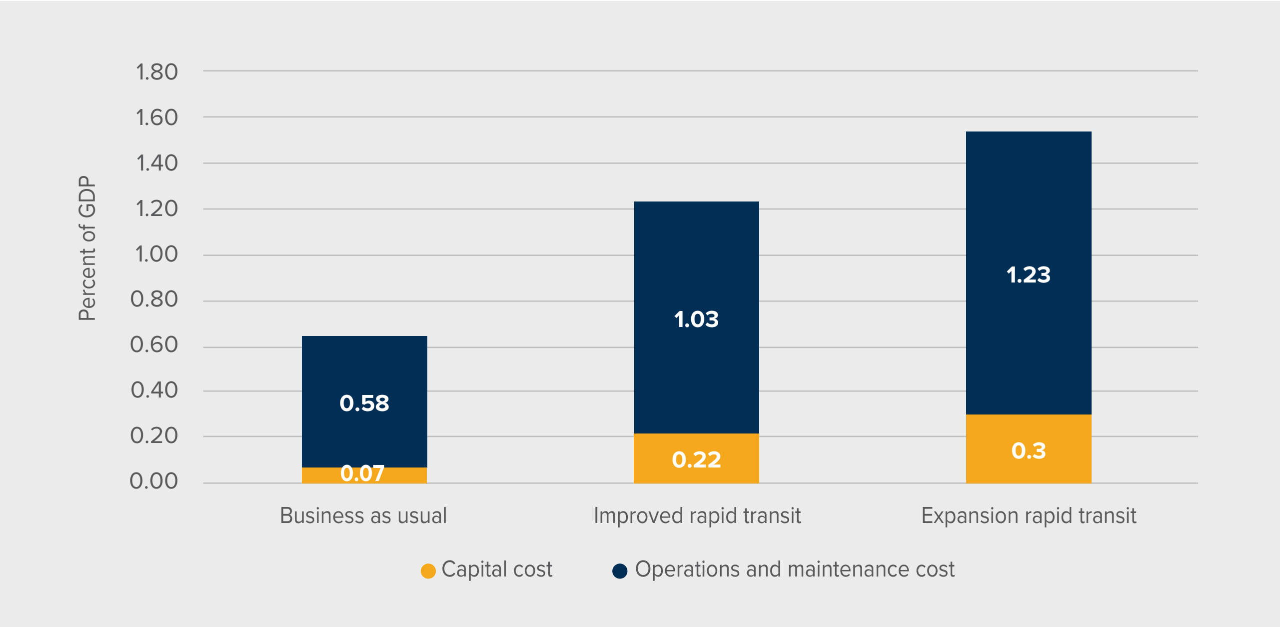
The scenarios were analysed using a set of models and empirical approaches. The quantification of the funding needs in urban transport follows a hybrid approach, which combines a bottom-up and a top-down approach. The assessment of urban accessibility follows an econometric utility-based approach (Ziemke et al., 2018), which captures access to opportunities (education, shopping, leisure, hospital, other medical facilities, police, social services, post office, banking, and work) through walking, cycling, minibus, and formal public transport (rail) for each 1 km by 1 km square in metropolitan areas. The quantification of the funding needs in rural transport follows the model developed by Ross & Townshend (2018) and refined by Townshend (2020). Its estimates of inputs have been verified by South Africa's National Treasury. The assessment of rural accessibility uses high-resolution population distribution data along with digitized road network data including road condition information following World Bank (2016). The road safety analysis is based on iRAP (2020).

Urban access

The restoration and improvement of rapid transit systems represent the lion's share of the funding needs. The funding needs under the BAU, IRT, and ERT scenarios over the 2022—30 period are R366 billion, R703 billion, and R864 billion respectively, which annualized represent 0.65%, 1.25% and 1.53% of GDP, under the baseline socioeconomic pathway (Figure 1.2).[9] The restoration and improvement of the urban rail system, including its O&M, demand 0.7% of GDP per year on average. The differences between the three socioeconomic pathways are small because of the relatively short period of time and the small differences in GDP growth.

9 The transport infrastructure investments under the IRT and LUT scenarios are the same, therefore the investment costs are the same.

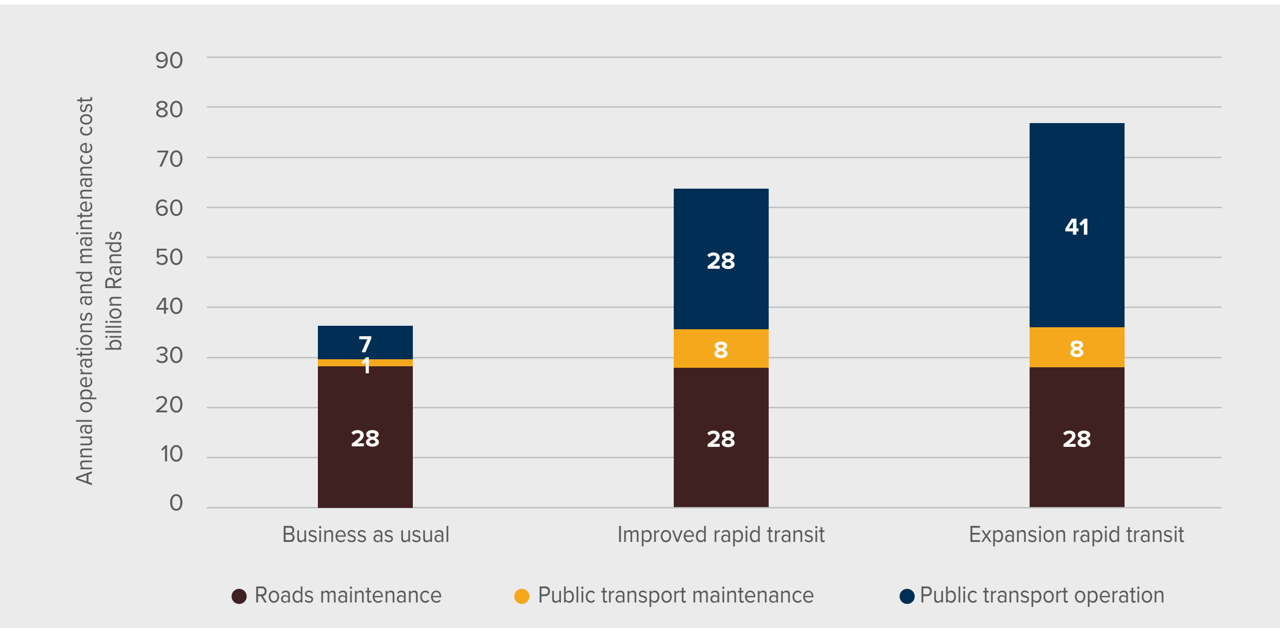
Figure 1.2: Average annual total cost under different scenarios, percentage of GDP



Note: The forecasted GDP in the baseline socioeconomic pathway is used.

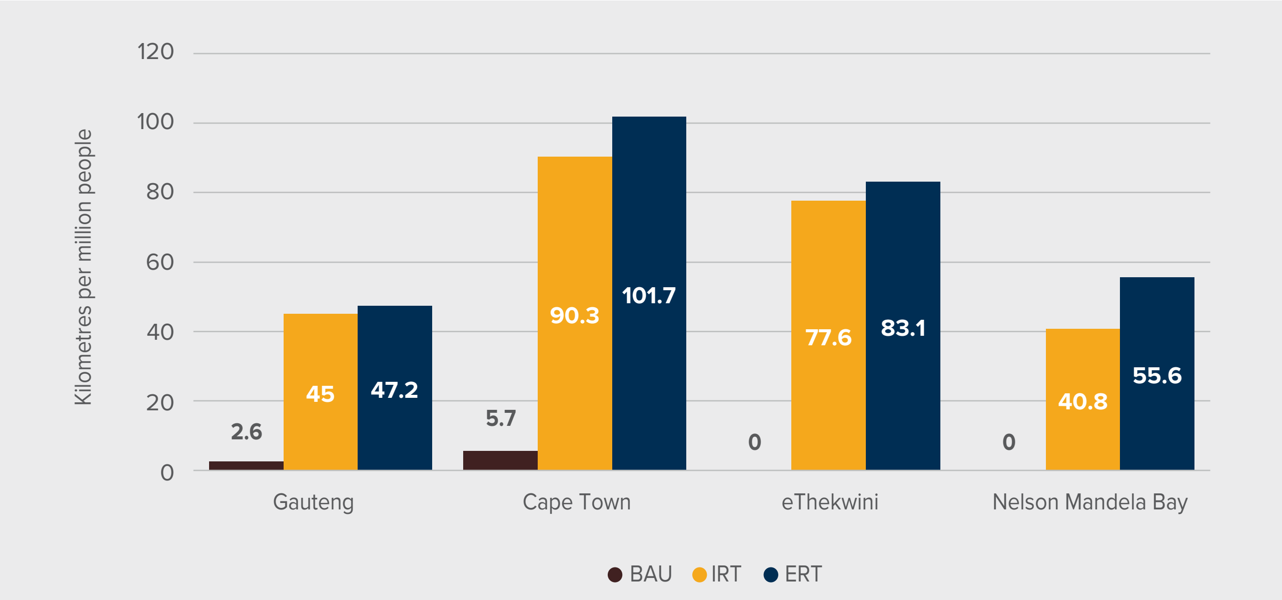
Cities should be prepared to spend significantly more resources on the operation of their public transport systems rather than on the construction of new infrastructure. O&M costs range from 80% to 89% of total funding needs. The total maintenance costs over the period range from R29 billion to R36 billion per year on average (Figure 1.3). The operation of public transport requires between R7 billion and R41 billion per year, on average, depending on the policy scenario.

Figure 1.3: Average annual O&M cost



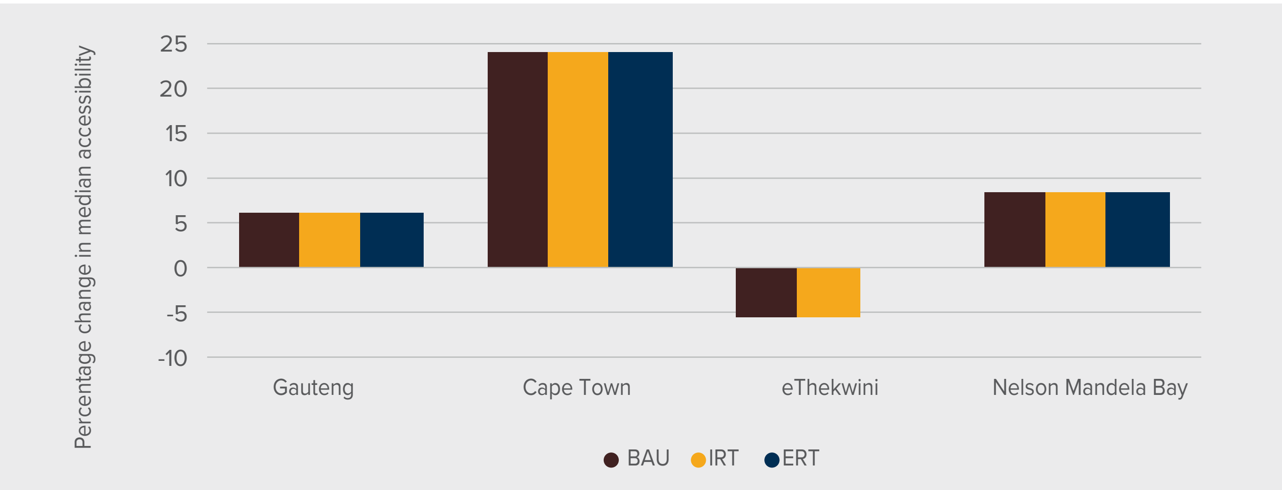
Transport infrastructure interventions alone are inadequate to bridge the historic and current urban access gap in South Africa. The improvement and expansion of urban rail and the expansion of BRTs would increase the RTR to around 60 km per 100 000 people in South Africa, with the RTR reaching around 100 in Cape Town (Figure 1.4). However, the improvement and the expansion of urban rail have limited effect on the accessibility in any of the four main metropolitan areas by 2030. The median accessibility increases between 2021 and 2030 in Gauteng, Cape Town, and Nelson Mandela Bay and decreases in eThekwini, but the changes are driven by the changes in population and opportunities, the latter driven by GDP growth, and not by improvement and expansion of urban rail (Figure 1.5).[10]

Figure 1.4: RTR in 2030 under baseline population, by metropolitan area



Note: The transport investments under the IRT and LUT scenarios are the same, therefore the RTR is the same in both scenarios.

Figure 1.5: Change in median accessibility between 2021 and 2030 under BAU, IRT, and ERT scenarios and baseline population



Note: The analysis only includes interventions in urban rail.

10 The accessibility analysis does not consider the expansion on BRT as the data required for the analysis is not available. That said, adding 120 kms of BRT across the four metropolitan areas would not have a significant impact on accessibility.

The limited impact on accessibility indicates the limitations of large infrastructure investments in urban rail in South Africa. The reasons for the limited impact of the infrastructure investments in urban rail are the spatial structure of the metropolitan areas, the location of the rail corridors, and minibus taxis dominating urban rail over short to medium distances. The South African rail service was designed and planned to move large groups of (displaced) workers from peripheral townships far from the economic centres. The improvements could reduce travel time and costs along those rail corridors, but they are not large enough to lead to higher accessibility than minibus taxis, which allow people to reach a broader range of activities at a lower generalized transport cost with a door-to-door service, while rail will only get the transport user from station to station. Therefore, improving minibus taxi services, which does not require large infrastructure investments, and the integration with urban rail have the potential to improve urban access and the experience of urban commuting over the short to medium term.

Integrated land use and transport planning yield higher accessibility per rand spent on transport and is the only policy intervention considered that tackles inequality in urban access. The results of the LUT scenario show that policies that support the development of opportunities closer to where people live, with an emphasis on the least accessible areas, have a large impact on accessibility. Under the baseline socioeconomic pathway, the median accessibility in 2030 increases in all four metropolitan areas considered (Figure 1.6). With the increase in Gauteng being three times the increase without land use planning. Integrated land use and transport planning consistently outperforms rail improvement and extensions in all socioeconomic pathways. The urban accessibility gap, measured as the difference between the highest and the lowest accessibility in a city, decreases with integrated land use and transport planning in all four metropolitan areas, under the baseline socioeconomic pathway (Figure 1.7). Under the urban and rural socioeconomic pathways, integrated planning decreases or limits the increase in the accessibility gap.

Figure 1.6: Change in median accessibility between 2021 and 2030 under IRT, and land use planning scenarios using the baseline population

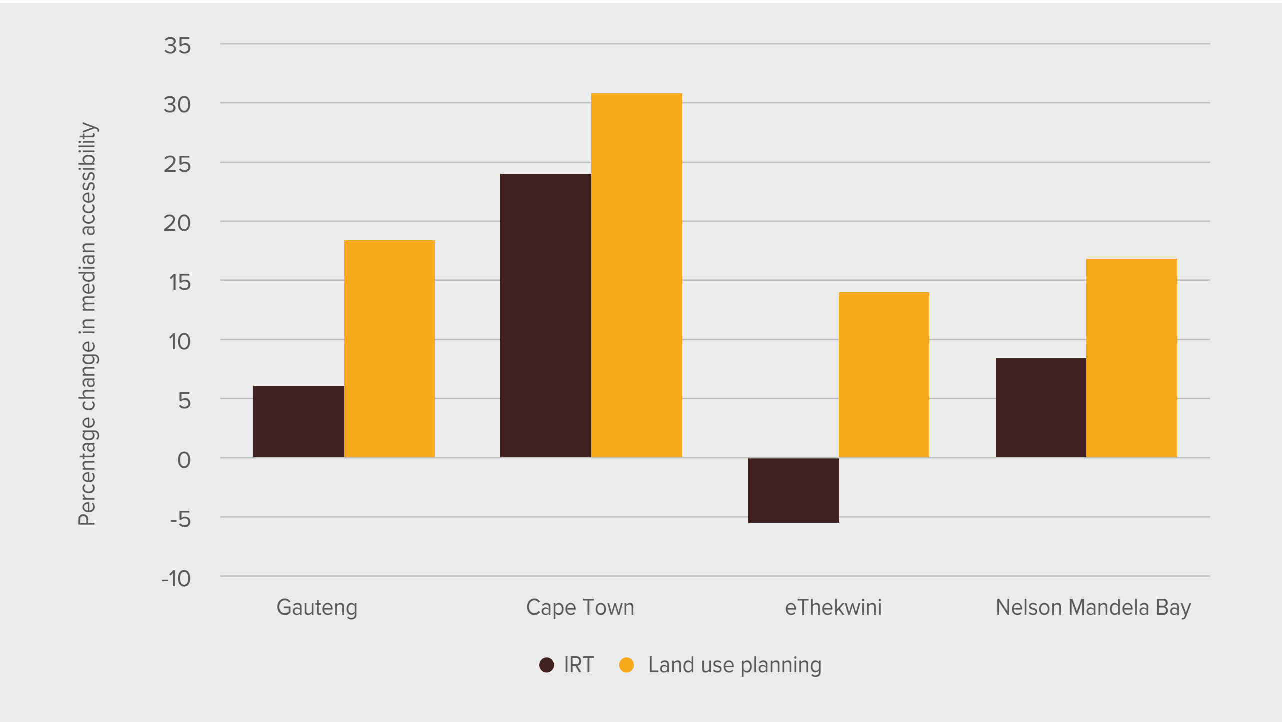
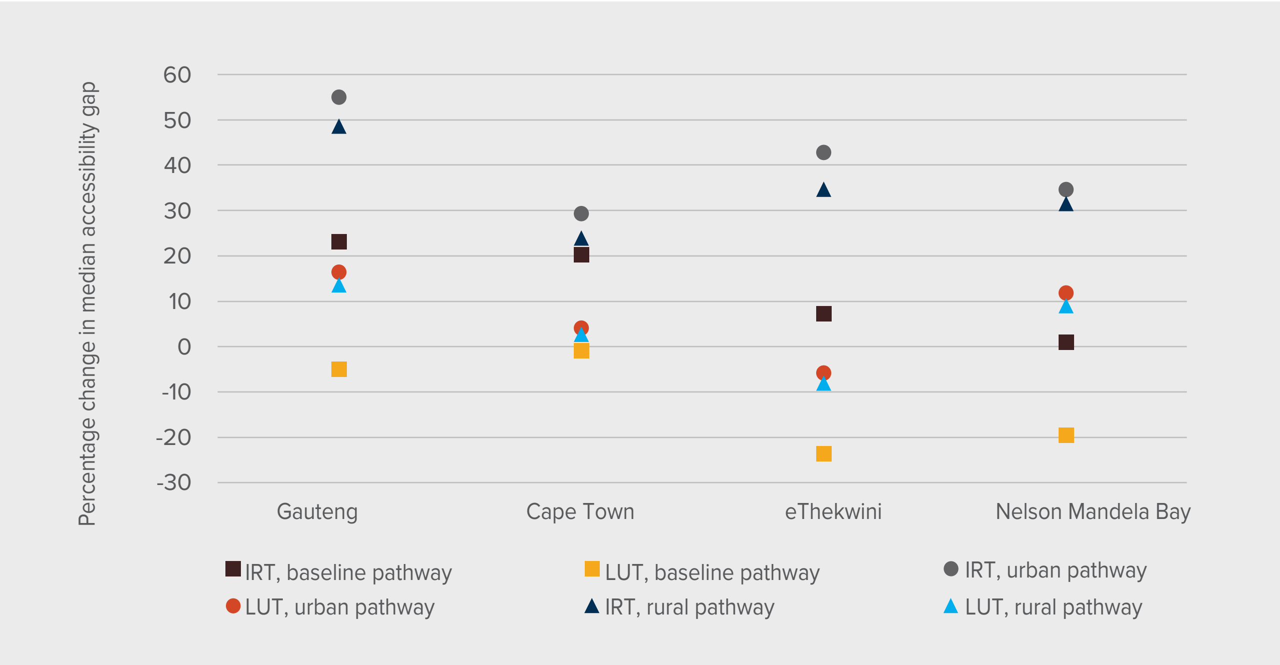


Figure 1.7: Change in accessibility gap between 2021 and 2030, with and without land use planning



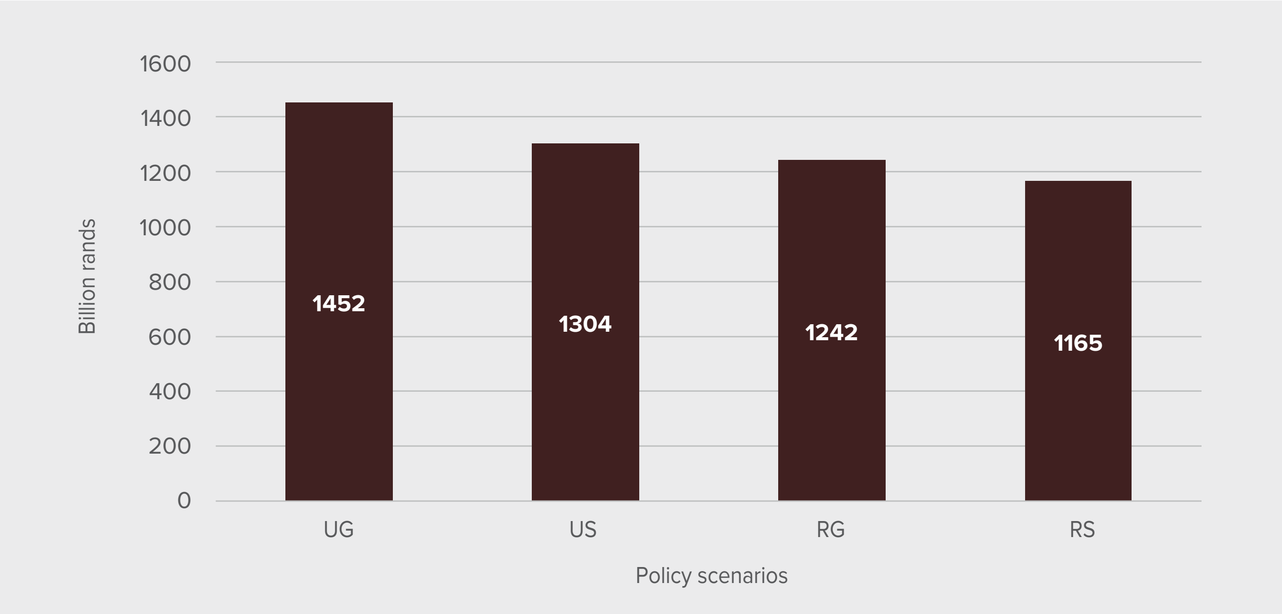
The popular phrase that we need to move people closer should clearly not be interpreted as requiring only transport infrastructure. A fundamental requirement for South African cities to reap the urban dividend is to relook, rethink and adopt a multi-pronged approach to addressing land use transport interactions to maximize urban development.

Rural access

A medium-term focus in selecting rural roads policy will lead to an inefficient policy choice. The highest possible RAI score without building new roads is 94%. The only technically feasible way of reaching that level of rural access by 2030 is by rehabilitating roads without changing the type of surface, that is the policy under scenario UG. That policy, however, would be more costly, over a 30-year horizon,[11] than a policy that paves all roads with a low-volume seal (RS scenario), which yields the lowest cost (Figure 1.8). The cost to reach an RAI of 94% by 2051 by sealing all existing rural roads is R1304 billion, under the baseline socioeconomic pathway, which is R148 billion less than that cost of rehabilitating existing roads without changing the type of surface.

11 A 30-year horizon captures the maximum effective lifespan of an unmaintained gravel road and aligns the analysis with the National Transport Master Plan 2050.

Figure 1.8: Total cost to convert entire rural roads network into all-weather roads by 2051



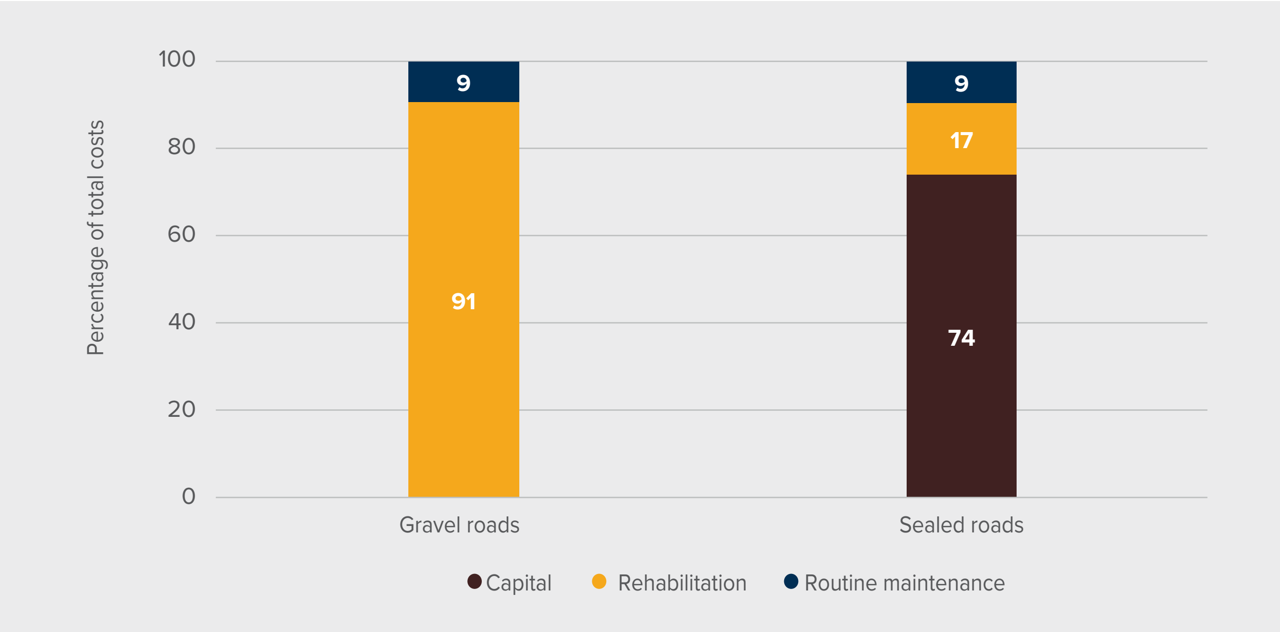
Note: The cost is calculated assuming the baseline socioeconomic pathway.

A strategic look at the rural road network would allow South Africa to reach the 94% RAI at a lower cost. Relocating small rural schools and clinics along some roads providing only basic access, without jeopardizing access to schools and clinics, can lead to a smaller rural roads network, and therefore, to a lower cost for achieving a given level of access (Figure 1.8). The cost to reach an RAI of 94% by 2051 by sealing roads in a rationalized network is R1165 billion, under the baseline socioeconomic pathway, which is R139 billion less than that cost of sealing all existing unpaved rural roads.

Relocating some small rural schools and clinics along specific roads will bring with it some complex issues. This will require coordination between multiple departments across the different spheres of government coupled with community consensus which brings with it high risk if this is not achieved seamlessly. South Africa' track record on these situations has not been encouraging to date.

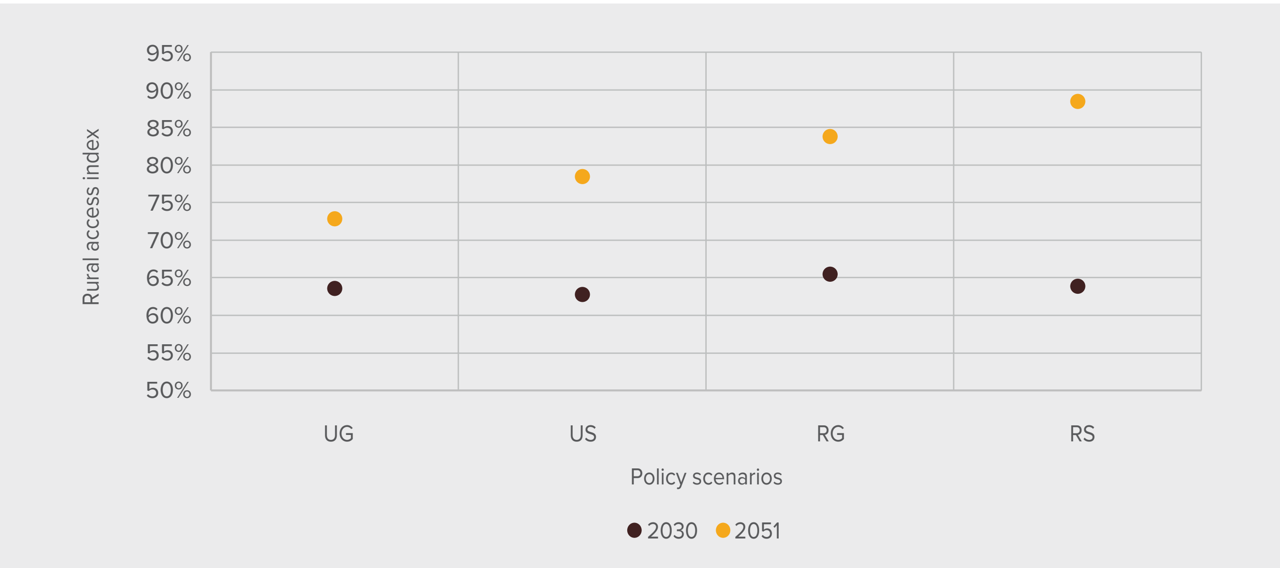
As with urban access, it is important to allocate resources for routine maintenance and rehabilitation to sustain access. Routine maintenance and rehabilitation costs represent 26% of costs under the policy of sealing rural roads (Figure 1.9). This contrasts with the policy to continue with gravel roads, where 100% of the costs go to rehabilitation and maintenance. The result highlights the importance of allocating adequate resources to both rehabilitation and maintenance of assets, even under the policy of sealing roads, which requires significant capital investments.

Figure 1.9: Total cost decomposition under different rural and surface policies



The projected fiscal resources available for rural roads for the 2022–51 period are not enough to cover the cost of achieving an RAI score of 94%.[12] By 2030, the highest RAI that can be achieved is 65.5% under the RG scenario, given the fiscal resources available for the 2022–30 period and the population under the baseline socioeconomic pathway (Figure 1.10). By 2051, the highest RAI that can be achieved is 88.5% under the RS scenario, given the available fiscal resources for the 2031–51 period.

Figure 1.10 RAI that can be achieved with available resources under different policy scenarios, and baseline socioeconomic pathway



12 The combined 2021 provincial and municipal rural road budgets were grown over the period 2022—30 and 2022—51 by GDP growth in the baseline socioeconomic pathway, and GDP growth adjusted for the investment-to-GDP ratios relative to the baseline scenario in the urban and rural scenarios. The projected fiscal resources range between 0.39% and 0.46% of GDP per year.

Road safety

Improving road infrastructure can help reduce road fatalities. Paved rural roads are not only less costly to maintain than gravel roads, but they are also safer, leading to lower injuries and fatalities and accident costs. Unsurfaced roads are associated with higher accident rates than surfaced roads as they are susceptible to slipperiness in both wet and dry weather and generate dust that reduces visibility for following and approaching vehicles (Table 1.1). Applying the average road accident costs published by the Road Traffic Management Corporation for 2015, for every 100 million vehicle-km travelled the accident costs on gravel roads are R73.7 million higher than for single carriage roads with a paved shoulder. The relatively low safety afforded by gravel roads therefore represents a significant avoidable cost to property and life.

Table 1.1: Accident rates and costs in South Africa

	Accident rates per 100 million vehicle-km			Total accident costs per 100 million vehicle-km (rands)
Road description	Fatal	Injury	Damage only	
Unpaved dirt road	13.9	141.7	988.2	188 591 089
Engineered gravel road	12.1	122.9	857.4	163 623 374
Single carriage with unpaved shoulder	6.9	70.7	492.8	94 053 140
Single carriage with paved shoulder < 1 m	6.6	67.6	471.2	89 932 255

Source: Authors' calculations, based on SANRAL's national HDM-4 configuration and Road Traffic Management Corporation data for 2015.

Table 1.2: Total funding needs to close the universal access and safety gaps, 2022—30

	Scenarios					
	Minimum spending		Preferred		Maximum spending	
	Billion rands	Percent of GDP per year	Billion rands	Percent of GDP per year	Billion rands	Percent of GDP per year
Urban	366	0.65	703	1.25	864	1.53
Rural	312	0.46	270	0.44	270	0.44
Road safety	322	0.57	322	0.57	322	0.57
Total	**1 000**	**1.68**	**1 295**	**2.26**	**1 456**	**2.54**

Note: The calculations are based on the forecasted GDP in the baseline socioeconomic pathway.

A key priority should be investments to improve the safety standard of high traffic roads to a 3-star rating standard. Infrastructure and speed management investments to achieve such an objective include improvements in road design, particularly design standards for pedestrian and cyclist infrastructure, and creation of safe environments for walking and cycling. Bringing 75% of the high traffic roads to a 3-star rating will require South Africa to invest 0.57% of GDP per year on average (iRAP, 2020), or R322 billion between 2022 and 2030.[13]

Aggregate funding needs

The scenario analysis, which assessed scenarios with varying levels of ambition, policies, and technologies identifies a preferred scenario for access and safety as well as a less ambitious or minimum spending scenario and more ambitious or maximum spending scenario.

The preferred scenario combines the ambitious and efficient rural policy of rationalizing the network and sealing all roads, the improved rapid transit with integrated land-use and transport planning policy scenario, which is the most efficient of the urban scenarios, and the policy to bring 75% of the high traffic roads to a 3-star rating. The funding needs under this scenario are R1.3 trillion for the 2022–30 period, which annualized represent 2.3% of GDP on average (Table 1.2).

13 The Rand values are based on the GDP projections developed for this study.

The minimum spending scenario combines the less ambitious rural policy of sealing all existing rural roads, the urban BAU policy scenario, and the policy to bring 75% of the high traffic roads to a 3-star rating. The most ambitious scenario of all those considered combines the rural policy scenario where rural roads are sealed and the road network is rationalized, the expanded rapid transit policy scenarios, which includes the expansion of urban rail and BRT, and the policy to bring 75% of the high traffic roads to a 3-star rating. The funding needs under these two scenarios are R1 trillion and R1.5 trillion for the 2022–30 period, respectively, which annualized represent 1.7% and 2.5% of GDP on average.

Recommendations

The recommendations presented here provide a high-level outline of the steps that need to be taken at a policy and implementation level in order to close the gaps that have been identified through the diagnostic and scenario analysis. While these measures are expected to have an impact in terms of universal access and safety, they will also contribute to green mobility and freight efficiency, helping achieve sustainable mobility, and thereby accelerating progress towards the achievement of the SDGs and the Paris Climate targets.

South Africa has an extensive, well developed, although deteriorating transport infrastructure base. The policy recommendations, therefore, prioritize initiatives that focus on leveraging the existing infrastructure by optimizing the utility of existing transport assets, before expanding its transport infrastructure. This should be coupled with ensuring the long-term sustainability of the network by ensuring the investments are climate resilient and aligned to the commitment of the Paris Agreement.

Urban transport

Implement longstanding policies for devolution of authority over public transport to metropolitan governments, while ensuring municipalities have capacitated themselves to assume responsibility for devolved modes of transport. With public transport functions at a local level, there is an opportunity for greater alignment between land use management and transport planning. Better resource allocation and accountability will be achieved by implementing longstanding policies to integrate and consolidate public transport responsibilities at city level. This implies furthering discussions on devolution of authority over various modes of transport to metropolitan and large urban local governments, and in the case of Gauteng, where multiple metropolitan governments neighbour each other, finding a resolution for the need for coordination across these adjacent metros. While some local governments are likely already in a position to assume responsibility for all modes of transport (Cape Town, eThekwini, and the Gauteng municipalities), others will need to be supported to adequately capacitate themselves before devolution can take place (Nelson Mandela Bay, Mangaung, and Buffalo City).

The devolution of authority for commuter bus and minibus taxi services comes with specific complexities. A process for re-tendering commuter bus services by cities that will ensure continuity of service needs to be developed and initiated. Provincial Regulatory Entities need to be absorbed into municipal structures. Cape Town and eThekwini have already made good progress preparing for these steps, while other cities still have to start.

Devolution of rail has a range of more complex challenges that need resolution. A detailed strategy needs to be developed that considers each metropolitan area's unique context and provides appropriate plans accordingly. The strategy also needs a response to the question of what the role of PRASA will be, how to deal with transfer of facilities and staff, how to manage ongoing long-term contracts, how to repair vandalized infrastructure, how to devolve subsidies, and how to involve the private sector.

Review and update the integrated public transport network plans and strengthen integration between land use and transport planning to maximise access and ensure fiscal sustainability of proposals. Any public transport solution introduced in South African cities needs to be context sensitive. Implementing context-sensitive transport solutions is germane for project success, especially when the urban form and resulting travel patterns are so different to those of the Latin American cities where BRT was pioneered. South African cities, like many around the world, will need a variety of public transport modes to meet their growing needs. While BRT should play a role in the modal mix, there should be more careful consideration of the necessity for standards that increase capital costs without necessarily delivering operational and cost benefits. Weak ridership on current BRT systems also points to problems with network planning and market positioning.

Support PRASA to refine its recovery plan with clear and costed capital investment and operational action plans. Restoring rail services to full functionality will require significant investment in the repair and restoration of stations, signalling systems, track and per way infrastructure. PRASA should continue with the focused roll-out of Metrorail services, in parallel with focused investment to attain the full resumption of the services.

While restoring the passenger rail will improve the RTR ratio, these investments by themselves are not sufficient to impact substantially on accessibility. Improving accessibility will require supporting the rail mode through integration with complementary improved minibus taxi services and the supplementary BRT networks. Cities can support PRASA though transport planning alignment, safety and communication support initiatives, and urban and precinct planning support. Investments in public transport need to be supported by initiatives to promote the spatial transformation required to overcome the legacy of apartheid spatial planning either through a focus on transit-oriented development or other public transit centric land use development initiatives. Since land use planning and management and development control are within the jurisdiction of cities, it is important that PRASA's recovery plans and the consequent investments into the infrastructure at stations are carefully coordinated with city governments to maximize value through complementary investments by the cities and to minimize the disruption caused by construction at these key interchange points.

Over the longer term, actions to devolve authority over rail will need to be informed by a review of the role of PRASA in South Africa's integrated multi-modal public transport system and the prioritization of actions needed to support improved integration.

Recognise minibus taxis as a key part of solutions to South Africa's public transport challenges alongside other modes and work with minibus taxi industry role-players to enhance its efficiency. Minibus taxis should be integrated into formal public transport networks and planning exercises. There is significant potential to improve the quality of service offered by the industry directly through programs focused on introducing scheduled operations and electronic fare collection. Efforts should be directed towards investigating and implementing measures to support the taxi industry, to modernize its service offering, and to enhance the efficiency of their businesses.

Improving the service quality in the minibus taxi sector will render much more substantial returns to passengers (and operators) than will be possible and affordable through a direct redistributive type of subsidy. Investments should be directed towards improving ranking facilities, many of which are entirely informal, unpaved, and not serviced, developing bus stops and embayment at busy boarding locations on route, and investing in roads used by taxis to improve travel times and conditions.

Rural transport

Rehabilitate deteriorated paved strategic roads and pave all unpaved strategic roads, and develop a rationalized basic road network, sealing all roads in this network. The fundamental and structural problem of the South African rural road network is that it is too large to be adequately maintained given realistic fiscal resources. A long-term view of rural road development is therefore required to ensure fiscal resources are prioritized appropriately. The structural problems could be addressed by (i) rationalizing the network while also embarking on a carefully coordinated intergovernmental process to relocate or build additional basic services such as small rural schools and clinics in closer proximity to far flung rural communities, which will, over time, be much less expensive than rehabilitating and subsequently maintaining the entire over-extended network; and (ii) rehabilitating roads only with low-cost seals rather than gravel.

Ensure that sufficient resources are allocated to the maintenance of assets, which includes routine maintenance and rehabilitation and that the roads departments are adequately capacitated to manage the road assets under their control. While additional funding will be required to arrest the decline of the network, investment in better asset management systems and in the capacity of provincial road departments could help ensure that available resources are invested wisely. Achieving maximum efficiencies from roads budgets will require good data and knowledge regarding the condition of the network, and experienced and skilled staff to make decisions and oversee work at every stage of the project cycle.

Ensuring road authorities develop and adopt climate resilient standards. Rural accessibility is a key issue for the South African government's transformation agenda and will be vital to mitigate against the expected water stresses due to climate change. Maintaining rural connectivity on a core road network is essential for the sustainability of the agriculture sector and ensuring access to basic services for rural communities. Climate change adaptation requires capacity to develop climate resilient standards and then funding to ensure regular maintenance and adoption of standards developed to ensure longevity of the assets.

Safety

Systematize the use of road safety audits for all high traffic roads and ensure adequate funding for required investments. Recommendations for improved road safety over the coming decade should follow the principles of the safe system approach to road safety and include promoting shifts to more sustainable and safer transport modes (shifts from road to rail, private mobility to safer public transport and non-motorized transport) while addressing key gaps under the pillars of the United Nations Decade of Action.

The use of road safety audits for all high traffic roads and supporting investments to bring 75% of high traffic roads to a 3-star rating standard (iRAP, 2020) is required. This includes having the appropriate design standards in place for pedestrian and cyclist infrastructure and improving safety around schools.

Reduce legal blood alcohol limits for young and novice drivers from 0.05 to less than 0.02, expand the deployment of random breath testing and the application of appropriate penalties and strengthen enforcement to increase seatbelt wearing. Introduce legislative and enforcement deterrence measures, including deployment of random breath testing and the application of appropriate penalties. Revise seat belt laws to require both front and rear seat occupants to be belted and enforcement to increase seat belt wearing (only 33% of drivers and 31% of front seat passengers use seat belts) and implement improved enforcement of helmet wearing standards for cyclists.

Introduce legislation to reduce speed limits and develop an integrated speed management plan. Introduce legislation to reduce speed limits to 30—50 km/hr in urban areas, 80 km/hr in rural areas, and 100 km/hr on motorways. Develop an integrated speed management plan that includes infrastructure changes on urban streets and rural roads starting with the highest risk locations (for example, schools, markets, and villages) through traffic calming measures (speed bumps, speed cameras), and include dedicated police enforcement combined with public awareness campaigns.

Adopt United Nations Economic Commission for Europe (UNECE) vehicle safety standards. Implement regulatory requirements for mandatory fitment of seat belts and anchorages, ensuring this includes public transport vehicles and adopt UNECE vehicle safety standards related to frontal impact and antilock braking systems (UNECE, 1998), with improved regulations relating to public transport, including vehicle safety requirements.

Gender

Institutionalize gender in transport policy and planning. Gender should be mainstreamed into national transport policies and plans to establish and improve the decision-making process on gender-sensitive transport. An important step in that direction would be to develop an appropriate gender and mobility framework or strategy for South Africa. This will require establishing a timeframe and budget for development and approval of the gender and mobility framework or strategy and ensuring that the framework or strategy includes associated budgets, resources, targets, and monitoring or evaluation protocols.

Key to this framework would be consultation with stakeholders, and although frameworks exist in South Africa to consult stakeholders, a stronger effort needs to be made to ensure that women and other vulnerable groups are able to participate, and that their voices are heard. Development of practical guidance on what gender specific data is needed to deliver gender responsive transport must be based on stakeholder engagement and international best practices (SuM4All, Forthcoming). Stakeholder consultation will allow for an improved understanding of the requirements of women travellers which could then be used to update design standards and develop gender responsive infrastructure and operations.

Freight transport

Develop a port sector strategy to increase competition and efficiency. The current institutional structure in the port sector and the dominant role of Transnet contributed to a lack of competition among ports and inefficiency. A strategy that removes the constraints to private sector participation in the operation of ports and attracts a diverse pool of operators, as done in countries with the most efficient port sectors will increase the efficiency of the sector and the competitiveness of the country. It is key that the strategy clearly establishes the role of the individual port in the network and sets the steps to ensure the ports are well placed to compete locally, regionally, and internationally. It is also important to ensure sufficient capacity to meet current and projected demand, bringing in private expertise to improve spatial and operational efficiency, and private capital for needed expansion. The port strategy should be linked with the freight rail strategy to improve integration between ports and rail, which will bring about decongestion at the ports.

Pursue initiatives to leverage additional private sector participation in rail to capture additional market share from road while ensuring climate resilient practices are adopted. Repositioning the intermodal rail service offering and capturing market share from the road should help reduce inland transport prices, port congestion, and the carbon footprint of the container supply chain. Two reform phases are envisaged: (i) Sale or lease of inland rail-based container terminals, with Transnet keeping a minority stake. One or more private sector operators will take over operations at the terminals as part of an integrated service offering; and (ii) Sale of current Natal Container Corridor container wagon fleet to wholesale customers who would own or lease wagon rakes, utilizing haulage services provided by Transnet.

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Chapter 2

WATER AND SANITATION

Introduction

South Africa has a good track record of water and sanitation infrastructure delivery for new services at scale, resulting in the rapid expansion of access to water and sanitation from 1994 to 2019. Data from the United Nations' Joint Monitoring Programme (JMP) indicates a gradually improving trend in access to safely managed water services nationally,[1] with the greatest gains in urban areas, largely through the new housing delivery process, with slower progress in rural areas. However, access to services has historically been measured based on the type of service and proximity to households, aligned to the Millennium Development Goals (MDGs), and not the more stringent requirements for safety and reliability provided in the SDGs. This difference is critical in terms of the sustainability of services, with a shift in emphasis from the rolling out of infrastructure to the quality of the service provided, which has exposed shortcomings in South Africa's ability to manage assets and operate and maintain services sustainably.

SDG 6 seeks to ensure the availability and sustainable management of water and sanitation for all. While the SDG covers clean water and sanitation in general, and contains eight targets, only three of these are assessed in this report:

- **SDG 6.1:** Universal and equitable access to safe and affordable drinking water for all.
- **SDG 6.2:** Access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.
- **SDG 6.4:** Substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.

South Africa reports regularly on the progress in achieving the SDGs (DWS, 2022a), and various estimates have been made of the investment need (DWS, 2017a; DWA & DBSA, 2012). However, no studies have investigated how the investment need might vary with different approaches to providing water services, and also what funding is available in the sector to cover the required expenditure. The assessment of the water and sanitation sector in this chapter looks at the underlying drivers of cost and what policy changes can be made to alter the cost while still achieving the SDGs. The assessment of water resources focuses only on the water resources required to serve potable water uses and therefore excludes non-potable water resources required to supply irrigation, energy, and industrial demand.[2]

This chapter first presents a brief diagnostic of the water sector in South Africa, followed by a description of the scenarios and methodology used for the study. Key messages coming out of the scenario analysis are presented before presenting recommendations and a preferred development scenario for the sector.

Diagnostic of the sector

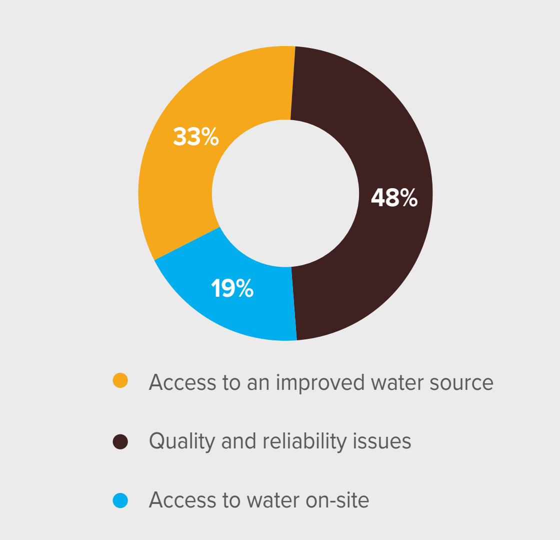
In urban areas most households already have access to a high level of service, such as sewered sanitation and piped water into the household. The remaining servicing challenges, however, are concentrated in informal settlements and informal backyard dwellings within formal areas, where the scale of service delivery has not kept pace with rapid urbanisation. The poor condition and operation of wastewater treatments works, predominantly in urban areas, and the severe impact these have on the environment and downstream users, are also a challenge for the achievement of the SDGs (DWS, 2022b). Service delivery has been challenged by fast growth and contestation over the legal status of the settlements, often associated with the rights to the land on which they are situated. The failure to address the basic water and sanitation services backlogs in these rapidly growing

1 The JMP definition is: Drinking water from an improved water source that is accessible on premises, available when needed and free from faecal and priority chemical contamination

2 Although the resources to supply potable and non-potable demand are usually shared, the costs thereof have been apportioned pro-rata to the potable demand only.

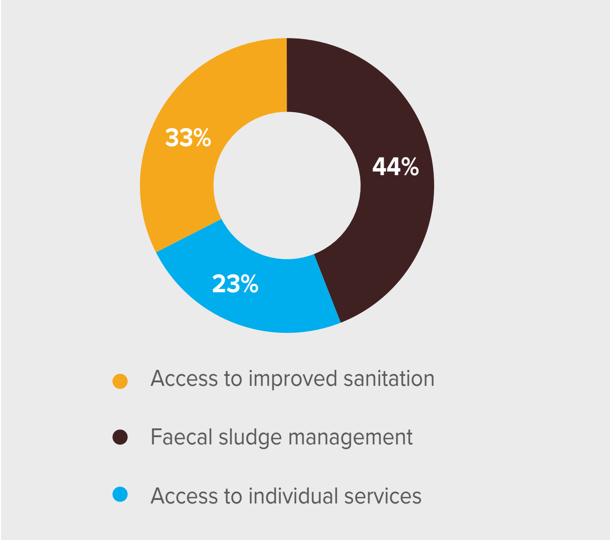
peri-urban areas also presents a significant risk to liveability and downstream water quality, which, in turn, impacts water security. The inequality in basic water services also varies significantly between municipalities and is often a legacy of poor planning and project implementation in the past.

Figure 2.1: Composition of the 46% gap to achieving the SDG 6.1 target for access to water



Source: Authors' calculations from Stats SA (2019).

Figure 2.2: Composition of the 49% gap to achieving the SDG 6.2 target for access to sanitation



Source: Authors' calculations from Stats SA (2019).

Large-scale rural sanitation programs undertaken in the early years of democracy have been successful at delivering discreet units, but the ongoing management of these facilities by municipalities has been inadequately addressed, leaving households responsible for the operation and maintenance of on-site sanitation facilities. As a result, FSM is a pressing issue in South Africa, particularly in rural areas (DWS, 2021). Continued population growth, climate change, and environmental degradation are also likely to have a significant impact on the water resource quality and availability, which directly impacts the country's ability to meet the objectives of SDG 6.

The SDG targets for water and sanitation use the JMP definitions of a 'safely managed' service. A cross-tabulation of Stats SA 2019 General Household Survey data shows that only 54% of households have access to a 'safely managed' water supply.[3] Figure 2.1 shows that 48% of the households with an inadequate water supply need quality and reliability issues to be addressed. Only 33% of households with inadequate service require improved services, while a further 19% (mostly in rural areas and urban informal settlements) require communal facilities to be replaced with on-site water to meet the SDG 6.1 requirements. The interventions required to address each of these issues, and thus achieve the SDG target are different.

Similarly for sanitation, the JMP definitions have been used to calculate that only 51% of households have access to a safely managed sanitation service.[4] Two important components of the JMP definition are that sanitation facilities must not be shared by households, and effluent from wastewater treatment works, sludge from treatments works, and faecal sludge removed from on-site sanitation facilities, needs to be properly treated, managed, and safely returned to the environment. In some cases, the sanitation facility needs to be improved, in other cases it needs to be provided on the property (not shared), and in many cases the faecal sludge needs to be properly managed. The largest share of the sanitation 'gap', 44%, is due to inadequately managed faecal sludge (Figure 2.2).

3 This is lower than the 63% of households with a safely managed supply being reported by demographic and health surveys due to a difference in methodology for cross tabulating the data.

4 The Department of Water and Sanitation does not currently report on percentage of households with a safely managed service because of a lack of data on FSM. This study has used proxy data and assumptions to estimate the percentage of households with safely managed sanitation.

In addition to issues of access, South Africa also struggles with availability of water resources, given the general water scarcity and uneven distribution of surface water resources. Over 50% of water resources come from only 8% of the land, referred to as the Strategic Water Source Areas. South Africa has a long history of effective and efficient water resources planning and operation, and, as a result, has developed complex and integrated bulk water supply systems providing water security to the main economic hubs of the country.

However, in recent years these systems have come under threat, primarily due to lack of investment in the operation of the systems, lack of attention to planning revisions and poor adaptation to changes in demand and surface water availability. Delays in the implementation of critical infrastructure such as the Lesotho Highlands Water Project Phase II, the raising of Clanwilliam Dam, the Berg River Voelvlei Augmentation Scheme, the Vaal Gamma-Gamma pipeline, and other schemes, has resulted in an increase in water security risks for the country. Similarly, failure to address the threat of acid mine drainage, and water quality more generally, and to provide sufficient funding for the clearing of IAPs, increases the risk further. Recent droughts in the Western Cape and the Eastern Cape provinces indicate vulnerability of supply and reduced levels of resilience.

Current average water consumption in South Africa is 237 litres per capita per day, which is 37% higher than the global average of 173 litres per capita per day (DWS, 2018). Part of the reason for this excessive consumption is the high levels of NRW, estimated to be 41% of system input volume (DWS, 2018), which is also significantly higher than the global average of 30% (Limberger & Wyatt, 2018). The bulk of this NRW (85%) is through real losses in the system (technical losses, including leaks and bursts) while the remainder is through apparent losses (inaccurate meter reading and unauthorised use).

While some of the physical losses due to infrastructure or construction defects may be unavoidable, most are due to poorly maintained infrastructure or slow responses to reports of leakage (McKenzie, 2014). Multiple reports and policy documents have recommended that municipalities increase their efforts to reduce NRW and the negative impact it has on their ability to generate own income and run a viable water business. The fact that the required level of expenditure on renewal is not being incurred is evident in the condition of the infrastructure networks as measured through the water and wastewater quality compliance indicators, such as the level of intermittent water supply or compliance with wastewater effluent standards, and the high levels of technical losses. The Department of Water and Sanitation (DWS) (2018) states that municipalities are losing about 1660 million m^3 per year through NRW. At a unit cost of R6/m^3 this amounts to R9.9 billion each year.

The current performance of water services in South Africa, particularly in terms of reliability and quality, is indicative of a decline in local government capacity to manage infrastructure assets and sustain water services. Shortcomings in municipal capacity are not universal, as a third of municipalities are performing adequately. Performance is also uneven across the infrastructure provision process: access to services has increased in the sense that infrastructure is in place; but the lack of capacity to operate and maintain the resulting infrastructure has resulted in excessive system failure, partly because the assets are left to deteriorate, partly because of inadequate operational systems, and partly because of weak management of operational activities.

One of the recognised issues in the sector is the lack of adequate technical skills in the public sector, and in particular the low number of engineers managing water services in municipalities (Lawless, 2016). The shortage of engineering professionals in municipalities is not due to a shortage of engineers in the country, rather it is due to conditions specific to those in municipalities which do not attract existing or new professionals to the public sector (SAICE, 2019). Although there are government programmes to provide technical support to municipalities (such as the Municipal Infrastructure Support Agency), or supplemental technical capacity where there is little or none (such as the Cuban engineers brought to South Africa), there is currently no comprehensive capacity building programme for water and sanitation services specifically.

Efficient governance systems and executive and political leadership also pose important capacity challenges. At local government level, there is evidence of malfeasance in the awarding of contracts to politically connected contractors (Muller, 2020), and a lack of attention paid to water and sanitation infrastructure (Auditor-General

South Africa, 2018). The Auditor-General (2018) also found that there was inadequate monitoring and oversight of contractors, planning, and poor quality of workmanship leading to unnecessary project delays. At the national government level, the DWS is responsible for setting the policy direction for the delivery of water and sanitation services. The apex non-political position is that of a Director-General (DG). In the period 2009—17, the average tenure of a DG was 11 months, with nine incumbents over the period, and five of these in Acting positions (Auditor-General South Africa, 2018).

The management instability in the DWS is likely to have impacted on water services policy and regulation. Examples of this include the delays in establishing Catchment Management Agencies, many delays in setting up the Independent Economic Regulator, delays in rationalizing Water Boards, and delays in reviewing the water sector legislation. Regulation of municipal water tariffs has not been occurring and regulation of water board tariffs has been erratic. The delay in finalising the Draft Revised Water Pricing Strategy means that raw water has been under-priced for many years. Poor governance in the sector and the absence of ring-fenced utilities has also contributed to the provision of financially unsustainable water businesses in municipalities. Non-payment and lack of revenue collection is a result of a combination of factors: unregulated supply, unclear payment contracts in communal land areas, historical payment boycotts, lack of municipal management capacity and systems, and a lack of political will to support payment for services. The result is unregulated consumption and minimal tariff revenue.

Methodological approach and scenarios

The water sector objectives of the study were based on the above SDG indicators but interpreted at a country level in the context of South African water sector policy. The first objective is drawn directly from the SDG target and relates to the provision of universal, safe, and reliable water services. Secondly, services need to be financially sustainable and affordable to both the state and to households. Thirdly, expansion of water services needs to be resource efficient in order not to exceed available water resources. Fourthly, water services and water resources need to be planned to increase water resilience, or the ability to withstand increasing adverse climatic events related to climate change. Fifthly, reducing climate change impact is present throughout South Africa's water sector policy objectives, and in the overarching NDP. Finally, the South African public sector, including local government, needs to have sufficient institutional capacity to expand water services access and to operate and maintain these services sustainably.

Technical servicing options were identified through the local and international literature and through interviews with water sector experts in South Africa. Households were divided into four geographic contexts using Census data: urban formal, urban informal, rural traditional, and rural farms, and technology choices were differentiated by geographical context.

The above factors were combined to define eight policy scenarios incorporating:

- Two service level goals:
  - universal basic servicing to minimum standards set out in South African water policy (DWS, 2017b); and
  - achievement of SDG 6.1 and 6.2 to the JMP standard.
- Four technology options:
  - full conventional technology – water and sanitation provided in the same mix of technologies as currently supplied to the four geographic contexts;
  - low-cost technology – maximum use of yard taps, public standpipes, wells, pour flush toilets and ventilated improved pit latrines where possible;
  - alternative technology – maximum use of onsite boreholes, pour flush toilets, next generation sanitation and decentralised wastewater treatment; and
  - extreme WCDM – as for alternative technology, but with additional WCDM measures.

The policy scenarios were analysed assuming the three socioeconomic pathways that were developed for this study and presented in the introductory chapter. This assesses the sensitivity of the findings to exogenous factors, particularly population and GDP growth. Climate change was also identified as the main exogenous factor for the achievement of the water and sanitation SDGs and included in the analysis as explained below.

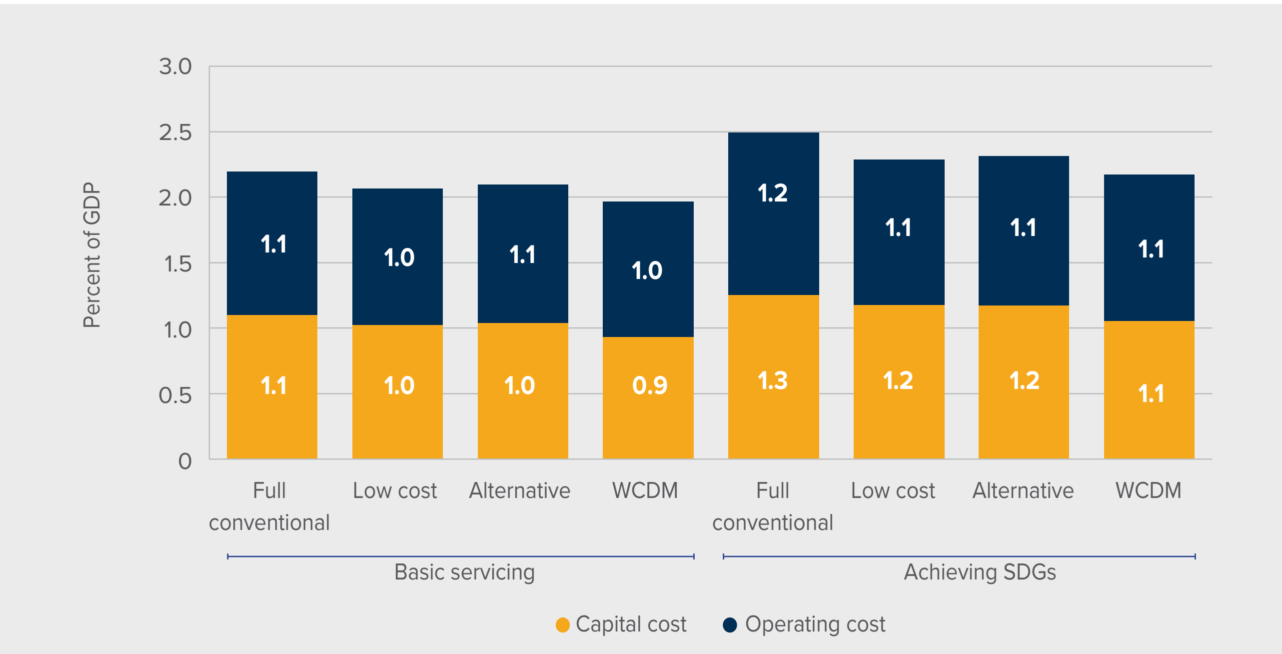
Each of the policy scenarios were modelled using two bespoke Microsoft Excel models. The first, a Water Services Model, calculated potable water demand requirements, capital and operating costs, and carbon emissions over a ten-year period from 2021 to 2030. The second, a Water Resources Model, quantified the additional capital and operating expenditure that would be required to be spent on water resources infrastructure to satisfy this potable water demand. The Water Resources Model included nine scenarios related to climate change (10th percentile, 50th percentile and 90th percentile of Representation Concentration Pathway (RCP) 8.5[5]) and IAP clearing (do nothing, maintain current levels, maximum clearing).

The model outputs were produced for the country as a whole and were not disaggregated at a subnational scale, although a post-hoc allocation was undertaken to assess relative needs of different categories of municipality.

Closing the gap in water and sanitation

Much of the expenditure required in the sector is required for operating, maintaining, and renewing existing infrastructure. Mirroring the shift in focus from the MDGs to the SDGs, the focus in spending needs to shift from the provision of new infrastructure to the maintenance of existing infrastructure and services through proper asset management. This includes the renewal backlog to bring the service levels back to where they should be. The implication of this finding is that the investment needs are high, regardless of the scenario chosen, and the chosen scenario will only impact on new additional costs. The overall cost differences between the scenarios are therefore relatively small. The ratio of capital costs to operating costs is approximately equal (Figure 2.3).

Figure 2.3: Capital and operating costs under different scenarios



Note: The baseline socioeconomic pathway was used.

5 RCP 8.5 is one of many RCPs or climate modelling scenarios, and refers to a scenario in which the concentration of carbon that delivers global warming at an average of 8.5 watts per square meter across the planet.

The total cost of the highest cost scenario is 27% higher than the lowest cost scenario, approximately half of which is due to service level choices and half associated with technology choices. The low cost for the basic servicing scenarios is driven by the maximum use of shared services and the reduced amount of capital required to provide bulk and connector infrastructure. Cost results are particularly sensitive to high-cost, individual, on-site options. Private boreholes are the highest capital cost option for water and the wide adoption of this technology results in high total cost. For sanitation, containerised toilet options used in urban informal settlements have a low capital cost but very high operating costs that results in a high lifecycle cost.

A differentiated approach in rural and urban areas

The water and sanitation challenges in rural and urban areas are different, requiring a differentiated and nuanced approach. An analysis of the spatial distribution of the 'gap' to achieving SDG 6.1 and 6.2 indicates that the service access backlogs have different characteristics for water and sanitation in urban and rural areas. These are summarised in Table 2.1.

Table 2.1: Nature of the key challenge in the different geographies

Context	Water	Sanitation
Urban-Informal	Individual access and continuity of supply (quality and management challenge)	Appropriate technology combined with political stance around the permanence of settlements (technical and political challenge)
Urban-Formal	WCDM (management challenge)	Quality of wastewater effluent (management challenge)
Rural-Informal	Access in the face of high cost and low affordability (funding challenge)	FSM (funding and management challenge)
Rural-Formal	Continuity of supply in the face of climate change (regulatory and management challenge)	FSM (funding and management challenge)

One major issue that needs to be addressed is the sanitation service level in urban informal settlements. Density limits the technical options provided in urban informal settlements and makes the provision of individual sanitation services difficult without relocating households. National policy to date has focussed on a basic level of sanitation in these settlements which allows for sharing of toilets by up to five households as a minimum standard. However, this is not compliant with the JMP definition of safely managed sanitation. To achieve the JMP standard, individual toilets would need to be provided, which has large practical implications around the need to de-densify settlements and procure land for this purpose, but also on the cost of the intervention. Scenarios that include for individual provision of sanitation in informal settlements are more costly than those that provide the current basic level of shared toilets. The operating cost per household to achieve the SDGs in urban informal areas is 1.4 times the cost in urban formal areas (in the Full Conventional scenario) due to the use of expensive, unshared containerised chemical toilets where full flush systems connected to the sewer mains are not possible (in approximately 15% of urban informal households). This points to affordability issues in providing the individual services required by the SDGs in urban informal areas.

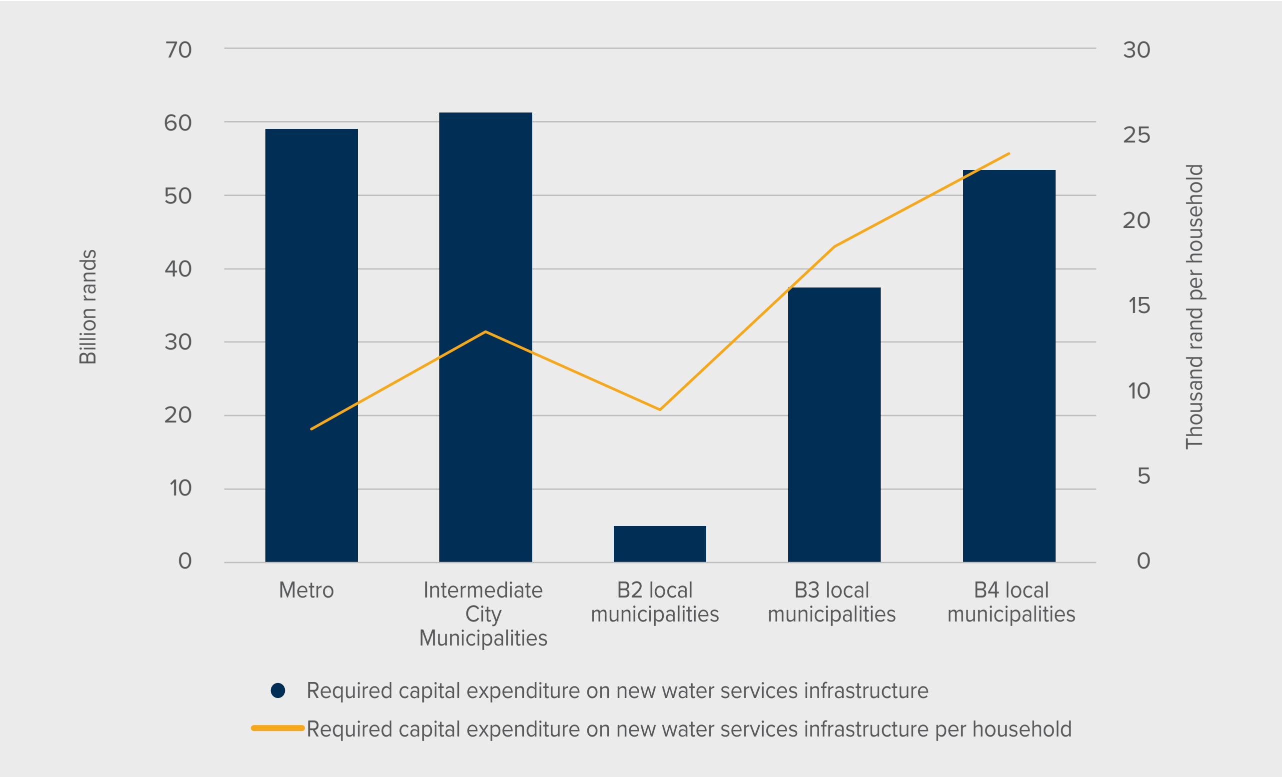
In rural areas, there is much uncertainty around the costs of FSM as well as the incidence of this cost. This is likely to impact on the affordability of achieving the SDGs. There is a lack of awareness or knowledge by households and even service providers around how to manage faecal sludge safely and also a lack of clarity around who – municipality or households – is responsible for this activity. The DWS has identified this as a constraint in the achievement of SDG 6.2 and has developed a draft National Faecal Sludge Management Strategy (DWS, 2021) to try to resolve this issue. The National Norms and Standards (Water Services Act) should also provide guidance on FSM in rural areas.

The differences between rural and urban cost projections are small. The relative cost differentials in providing services in rural and urban areas tend to offset each other. For example, in comparing a rural household with an on-site borehole and ventilated improved pit latrine, with an urban household having an onsite piped water connection and a sewered flush toilet, the rural household will have higher water capital costs, but lower sanitation capital costs. Density is an issue that affects costs differently in rural and urban areas. In lower density rural areas, reticulated water supply is more expensive for water, but there are more, cheaper, on-site sanitation options available.

Geographic focus

In terms of the geographic distribution of expenditure need, the results indicate that the largest capital investments are required in intermediate city municipalities and in metros, followed by B4 rural municipalities[6] (Figure 2.4). Much of the operating expenditure is necessary in urban formal areas, where 62% of customers live, and where the largest proportion of high levels of service currently exist. South Africa is urbanising at a rapid rate, therefore there is a high demand for new services in urban formal areas and the renewal of existing infrastructure. When the capital expenditure is normalised per household, the relative expenditure patterns shift away from metros (where the number of households is highest) to the more rural, sparsely populated municipalities. This indicates that the greatest expenditure is required in dense urban areas, where the cost per household is also the lowest, indicating an efficient use of resources. The servicing cost per unit is highest in rural formal (commercial farming) areas, due to the dispersed nature of settlements, but this represents only 3% of the population, thus the total expenditure in these areas is the lowest.

Figure 2.4: Required capital expenditure on new water and sanitation infrastructure by municipal category

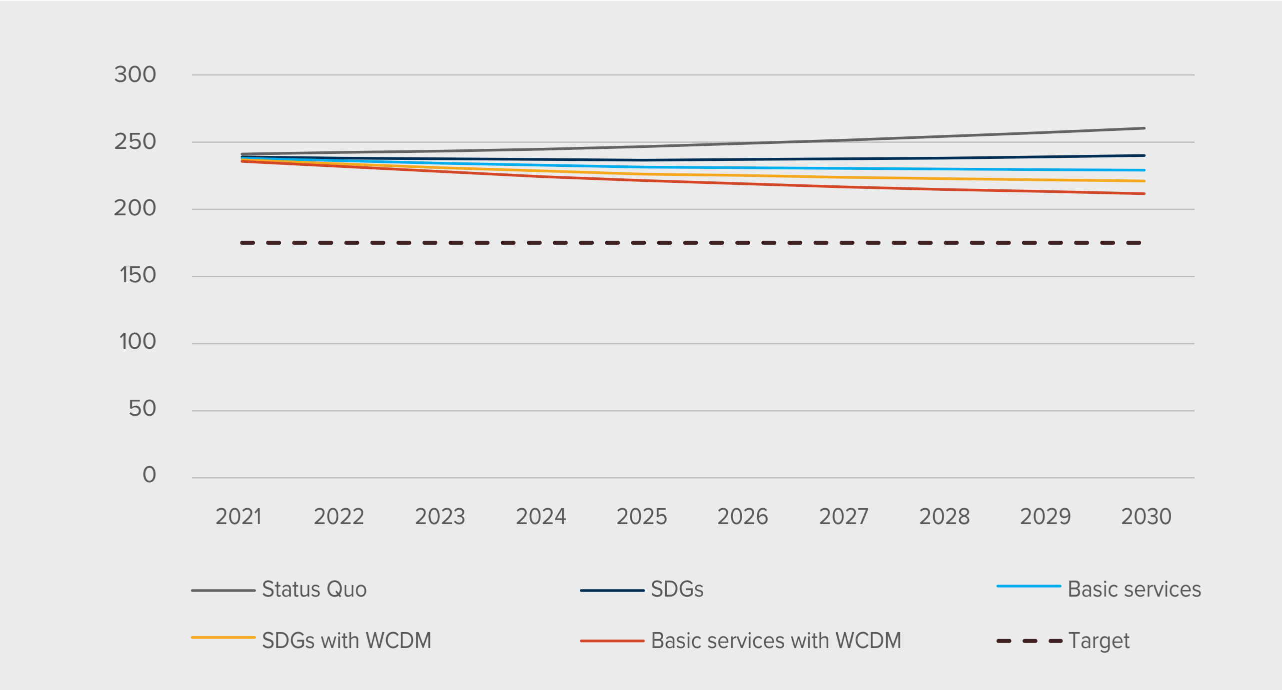


6 Intermediate City Municipalities, which include secondary cities, are a grouping of 39 municipalities identified by the Department of Cooperative Governance as densifying urban settlements that do not yet have the characteristics of metros. The categories of B2—-B4 municipality refer to the DBSA Municipal Infrastructure Investment Framework categorization of municipalities into municipalities with a large town as urban core (B2), largely urban municipalities with small towns (B3) and municipalities dominated by communal land tenure (B4).

WCDM

Options that focus on reducing water losses and on-site consumption have multiple benefits. The cost of WCDM is approximately 1.3% of the total cost of achieving the SDGs but has multiple benefits, including a significant impact on the environmental impact of the water service. The national target set for water use efficiency is a reduction in NRW by 15% (DWS, 2018). This was used as an input in all scenarios and was therefore assumed to be achieved through a range of technical and non-technical measures. The projections of overall potable water demand in all scenarios result in lower water demand than the status quo scenario (Figure 2.5), but still well short of the national target of 175 litres per capita per day. This is because all scenarios include a target to reduce NRW by 15% at a cost of R12.5 billion. The more aggressive WCDM scenarios, which shift the assumed saving from 15% to 21% require an additional R3.5 billion.

Figure 2.5: Potable water demand projections



Although the direct capital and operating costs that are specific to WCDM interventions are a small proportion of the overall operating costs, they impact on water resources, bulk water purchase and water treatment costs in a way that can actually reduce operating costs below what is currently being spent. Multiple reports and policy documents have recommended that municipalities increase their efforts to reduce NRW and the negative impact it has on their ability to generate own income and run a viable water business. In addition to freeing up resources for growth and for productive uses, a reduction in NRW and improved water use efficiency have financial benefits to municipalities.

The results indicate two important points: 1) the increase in demand through providing higher levels of service can be offset through savings in NRW; and 2) aggressive WCDM means that universal basic servicing can be achieved without a significant increase in total water demand above current levels. However, the resulting water consumption from these measures is still well above the national target of 175 litres per capita per day, even in the most water conservative scenario. However, the savings have been focussed on WCDM in the residential sector, and within municipal networks while still increasing the level of access to the water service. Only nominal savings of 15% over ten years on non-residential water uses have been assumed for all scenarios. This finding indicates that South Africa will not achieve the desired water use efficiency targets without drastically influencing technology and behaviours adopted amongst all water users, in addition to technical solutions (such as pipe replacement and pressure management zones).

Environmental impact and ecological infrastructure

The difference in environmental impact between the scenarios is noticeably large. For the achievement of the SDGs, all technology options result in increased CO_2 equivalents 2% to 8% above the baseline due to greater volumes of water and wastewater from higher levels of service. However, the amount of CO_2 equivalents produced in year ten can be reduced below the levels in 2021 in three of the four basic servicing scenarios. The use of alternative technologies that generally rely less on energy-intensive, centralised treatment systems can reduce CO2 equivalents to 4% lower than the baseline levels. It was to be expected that the alternative technology options produce less CO2 equivalents than the low cost or full conventional options as this was the basis for the scenario design. However, further reducing demand through aggressive WCDM reduces the GHG emissions in year ten by up to 6% below the baseline through a lower requirement for water treatment and pumping and wastewater treatment. Therefore, key interventions to reduce the carbon emissions of the water sector are to select technology options that reduce pumping, and service levels that reduce overall water demand. These also happen to be the lowest cost scenarios.

South Africa's raw water supply augmentation options are limited, and ecological infrastructure has a major role to play in increasing water availability at a low marginal cost. The allocation of water between users is obviously a key policy choice which has a significant impact on urban water security, particularly in those Water Management Areas where the urban allocations are small. However, this policy discussion is beyond the scope of this study. Water resilience is improved by the diversification of water sources. The National Water and Sanitation Masterplan (NWSMP) states that 'By 2040, treated acid mine drainage and desalinated seawater will make a significant contribution to South Africa's water mix, groundwater usage will increase, and the overreliance on surface water will reduce' (DWS, 2018:12). Increasingly the importance of investing in ecological infrastructure, particularly the protection of water supply catchments, is being recognised as crucial to improved water security and resilience against the impacts of climate change. While the analysis of water resource costs indicate that these represent a relatively small percentage of the overall cost (between 6% and 11%), they do vary considerably due to the large impact of the climate scenarios and the levels of IAP infestation on water availability and thus on raw water costs. This indicates that South Africa's water resilience, and the investments required to secure water to achieve the SDGs are highly susceptible to climate change and catchment management.

The human element

Achieving SDG 6 is not only about the provision of new infrastructure; addressing inadequate management of existing systems is one of the major interventions required. While the root causes of inadequate management of existing systems are multiple, some of the major issues to address in the sector are governance and institutional capacity. Improvements in governance are difficult to model, as the interventions are abstract and the impacts indirect. However, addressing the issue is critical. For this reason, the modelling included a programmatic response to capacity building in every scenario to make up for the lack of a nationally coordinated strategy. The cost of capacity building interventions is a very small proportion of the total expenditure required (1.3% to 1.6%). However, it is essential to the implementation of any of the possible scenarios. This expenditure should therefore be seen as a priority to improve the performance of the sector. It is evident that the shortage of engineering professionals in municipalities is not due to a shortage of engineers in the country, rather it is due to conditions specific to those in municipalities which do not attract existing or new professionals to the public sector.

Total funding needs

South Africa has difficult choices to make in the face of a constrained fiscus and declining sector performance. It is assumed that South Africa needs to uphold its international commitments to achieving the SDGs and thus must aim for a trajectory that provides this level of service. It also needs to provide services that are future proofed through building in water resilience in the face of climate change and mitigating the climate impact of water sector interventions. The preferred scenario would therefore be one that achieves all of the above at the least cost to the country, which is the scenario that aims to achieve the SDGs 6.1 and 6.2 following the JMP standard with aggressive WCDM. This scenario balances a mix of context-appropriate service levels with a focus on alternative technologies, and in addition, providing resources dedicated to reducing water demand and water losses.

Table 2.2, below, sets out the total funding requirements and the average annual expenditure as a proportion of GDP required to be spent on water and sanitation to meet the standards set out in the respective scenarios. The preferred scenario requires an expenditure of R1243 billion between 2022 and 2030, which annualized represents 2.17% of GDP per year. This is R119 billion more expensive than the lowest cost scenario, which uses the same technology choices, but sets the service levels at the current basic levels and not the SDG levels. The highest cost scenario is one that achieves the SDG target level using conventional technologies in line with the status quo and is R183 billion more expensive than the preferred scenario[1].

Table 2.2: Total funding needs in water and sanitation, 2022–30

Scenarios	Billion rands	Percent of GDP per year
Minimum spending	1 125	1.97
Preferred	1 243	2.17
Maximum spending	1 427	2.49

Note: The calculations are based on the baseline socioeconomic pathway.

Recommendations

Develop and implement a nationally coordinated capacity building and institutional strengthening strategy. Given that a large portion of the current backlog in service access relates to the operation and management of services, and that the lowest cost scenarios emphasize the use of alternative technologies and aggressive WCDM, increased institutional capacity is essential. It is proposed here as the priority, given the limited amount of funding that it requires, approximately R10 billion, in relation to the potential benefits. Fundamental to increasing municipal capacity is to have clearly defined and funded programmes at national level. This funding is needed to build technical capacity and to set up partnerships with the private sector to provide services through a range of contracting styles. The success of these programmes will, in turn, depend on building the capacity of the national departments and agencies supporting municipalities.

The institutional capacity building required includes building sector leadership and improved governance at the national and local spheres of government, and increasing technical capacity at local government level along six strands:

- Reduce senior leadership turnover at the DWS and introduce mechanisms to ensure accountability for implementing the NWSMP.
- Improve governance of water through more coherent regulation, for example through water allocations, tariff regulation, and reporting on procurement and capital expenditure.
- Increase performance incentives for municipal good governance through peer-to-peer learning and incentive grants.

1 These estimates include the spending needs on water resources for potable water supply only. A follow up study estimated that the funding needs on water resources for both potable and non-potable water supply range between R361 billion and R732 billion for the 2023-2030 period (DBSA, NPC, PCC and SA-TIED 2023).

- Focus on technical capacity in municipalities, but also of national government and support agencies, by implementing the capacity building strategy developed by the South African Local Government Association (PDG, 2020).
- Develop mechanisms and refine incentives to facilitate partnerships with the private sector to supplement public sector capacity.
- Investigate and develop measures to improve the attractiveness of the municipal environment for qualified technical personnel.

Technical capacity interventions should help ensure that local political leadership is held accountable for the governance of infrastructure development and services in their municipalities.

Prioritise WCDM. WCDM is the next priority as it makes the best use of existing infrastructure while, at the same time, increasing revenue to municipalities. The results indicate the numerous benefits of WCDM, which contribute to the objectives of 1) universal access (through reducing intermittent water supply); 2) financial sustainability (through lower total costs and reducing NRW); 3) resource efficiency (less wastage); 4) increased water resilience (through lower overall consumption); and 5) reducing environmental impact (through lower GHG emissions). Technical options that promote WCDM have the lowest costs and best environmental outcomes. However, alternative technology options and a comprehensive WCDM programme will require both capital and operating expenditure to be dedicated to achieving the desired reductions. There has been very limited success in prioritising these options to date (DWS, 2018). The capital and operating costs of WCDM represent between 0.8% and 1.3% of total cost. Implementing aggressive WCDM would require government to:

- Prioritise and incentivize WCDM through regulation. WCDM initiatives have largely been left to local government to manage, but there is scope for the DWS to impose strict WCDM targets on municipalities, potentially with penalties for not meeting these targets.
- Allocate dedicated funding to WCDM initiatives, either as an incentive grant or as a ringfenced portion of one of the existing water sector grants.
- As per the Minister of Water and Sanitation's 10-point plan, initiate the DWS 'No Drop' monitoring programme to collect data and report transparently on the levels of NRW in each municipality.
- Implement the recommendations made in the Final Report on the Status of Water Losses in the 8 Large Water Supply Systems (DWS, 2020).
- Address NRW through focusing on unmetered, unbilled connections, particularly in rural areas, through the installation of meters and flow limiters. This will require political buy-in from councillors and traditional leaders to support measures that may restrict flow but increase assurance of supply and revenue to municipalities.

Improve economic regulation of water services to address chronic revenue shortages. The cost of the scenarios modelled exceed the currently available funding. Without either an increase in the water tariff level or an increased allocation from the national fiscus, South Africa will be unable to afford to reach the SDG 6 targets by 2030. Recommended measures to address this are:

- Establish an independent economic regulator to review and regulate water and sanitation tariffs.
- Undertake water audits to ensure that all connections that are intended to be billed are metered.
- Investigate municipalities with poor cost recovery and provide capacity support to set cost reflective tariffs.
- Undertake a nationwide campaign to address non-payment for water services.

Incentivize proper integrated asset management. The findings around universal access to services have shown that asset management is a critical component of maintaining current levels of services (to prevent decline) and maintaining revenue, as well as addressing quality and reliability issues that form a large portion of current service backlogs. Measures to address integrated asset management are as follows:

- Incentivize expenditure on O&M and integrated asset management by sustaining the Blue Drop and Green Drop monitoring programmes.
- Increase monitoring of water quality downstream of water treatment works to detect non-compliance with effluent discharge standards early.

Make appropriate service level choices. The findings show that South Africa cannot afford to achieve even the universal basic servicing targets, let alone the SDG targets by 2030, without radical revision to tariff levels and/or fiscal allocations. Hard choices need to be made to spend on the highest impact solutions with the lowest cost. Measures to increase value for money of expenditure are as follows:

- Avoid the continuation of low capital cost, high operating cost service options introduced as 'interim' or 'emergency' services. For instance, wherever water tankering is taking place or portable chemical toilets are in use, municipalities must be supported by the DWS or relevant province to investigate and propose more long-term, permanent solutions with a lower lifecycle cost.
- Alternative technology options, particularly for sanitation should be used where they are acceptable and can be delivered at scale. The government should support the research and development efforts in this field. This is currently taking place within the DWS and the Water Research Commission and this research and development work should continue to be supported. South Africa could engage more systematically with global research initiatives, such as those conducted by the Gates Foundation, and under the World Bank's Citywide Inclusive Sanitation initiative.
- Clarify the national policy position on housing provision and the servicing of informal settlements, including service level standards (shared vs individual).

Initiate a national FSM programme. The access figures for sanitation are difficult to determine accurately because of a lack of data around FSM, particularly in rural areas, as well as unclear policy guidance as to what constitutes safe FSM. The DWS has developed a draft National Faecal Sludge Management Strategy (DWS, 2021). An effective means to radically improve sanitation service levels in rural areas is to make use of the current on-site sanitation facilities and focus on supporting households to manage faecal waste safely, preferably with on-site beneficiation. This will not entail a standardised method but may include any one of: safe manual emptying with on-site burial or composting; manual vacuum pump emptying and disposal; or mechanical emptying by tanker for centralised disposal or treatment and reuse, either by the municipality or private service providers. The recommended actions are to:

- Include in the National Faecal Sludge Management Strategy a clear policy position on who is responsible for the costs of FSM in rural areas.
- Undertake FSM campaigns, clarifying what constitutes safe FSM, that should progressively replace a focus on toilet provision in rural areas.

Better manage water resource allocations. Ensuring adequate water for competing uses requires clear allocations of water in each Water Management Area and the regulation thereof. To this end, DWS, and its Catchment Management Agencies, should:

- Review water allocations, particularly the urban / agriculture split for systems serving large urban centres.
- Better regulate and monitor the abstraction of raw water.

Coordinate national efforts on IAP clearing. The water resources modelling shows that additional infestation of IAPs can reduce water availability, while clearing can increase available surface water resources. DWS, in collaboration with other sector stakeholders, should:

- Identify priority areas for IAP clearing and develop catchment protection plans, including IAP management planning at a catchment level, focused on those catchments or sub-catchments that are either at highest risk of reduction due to infestation, or the highest potential increase in yield through clearing.
- Clarify institutional responsibility (probably catchment management agencies) and funding model for IAP clearing.

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Chapter 3

BASIC EDUCATION

Introduction

There is growing evidence that high quality school infrastructure facilitates better instruction, improves student outcomes, reduces dropout rates, and increases teacher motivation, among other benefits. Schools that are soundly built and protected against natural disasters; schools that are not overcrowded; schools that have access to basic services such as water, sanitation, waste disposal, electricity and digital connectivity; and schools that have good environmental quality in relation to air quality, dampness, outside play areas and are maintained in good physical condition, are the basic minimum requirements that countries should aspire to have in order to provide the basic learning conditions for students and teachers. But evidence from South Africa and other countries shows that school infrastructure often falls short of these basic minimum requirements, and it is often the most disadvantaged students who experience these sub-optimal learning conditions.

Aside from the existing stock of schools that need to meet these minimum standards, there is also pressure in South Africa to build more schools to accommodate a growing population, particularly in some provinces such as Gauteng and the Western Cape.

In establishing the infrastructure needs and the associated costs, the education sector was chosen for application of the Beyond the Gap framework (Rozenberg & Fay, 2019) because of its important role in achieving SDG 4 on quality and equitable education. SDG 4 was ratified by the government of South Africa and became part of the national objectives reflected in the NDP. While SDG 4 covers ten targets, the following four targets are relevant to infrastructure needs:

- **SDG 4.1:** Ensure that all girls and boys have access to basic and secondary education that is free, equitable and of high quality.
- **SDG 4.2:** Ensure that all girls and boys have access to quality early childhood development (ECD), care, and preschool education in readiness for primary education.
- **Target 4.a:** Build and upgrade education facilities that are child, disability, and gender sensitive and provide safe, nonviolent, inclusive, and effective learning environments for all.
- **Target 4.c:** Increase the supply of qualified teachers to cope with increased learners due to the expansion of basic education; including through international cooperation for teacher training in developing countries.

Other SDGs related to improvements in school infrastructure include SDG 6 on clean water and sanitation, SDG 7 on energy for all, and SDG 10 on reduced inequalities.

This chapter first presents a brief diagnostic of the basic education sector in South Africa, followed by a description of the scenarios and methodology used for the study. Key messages coming out of the scenario analysis and a preferred development scenario for the sector are presented before presenting recommendations.

Diagnostic of the sector

Structure of basic education and population of eligible children and youth

The school system in South Africa is divided into two bands: the General Education and Training (GET) Band, and the Further Education and Training (FET) Band. The GET Band comprises three phases – Foundation, Intermediate, and Senior – covering grade R (preschool) to grade 9. The FET Band covers grades 10 to 12 as presented in Table 3.1 (see Classification 1). The Basic Education Laws Amendment Bill, introduced in 2017, proposed to make two years of preschool education compulsory (i.e., grades R and RR). This means that children aged five, or children aged four born before 30 June would be eligible to enter grade RR. This creates a second classification of the school system (see Classification 2), which is used in some DBE documents, dividing the system into three levels: preschools (grades R and RR), primary schools (grades 1 to 7) and secondary schools (grades 8 to 12). As of 1 April 2022, the DBE assumed responsibility over coordination of ECD services, having inherited this function from the

Department of Social Development. This report has made use of Classification 2, with slight modification on the concept of preschool, equating it to grade R since grade RR was yet to be rolled out countrywide at the time of the analysis. Another modification is a split in secondary to accommodate lower and upper secondary, given the proposed introduction of a General Education Certificate at the end of grade 9 that will influence the flow of enrolments in basic education.

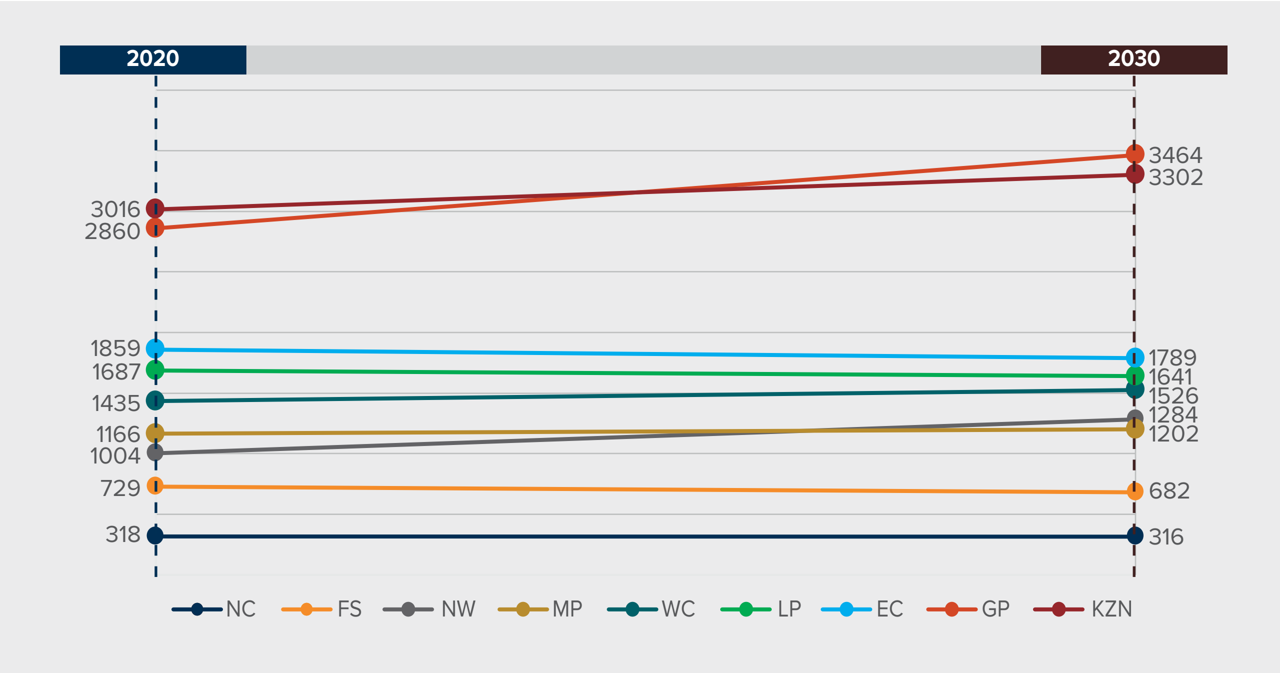
Table 3.1: Structure of South Africa's Basic Education System, 2022

<table>
<tr><th>Age</th><th>Grades</th><th colspan="2">Classification 1</th><th>Classification 2</th><th>Classification for this study</th></tr>
<tr><td>0-4</td><td>Grade RR or 00</td><td colspan="2">Pre-Grade R</td><td rowspan="2">Preschool</td><td>ECD</td></tr>
<tr><td>5</td><td>Grade R</td><td rowspan="4">Foundation phase
Grade R—3</td><td rowspan="10">GET Band</td><td>Preschool</td></tr>
<tr><td>6</td><td>Grade 1</td><td rowspan="7">Primary School
Grades 1—7</td><td rowspan="7">Primary School
Grades 1—7</td></tr>
<tr><td>7</td><td>Grade 2</td></tr>
<tr><td>8</td><td>Grade 3</td></tr>
<tr><td>9</td><td>Grade 4</td><td rowspan="3">Intermediate phase
Grade 4—6</td></tr>
<tr><td>10</td><td>Grade 5</td></tr>
<tr><td>11</td><td>Grade 6</td></tr>
<tr><td>12</td><td>Grade 7</td><td rowspan="3">Senior phase
Grade 7—9</td></tr>
<tr><td>13</td><td>Grade 8</td><td rowspan="5">Secondary School
Grades 8—12</td><td rowspan="2">Lower Secondary School Grades 8—9</td></tr>
<tr><td>14</td><td>Grade 9</td></tr>
<tr><td>15</td><td>Grade 10</td><td colspan="2" rowspan="3">FET Band
Grade 10—12</td><td rowspan="3">Upper Secondary School Grades 10—12</td></tr>
<tr><td>16</td><td>Grade 11</td></tr>
<tr><td>17</td><td>Grade 12</td></tr>
</table>

Note: Grade R means reception year. Grade RR or grade 00 means: Pre-grade R.
Source: Consolidated from DBE documents.

Stats SA (2020) estimated that the country's population was 59.6 million in 2020, including 14 million people eligible for basic education. Eight percent of the school age population was estimated to be eligible for preschool, 56% for primary, 15% for lower secondary and 21% for upper secondary. More than half of the children in the school age population were located in KwaZulu-Natal, Gauteng, and the Western Cape provinces. These provinces expect further significant growth in population between 2022 and 2030. Figure 3.1 shows the projected growth (blue lines) and decline (orange lines) by province of the school age population by 2030. Gauteng, North West, and KwaZulu-Natal have the sharpest increases in school age population, whereas Limpopo and the Eastern Cape provinces have the sharpest declines. In these provinces, particularly the Eastern Cape, schools are already closing down as a result of declining school age population.

Figure 3.1: School age population by province, 2020—30



Source: Authors' graph with data from Stats SA (2020).

Access to basic education and related indicators

The basic education system in South Africa has about 25 200 public and independent (private) schools, which together enrolled more than 13.5 million learners in 2020 (see Table 3.2). In 2020, besides preschool education, almost all other learners attended public schools. For preschool, two-thirds of learners were enrolled in public schools and the rest in private schools. Below preschool, all children attend private/community-based ECD programs.

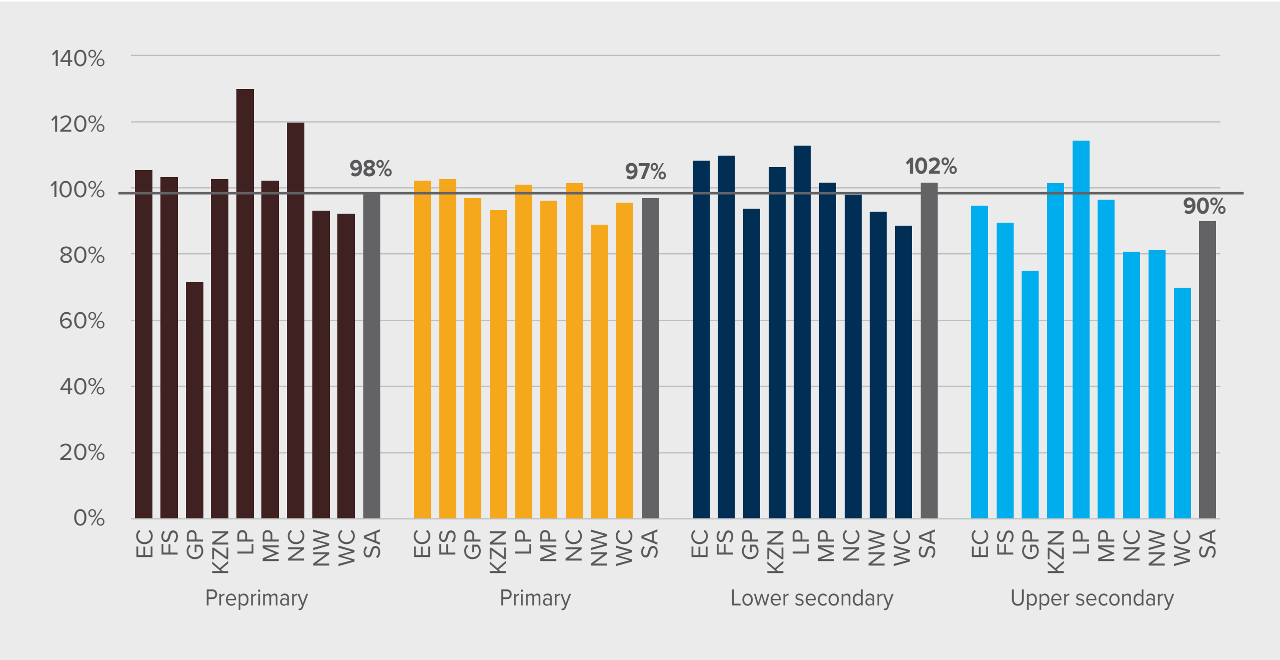
Table 3.2: Learners enrolled in basic education schools, 2020

	Grade R	Primary G1-G7	Secondary G8-G9	Secondary G10-G12	Total
Public	760 184	7 293 413	1 994 556	2 484 148	12 532 301
Independent	389 579	408 550	96 223	116 277	1 010 629
Total	1 149 763	7 701 963	2 090 779	2 600 425	13 542 930
% in public	66.1	94.7	95.4	95.5	92.5
Gross enrolment ratio	98.3%	96.9%	101.5%	89.8%	

Source: DBE (2021).

More than 1.1 million learners were enrolled in preschool in 2020, translating to a GER of 98%. At primary level, the more than 7.7 million learners enrolled in school translated to a GER of 97%, while at lower secondary level, the GER surpassed the 100% mark, due to overage and underage students and large numbers of students repeating grades. At secondary level, there were nearly 4.7 million learners in school. The GERs are characterized by variations between provinces at each of these levels of education (see Figure 3.2). For instance, while the average GER for the country's preschool is 98%, this ranges from a high of 130% in Limpopo to a low of 71% in Gauteng, highlighting the existence of overage and underage children in Limpopo and the inadequate capacity of existing preschools to accommodate all eligible learners in Gauteng. The variations in the GER across provinces are largest at upper secondary level, where the average GER is 90%, but ranges from a high of 114% in Limpopo to a low of 70% in the Western Cape. All provinces that have GERs above 100% signal the need for expansion of the schooling system, including infrastructure and teachers, to accommodate more eligible learners.

Figure 3.2: GERs by level of education, 2020



Source: Authors' graph with data from DBE (2020) and Stats SA (2020).

Repetition and dropping out of basic education

While access to basic education is good for boys and girls in South Africa, the internal efficiency of the system (characterized by repetition and students dropping out of the schooling system) is low. A 2019 University of Stellenbosch research paper estimated 1 180 000 students in public schools to have been repeating grades 1 to 12 (Van der Berg et al., 2019). In monetary terms, the paper estimated that the cost of having repeaters in the public education system was around R20 billion (in 2018 prices) and at least half of the repetition costs were attributed to the high prevalence of repetition in the secondary school phase (grades 8 to 12) with the largest number of repeaters located in grade 10 (at least one in every five grade 10 learners repeat that grade). The report also estimated that around 300 000 students drop out of public schools each year without having reached matriculation. Those who drop out of school very often failed a grade, repeated a grade, or were overage. Spending on teachers, classrooms, textbooks, and other learning materials to accommodate repetition can generally be regarded as wasted expenditure, as repeating (especially at the higher grades) is unlikely to add to learners' educational and labour market prospects. Addressing these inefficiencies in the basic education system is a priority. For this report, the repetition rate for primary and upper secondary education was estimated to be about 15% respectively and 8% for lower secondary education in 2020.

Teachers and classroom distribution across levels of education and provinces

Teachers are an essential resource to support learning of students in schools. STRs generally indicate the contact time teachers have with learners, especially in cases where students need individual learning attention. Teachers attending to large numbers of students are less likely to provide individualized attention to learners due to the competition for time by the many learners. In South Africa, there were more than 400 000 teachers (56%) in basic education in 2020 who were teaching at primary schools (see Table 3.3). In grade R, the STR ranged from 30:1 in the Eastern Cape to 37:1 in Limpopo. Similar patterns were observed in primary schools, while in secondary, only a marginal variation was observed between the provinces. The STR for South Africa is amongst the lowest compared to other countries in the SSA region for all levels of basic education. SSA Averages are estimated at 30 students for every teacher at preschool level, and 37 at primary level, considerably higher than the averages for South Africa. At secondary level, the STR average is higher in South Africa (30:1) compared to the SSA region (21:1), but this may be due to the low levels of secondary school enrolment in other countries in SSA. In contrast, the STRs in high-income countries are relatively low, averaging 14:1 in preschool and primary schools, and 13:1 in secondary schools (World Bank, 2020). Even among the Organization for Economic Co-operation and Development countries, which includes some non-high-income countries, the ratios remain low (OECD, 2021).

Table 3.3: Teachers and STRs in basic education schools, 2020

	Teachers			STRs		
Province	Grade R	Primary	Secondary	Grade R	Primary	Secondary
Eastern Cape	3 781	35 125	19 805	30:1	30:1	31:1
Free State	1 180	12 507	8 687	33:1	33:1	29:1
Gauteng	3 236	40 365	27 974	33:1	33:1	27:1
KwaZulu-Natal	5 717	50 342	36 315	31:1	31:1	29:1
Limpopo	3 222	25 416	20 333	37:1	37:1	31:1
Mpumalanga	1 919	18 406	13 456	33:1	33:1	30:1
Northern Cape	664	5 861	3 431	31:1	31:1	28:1
North West	1 502	14 618	9 429	34:1	34:1	31:1
Western Cape	2 152	22 542	12 109	32:1	32:1	31:1
South Africa	**23 373**	**225 182**	**151 539**	**33:1**	**32:1**	**30:1**

Source: Authors' computations based on DBE (2020).

Aside from having adequate numbers of teachers, there needs to be enough classrooms to accommodate all students which is measured by the Student to Classroom Ratio (SCR), which is the total number of students per class. As with STRs, smaller SCRs are desirable since they facilitate individualized interactions between teachers and learners. The SCRs in South Africa on average, are favourable at 36:1 for grade R and primary levels and 33:1 for secondary level (the DBE's 2017 Guidelines for Rationalization and Realignment of Public Schools: A Holistic Approach provide for a maximum of 40 learners per class). There is significant variation across provinces with Mpumalanga, Gauteng and the North West having higher SCRs, while the Eastern Cape and the Northern Cape have the lowest SCRs.

Status of school infrastructure in basic education

As of 2021, the condition of the existing stock of schools in South Africa was not good and many schools did not meet the Minimum Norms and Standards for Public School Infrastructure published in 2013 by the DBE. The government has made progress in eliminating classrooms constructed from inappropriate/non-permanent materials in South Africa, thanks to government efforts through the Education Infrastructure Grant, Infrastructure Development Budget Programme, Accelerated Schools Infrastructure Delivery Initiative, and Sanitation Appropriate for Education Initiative. The progress notwithstanding, there is still a considerable number of schools (mostly in Limpopo, the Eastern Cape, KwaZulu-Natal, and Mpumalanga provinces) that do not meet the minimum acceptable standards of infrastructure. Out of the almost 567 000 toilets across preschool, primary, and secondary levels of education, about 124 000 do not meet the minimum acceptable standard of Ventilated Improved Pit (VIP) latrine toilets (see Table 3.4). More than one quarter of schools do not have access to adequate water during school sessions, a situation which weighs negatively on the sanitation in affected schools and potentially affects school attendance and learning outcomes in the long run. Moreover, 3% of schools do not have access to any power source, and this rises to 9% when considering schools have intermittent access to electricity whenever schools are in session and can therefore neither extend learning time beyond dusk nor carry out any learning activity that requires electricity, for example, science experiments. Very few schools have access to facilities (servers) that can enhance the transition to digital learning. Only 31% of schools have access to computer rooms, 25% to libraries, and only 15% have access to laboratories. The infrastructure deficit highlighted in existing schools, together with the additional students expected to enter the basic education system by 2030, will be the key drivers of infrastructure development in basic education over the coming years.

Table 3.4: Facilities that require upgrading in basic education across the country, 2021

Facility	Primary	Secondary	Combined	Total
Computer Room	10 630	3 232	1 746	15 608
Library	11 293	3 579	1 961	16 833
Laboratory	13 200	3 463	2 378	19 041
Server	13 578	5 393	2 989	21 960
VIP toilet seats needed	75 326	37 851	10 622	123 799
Water (<25%)	-	-	-	2 292
Electricity (<25%)	-	-	-	1 956
Mud/Clay/Wood	467	1, 743	198	2 408
Broken floor	437	2 920	897	4 254
Broken Ceiling	272	1 688	1 124	3 084

Source: Author's computation based on DBE (2021).

The condition of schools has led to the preparation of numerous infrastructure action plans by the government in the past to address the infrastructure backlog and deficit in schools (including Action Plan to 2019, Action Plan 2019—30). The action plans have had varied commitments aligned to the periods they were to serve, some of the highlights being:

- By 2016, all schools should meet minimum standards with respect to water, toilets, electricity, and materials used for the school building (i.e., no 'mud' constructions and no asbestos).
- By 2020, all schools should have at least a minimum number of classrooms relative to enrolment, as well as electronic connectivity and fencing.
- By 2023, all schools should have libraries and laboratories.
- By 2030, all remaining standards should be in place in all schools (e.g., sport facilities, administration, etc.).

Notwithstanding these infrastructure plans and commitments, the infrastructure condition in some schools falls below the required minimum norms and standards. The pace of implementation of some of the infrastructure programmes has been slow and the unfinished business with existing infrastructure and new infrastructure required as a result of additional students entering basic education is a significant challenge for the government of South Africa.

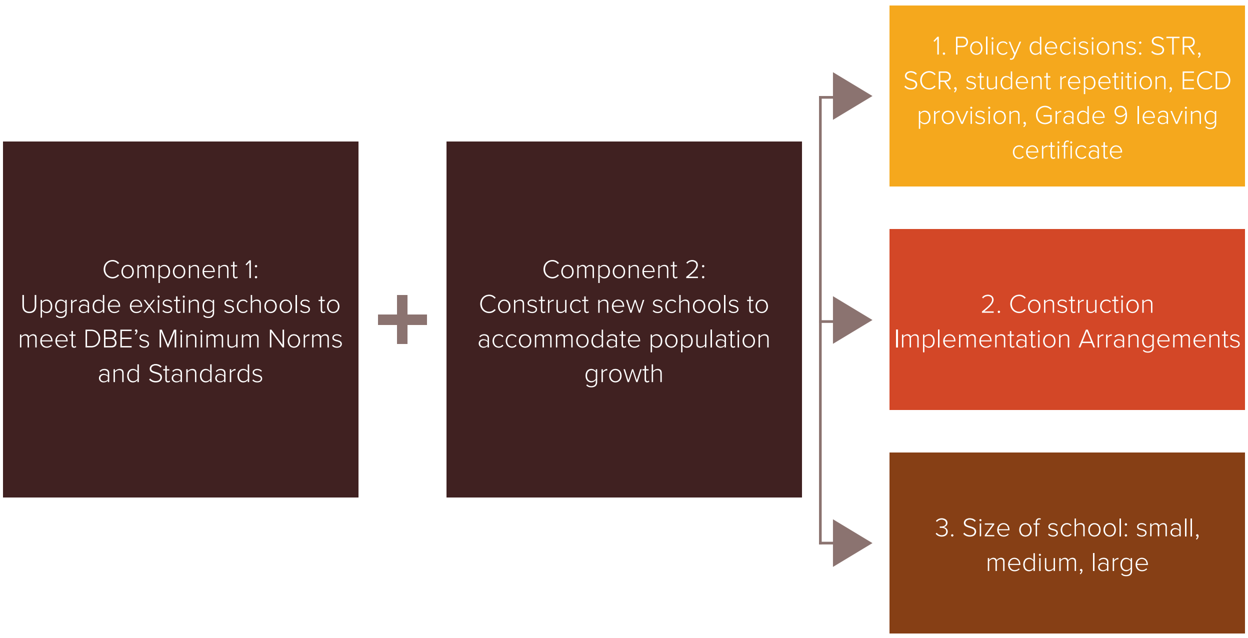
Methodological approach and scenarios

The analysis undertaken in this chapter is based on the World Bank's Beyond the Gap analytical framework (Rozenberg & Fay, 2019) and is anchored on the SDG 4 indicators adapted to the South African education policy context. Apart from the education specific context, the analysis considered different development trajectories in education until 2030, allowing the analysis to estimate the spending likely needed to address backlogs in school infrastructure as well as new infrastructure.

The infrastructure demand in basic education is analysed in two components: (i) upgrading facilities in existing schools to bring them up to recommended or acceptable norms and standards (addressing the backlog), and (ii) expanding the network of schools in basic education to accommodate new students entering the system. The needs and costs of the expansion of the network of schools are driven by three factors (represented in the oval shapes in Figure 3.3). The first factor relates to education performance policy decisions such as GER in preschool, primary and secondary (higher GERs means more school infrastructure is needed to accommodate all students); grade repetition (more repetition means bigger class sizes driving the need for more classrooms); average class sizes in public schools (smaller class sizes means more classrooms are needed, bigger class sizes means few classrooms) and STRs in public schools (lower STRs mean more teachers are needed and higher STRs mean less teachers are needed); and other decisions such as whether to expand public support for ECD and the possible introduction of a school leaving certificate at the end of grade 9 which could potentially affect the flow of students from lower secondary to upper secondary school.

The second factor driving the costs of infrastructure is the modality for implementing school construction which takes three forms in South Africa: (i) centralized implementation by the DBE, (ii) decentralized to the provincial level, and (iii) community-based implementation. Overall, construction costs are higher with centralized implementation of school construction and lowest for community-based implementation. The third factor driving costs is the size of a school, i.e., whether it is small, medium, or large as per DBE's definition. Larger schools require more facilities than smaller schools and would cost more to construct.

Figure 3.3: Cost drivers of school infrastructure



Source: Authors' framework.

Below is the outline of three options for upgrading existing schools to meet the DBE's current minimum norms and standards and three scenarios to expand the network of schools to accommodate additional students entering basic education analysed.

Component 1 (Backlogs): Upgrading the existing stock of schools to meet DBE norms and standards

The options for upgrading existing school infrastructure are based on the existing backlog and the facilities within each school that should be prioritized for upgrade within the next four years.

- **Option 1:** Addressing 100% of current backlogs related to toilets (i.e., converting all toilets below VIP status into VIP toilets), electricity, water, non-permanent classrooms made of mud/wood/clay, as well as broken floors and ceilings; and 100% of needs relating to computer rooms, libraries, laboratories, and servers;

- **Option 2:** Addressing 100% of the needs for toilets, electricity, water, replacing non-permanent classrooms, floors, and ceilings; and addressing 70% of the needs relating to computer rooms, libraries, laboratories, and servers;
- **Option 3:** Addressing 100% of the needs for toilets, electricity, water, replacing non-permanent classrooms, floors, and ceilings; and addressing 50% of the needs relating to computer rooms, libraries, laboratories, and servers.

Component 2 (New infrastructure): Expansion of schools to accommodate the projected increase in population by 2030

This second component addressing future infrastructure needs employs simulation modelling to establish the needs and costs of expanding basic education based on different scenarios. The scenarios are modelled around the three factors driving costs mentioned above (policy decisions on GER, STR, SCR; construction implementation modality, and the size of schools to be built). This report considered three scenarios in the simulation model, including (i) a business as usual (BAU) scenario, (ii) a full access scenario, and (iii) a full access with efficiency scenario. These scenarios are described below.

- **BAU:** Assumes GER, STR, SCR and repetition rates remain the same as they were in 2020 (as described in the earlier sections) and the share of recurrent non-salary expenditure is maintained at 8% as it was in 2020.
- **Full access:** Assumes access (GER) will improve to 100% for grade R, primary, and lower secondary level and remain at 90% for upper secondary level; lagging provinces would improve their STRs to a maximum of 34 at grade R and primary level and 31 at secondary level; lagging provinces would improve SCRs to a maximum of 38 at grade R and primary level, and 35 at secondary level; and the share of recurrent non-salary expenditure is maintained at 8% as it was in 2020.
- **Full access with efficiency:** Assumes access (GER) will improve to 100% for grade R, primary, and lower secondary level and remain at 90% for upper secondary level; lagging provinces would improve their STRs to a maximum of 34 at grade R and primary level and 31 at secondary level; lagging provinces would improve SCRs to a maximum of 38 at grade R and primary level, and 35 at secondary level; reducing repetition rates at primary and upper secondary levels from 15% to 10%; and improving the share of recurrent non-salary costs from 8% to 10%. Reducing repetition rates to reduce the numbers of students in each class and increasing the recurrent non-salary costs in the total budget will support efficiency gains in the basic education system.

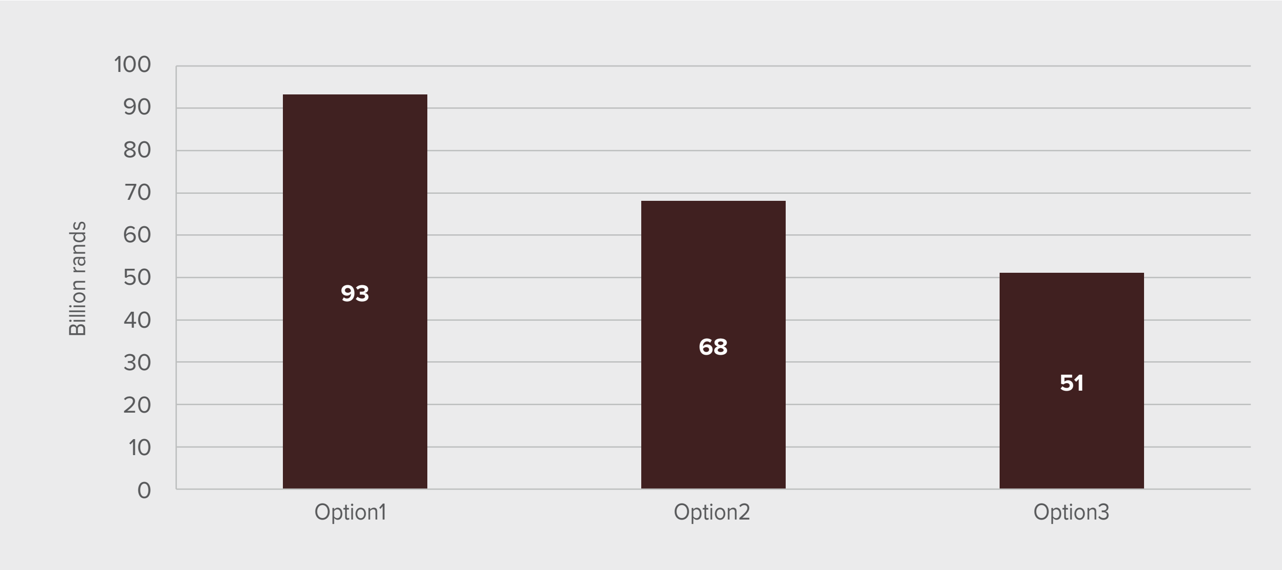
The scenarios were analysed assuming the three socioeconomic pathways that were developed for this study and presented in the introductory chapter. This assesses the sensitivity of the findings to different population and GDP trajectories.

Addressing school infrastructure through upgrading and expansion

Options for upgrading existing school infrastructure and associated costs

The total cost of upgrading the existing stock of schools to DBE's current minimum norms and standards ranges between R51 billion and R93 billion depending on the option (Figure 3.4). If all the needs are addressed under option 1, school upgrading costs R93 billion. If 70% of the needs for computer rooms, libraries, laboratories, and servers are addressed (option 2), school upgrading costs R68 billion. And if 50% of the needs for computer rooms, libraries, laboratories, and servers are addressed (option 3), it costs R51 billion. It is important to note that the combinations of facilities to be upgraded are not cast in stone hence additional options can be generated based on the priority given to various types of facilities as well as the human and financial capacity to implement programs that address the backlog. The most important aspect for the upgrade would be to address the needs in the short term to ensure all learners have similar learning opportunities as soon as possible.

Figure 3.4: Cost of upgrading schools under each option



Source: Author's computation based on available unit cost data.

The minimum norms and standards for each school are also evolving as innovative teaching and learning methods emerge. For example, library corners within primary school classrooms have proved more effective in getting children to read as opposed to separate library structures that are often not accessible to young children and are costly to maintain. For secondary education, moving towards virtual libraries will require different types of facilities compared to the traditional library. Science laboratories are also expensive to build (they require plumbing for water access and several electricity ports) and maintain and some countries are moving towards science toolkits for primary and lower secondary schools, which can be used in any classroom. The requirements for the digital connectivity of schools have increased as all students are expected to be digitally literate, however, digital connectivity is not within DBE's minimum norms and standards. Moving forward, the DBE should consider revising its minimum norms and standards for school construction to meet the requirements of today's education system and consider where costs can be saved through innovative teaching and learning methods.

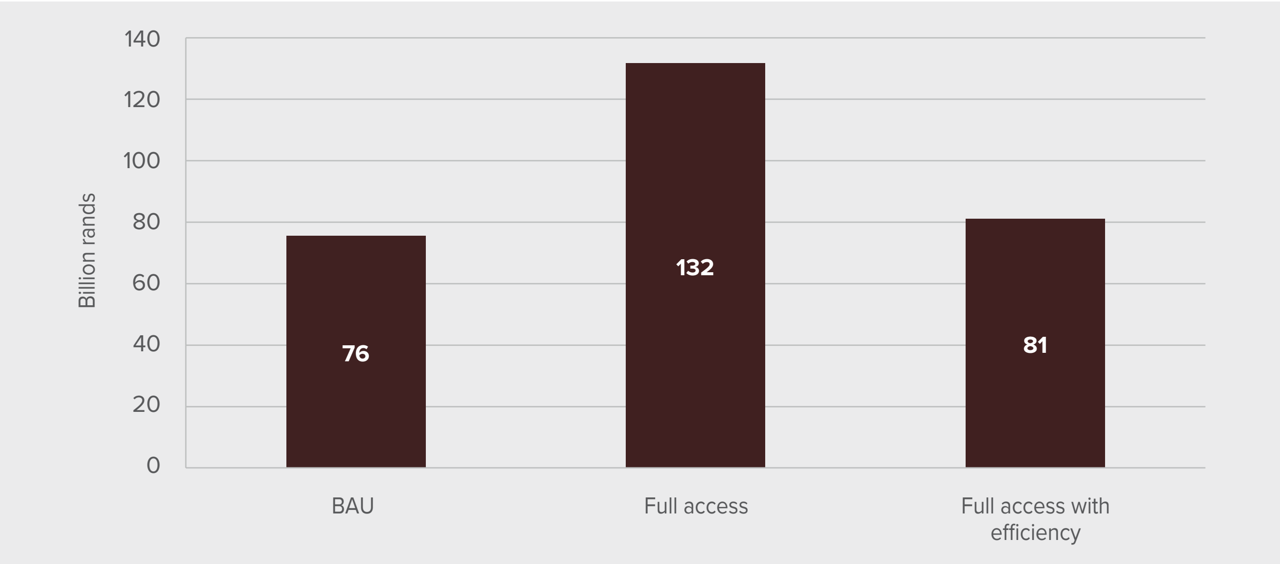
Another area of cost saving is the implementation modality for school construction. There are large variations in the cost of construction based on whether it is undertaken centrally, provincially, or through communities. The centralized approach costs R31 700 to construct a square meter of school facilities. Construction by the provinces costs 40% of the centralized cost, while communities delivered the similar scope at 25% of the centralized cost or 60% of the provincial cost. Community based construction, while the most cost-effective of the three, is nascent in South Africa and has only been implemented in a handful of schools in a few provinces, which potentially raises questions on the precision of the estimated cost for the community approach. Better data collection systems on school construction would be necessary to address this limitation. Scaling up community-based construction, where capacity exists, is an area of potential cost saving (and better ownership of schools by communities) which needs to be further explored.

Infrastructure expansion scenarios and associated costs

While costs associated with upgrading of the existing stock of schools is limited to infrastructure, the expansion of the network of schools is associated with increases in the cost of infrastructure (capital costs), the cost of additional teachers, as well as operational maintenance costs (recurrent costs).

Figure 3.5 shows that the full access scenario which supports 100% access of all eligible students in preschool, primary, and secondary education with favourable STRs and SCRs would be the costliest in terms of capital investments at R132 billion. In primary education, for example, the government will have to put in significant effort to increase coverage in provinces like Gauteng (97%), KwaZulu-Natal (93%), Mpumalanga (96%), North West (89%) and the Western Cape (85%) to 100%.

Figure 3.5: Capital cost of expanding the network of schools under three scenarios



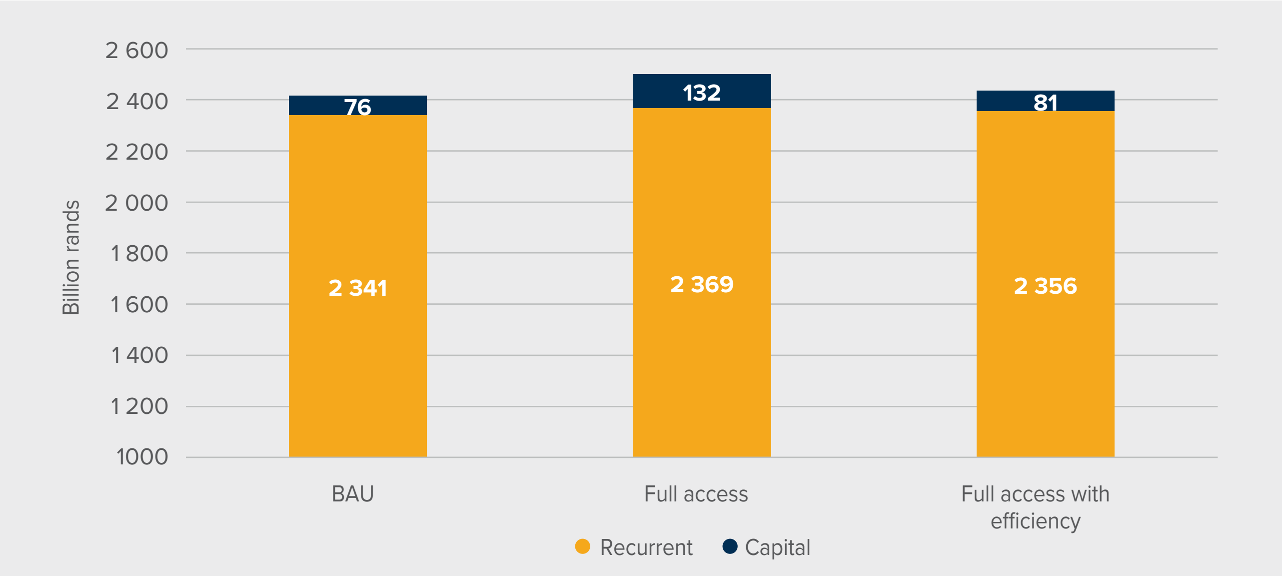
Source: Author's computation based on available unit cost data.
Note: Estimations based on baseline socioeconomic pathway.

The additional 1.2 million students entering the basic education system alongside adjustments made in the average class sizes, i.e., reducing class sizes in provinces with high SCRs, will necessitate an increase in the number of total classrooms required in the basic education network from 361 500 in 2020 to 401 400 in 2030 under the full access scenario. There will be a net addition of 40 000 classrooms with 18 000 classrooms at primary level and 21 700 at secondary level. The capacity of the public grade R system is assumed to remain constant and additional learners will be channelled to private schools with support through ECD subsidies and will, therefore, not trigger additional infrastructure need for grade R.

Under the BAU scenario, where indicators related to access (GER, STR and SCR) remain the same as the baseline, the additional students entering the basic education system trigger the need for 25 300 additional classrooms, the majority of which will be required in secondary schools. The cost related to this infrastructure is estimated at around R76 billion. While this is the least costly scenario, it does not provide for full access to schooling for all eligible students. Under the full access with efficiency scenario, the assumption – as with the full access scenario – is full access to schooling for all eligible students in preschool, primary and lower secondary education, but the full access with efficiency scenario also makes provision for efficiency gains in terms of reduced repetition in primary and upper secondary education which would also reduce the need for more classrooms. This scenario would necessitate a net addition of 19 400 classrooms with 4700 at primary level and 14 800 at secondary level, which would cost approximately R81 billion.

In addition to the capital costs of new infrastructure required for the expansion of schools, new teachers will be needed to keep STRs at an appropriate rate as well as more budget for maintenance and operations of the new schools. These recurrent costs far exceed the capital costs required over the period 2022 to 2030 as shown in Figure 3.6.

Figure 3.6: Recurrent and capital costs of expanding the network of schools under three scenarios



Source: Author's computation based on available costs from DBE (2021).
Note: Estimations based on baseline socioeconomic pathway.

For the BAU scenario, the number of teachers required to maintain the current learning experience will increase from 400 000 in 2020 to 431 300 by 2030; i.e., more than 31 000 additional teachers within the decade, (7200 teachers at primary level and 24 800 teachers at secondary level). The full access scenario will require an additional 42 000 teachers (17 700 at primary level and 24 700 at secondary level) and the full access with efficiency scenario will require an additional 25 000 teachers (5500 at primary level and 19 600 at secondary level) within the decade. The costs of teachers and additional operations/maintenance and administrative costs of the new schools will require approximately R2.3 trillion under each scenario which dwarfs the funding requirements for capital costs.

Total funding needs for the most feasible option for upgrading existing school infrastructure and scenarios for expanding school infrastructure

The combined recurrent and capital costs of expanding and upgrading basic education ranges between R2.48 trillion and R2.57 trillion. Assuming that the government would consider the second upgrading option (middle ground) in addressing the infrastructure backlog – that is, addressing 100% of the toilet needs, electricity, water, replacing of mud classrooms, floors, and ceilings, and tackling 70% of the needs relating to computer rooms, libraries, laboratories, and servers – which is the most feasible option, the funding needs for upgrading are R68 billion. Of the three expansion scenarios, the full access with efficiency scenario is the preferred one given that it supports improvements in access to education as well as better internal efficiency in terms of student progression and would cost 62% less than the full access scenario. As a result, the total funding needs under the preferred scenario are R2.51 trillion, which amounts to the annual average of 4.73% of GDP for the 2022—30 period (Table 3.5). The total funding needs under the less ambitious scenario, which includes the BAU expansion scenario, amount to R2.48 trillion, or an annual average of 4.69% of GDP for the 2022—30 period. The maximum spending scenario, which includes the full access expansion scenario, yields the total funding needs of R2.6 trillion, or an annual average of 4.85% of GDP for the 2022—30 period.

Table 3.5: Funding needs for system expansion and upgrade of basic education, 2022—30

	Scenarios		
	Minimum spending	Preferred	Maximum spending
	Total (billion rands)		
Recurrent	2 341	2 356	2 369
Capital	144	149	200
Expansion	76	81	132
Upgrade	68	68	68
Total funding needs	**2 485**	**2 505**	**2 569**
	Annual average (% of GDP)		
Recurrent	4.42	4.45	4.48
Capital	0.27	0.28	0.38
Total funding needs	**4.69**	**4.73**	**4.85**

Source: Authors' estimation based on the baseline socioeconomic pathway.

Recommendations

The analysis shows the huge costs related to upgrading the existing stock of schools that do not meet the DBE's minimum norms and standards as well costs related to the expansion of the network of schools to accommodate approximately 1.2 million additional students entering the basic education system by 2030. While there is little that can be done to reduce the recurrent costs of the expansion of the network of schools (i.e. it would not be feasible or desirable to reduce teachers' salaries or increase STR norms which reduces the need for as many teachers), capital costs could be reduced by addressing three key areas: (i) review the minimum norms and standards for school infrastructure; (ii) change the implementation modality mix for school construction; and (iii) build better data monitoring and public dissemination avenues for school construction to improve accountability and sustainability. The issues to be addressed in each of these areas are described below.

Review the minimum norms and standards for school infrastructure

The minimum norms and standards for school infrastructure is one of the major drivers of cost of school infrastructure. Addressing the associated cost of school infrastructure would call for the review of the following:

- ***Prioritizing 'minimum' package of facilities over 'optimum'.*** The tendency in South Africa has been to build schools that meet the optimum standards in terms of space and the types of facilities provided. For example, many new schools provide the 'ideal' package such as a dining area or a school hall which are expensive and even classroom space is maximized rather than the minimum requirements which would clearly cost less. Given the significant needs of schools, the DBE may want to prioritize what facilities should be built in the first phase (the essential, minimum package) versus what facilities could be built in the second or third phase in the same school (the optimum package);

- ***Adopting classroom libraries in primary, and digital libraries in secondary schools.*** Classroom libraries in primary school and virtual libraries for secondary school are important alternatives to regular libraries and are a more sustainable alternative to the current gap of library buildings. They develop learners' reading skills and a love for reading in primary school. Books in a classroom makes them easier to access for students and thus more likely to be used than central libraries that are often closed and difficult to navigate for younger children. In secondary school, virtual libraries can be useful due to the many advantages they have, including the fact that they can be accessed anywhere, anytime, and instantly (over the internet); they require less physical space in schools; students can access unlimited resources including open education resources and rich multi-media resources; digital resources do not deteriorate with use as compared to print materials; it is easier and cheaper to update digital materials and updates are instantly available; materials are easier to find through search functions as well as through sophisticated cataloguing systems; teachers and students can also contribute materials to the digital library; and digital libraries are indispensable to remote learning, building resilient education systems and for schools of the future where learners can learn anywhere and at any time. While there may be some challenges related to copyright issues, challenges with connectivity, teacher capacity and skills to use digital resources, the advantages of digital libraries over traditional libraries are clear; and

- ***Making digital connectivity a norm in schools.*** South Africa has made impressive progress in the provision of electricity to schools and the existing Universal Service and Access Obligation (USAO) requirements of the telecommunications licensing system in South Africa. The government should focus on better monitoring of these USAOs to ensure the most disadvantaged schools (quintiles 1 to 3) are connected first and that the connection is high speed. The digital connection priority should start with the most disadvantaged schools offering secondary education and rapidly continue to primary schools. This will not only prepare schools for future crises and the need for remote learning but is also essential in promoting digital literacy in schools.

Change the implementation modality mix for school construction

The unit cost analysis shows that decentralizing school construction to provinces is cheaper than centralized school construction as per the unit cost analysis. While there can be different modalities of construction in any country, as is the case in South Africa, the international trend in school construction has leaned towards increased decentralization to the community level. In South Africa, provincial school construction is dominant accounting for 71% of the funding towards overall school construction and maintenance, but there is an opportunity to decentralize even further to the community level through:

- ***Community engagement for better value for money.*** This option could be piloted in one or two provinces – or in parts of some provinces – prior to being rolled out if the outcomes are positive. Based on international knowledge, this approach is likely to be more cost-effective than the provincial level construction modality and increases communities' ownership and interest in the school construction process. Building the capacity of communities/School Governing Bodies to manage this process will take time and resources, but the benefits accrued in terms of sustainability and community ownership are probably higher, if capacity to implement exists at the local level; and

- ***Focusing on small construction works rather than large ones.*** Moving from the current implementation strategy, which tends to package large construction works that are business opportunities for large contractors, towards small construction packages would open opportunities for small contractors. This approach is in line with the recommendation to focus on addressing school facilities deficit in existing schools which are typically 'small works'; e.g., latrine blocks, additional classrooms, replacement of some sub-standard or over-aged classrooms, admin-block, staffroom, etc. Small works tendered through local competitive bidding processes can also increase competition between small contractors, resulting in lower costs. This approach would also strengthen the small- and medium-sized segment of the construction industry, which is a positive externality of this type of programme, as evidenced in many countries.

Build better data monitoring and dissemination systems for school construction to improve accountability and transparency

The government needs to improve the data collection system to allow for regular and relevant analysis of the costs, effectiveness, and efficiency of school construction. This can be addressed through:

- **Regular updates of the NEIMS and its linkage to Education Management Information Systems**. One critical challenge in this study was not being able to match the student enrolment data by school with the infrastructure data by school. There were several missing schools and while the enrolment data was from 2020, the infrastructure data was from 2018. Ensuring these datasets are complete, consistent, updated in a timely manner is crucial for driving evidence-based policy analysis and decision-making. Particularly, the government needs to update NEIMS with data on new schools and schools that have been closed, as well as the number of other facilities built each year. While the provincial User Asset Management Plans provides information on needs, the status of construction, and future plans, it is not an effective tool for national level monitoring purposes since they are non-standardized; and

- **Development of a systematic process to collect data on costs of construction.** To increase transparency and accountability in the school construction system, the government should require implementing agents to submit to DBE-specific data on the programmes they implement, including designs, costs, and outputs on an annual basis. This information was hard to come by for the study making the calculation of unit costs of construction challenging. The government should strengthen the DBE to collect all the above-mentioned data, ensure its completeness, conduct annual analysis on the construction gap, and comparative analysis on the unit costs of the different construction programmes. Data should also be collected from municipalities through Provincial Education Departments on their contribution to the provision of services (water, sanitation, and electricity) in schools. The analysis of this data should be communicated with the public to improve the overall transparency of the school construction system.

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Chapter 4

TECHNICAL AND VOCATIONAL EDUCATION AND TRAINING

Introduction

South Africa faces a youth employment crisis. Almost 60% of South Africa's 10.3 million 15-24-year-olds were unemployed in early 2020 (prior to the economic disruption caused by COVID-19) and 34% were not in employment, education, or training, i.e., they were disengaged from both employment and education (Stats SA, 2020). This crisis is caused, in part, by the post-school education and training (PSET) system's inability to provide youth the skills and competencies that the labour market demands. The government of South Africa has placed solutions to the employment crisis high on its agenda and has emphasized the role that TVET can play in addressing it. Despite this focus, the COVID-19 pandemic, and resulting economic slowdown (the worst in three decades), have worsened the youth employment crisis. By the second quarter of 2021, 64% of 15-24-year-olds were unemployed (Stats SA, 2021).

Alongside its role in addressing the youth employment crisis, TVET is critical to achieving South Africa's SDG commitments. It has a direct and significant role in achieving SDG 4 on quality and equitable education, particularly the three targets below, and it has an enabling role in achieving several others, such as SDG 8 (decent work and economic growth) and SDG 10 (reduced inequalities).

- **SDG 4.3:** Ensure equal access for all women and men to affordable and quality technical, vocational, and tertiary education, including university.
- **SDG 4.4:** Increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs, and entrepreneurship.
- **SDG 4.5:** Eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples, and children in vulnerable situations.

This chapter aims to inform policy choices and investment decisions related to TVET infrastructure, by quantifying the infrastructure funding needs for the public TVET system for a range of scenarios to 2030. The needs arise from infrastructure backlogs in existing TVET colleges and from the anticipated expansion of the public TVET system that South Africa is targeting by 2030. In line with SDG 4, it also quantifies the funding needs arising from interventions to improve the quality of TVET services and to make access to TVET more equitable. These include improving the availability of instructors, providing adequate student housing, and providing financial support to trainees.

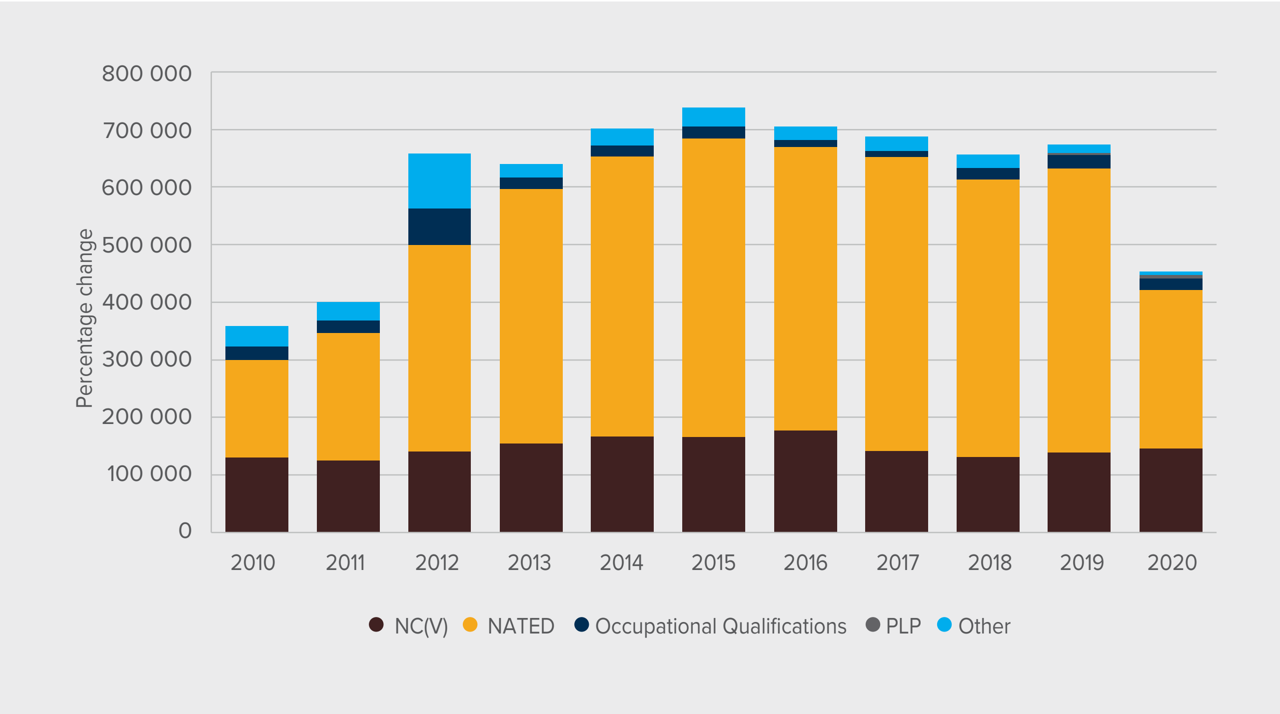
Participation in TVET and South Africa's TVET objectives

Public TVET colleges, that are the focus of this chapter, are the largest providers of TVET services in South Africa. In 2020, there were 50 public TVET colleges (hereafter referred to as TVET colleges) with 254 registered campuses (DHET, 2021a). These colleges offer four main types of programs, which can be accessed at different entry levels with either a grade 9 or grade 12 certificate:

- National Accredited Technical Education Diploma (NATED) programs require a grade 12 certificate for entry and combine 18-month college-based learning with an 18-month internship. NATED programs go up to level 6 (one level below a bachelor's degree) of the National Qualifications Framework (NQF).
- National Certificate (Vocational) (NC(V)) programs can be accessed with a grade 9 certificate and provide three years of training up to level 4 (equivalent to a grade 12 certificate) of the NQF.
- Pre-vocational Learning Programs (PLP) are foundational learning programmes to prepare students for access into a specific vocational or occupational learning pathway at TVET colleges.
- Occupational qualifications and part-time qualifications, including workplace-based learning, many of which are funded by a skills levy imposed on employers.

Enrolment in TVET colleges was 670 000 in 2019, up 88% from 2010 (Figure 4.1). Most of this growth was driven by NATED programs, where enrolment increased by more than 300 000 students over this period. As a result, TVET colleges are the fastest growing PSET sub-system, growing nearly four times faster than university education. However, COVID-related disruptions led to a sharp decline in enrolment, to 452 000 in 2020, driven mostly by a reduction in NATED enrolments by more than 200 000 students. The pace at which NATED enrolments have recovered will be known once data for subsequent years becomes available.

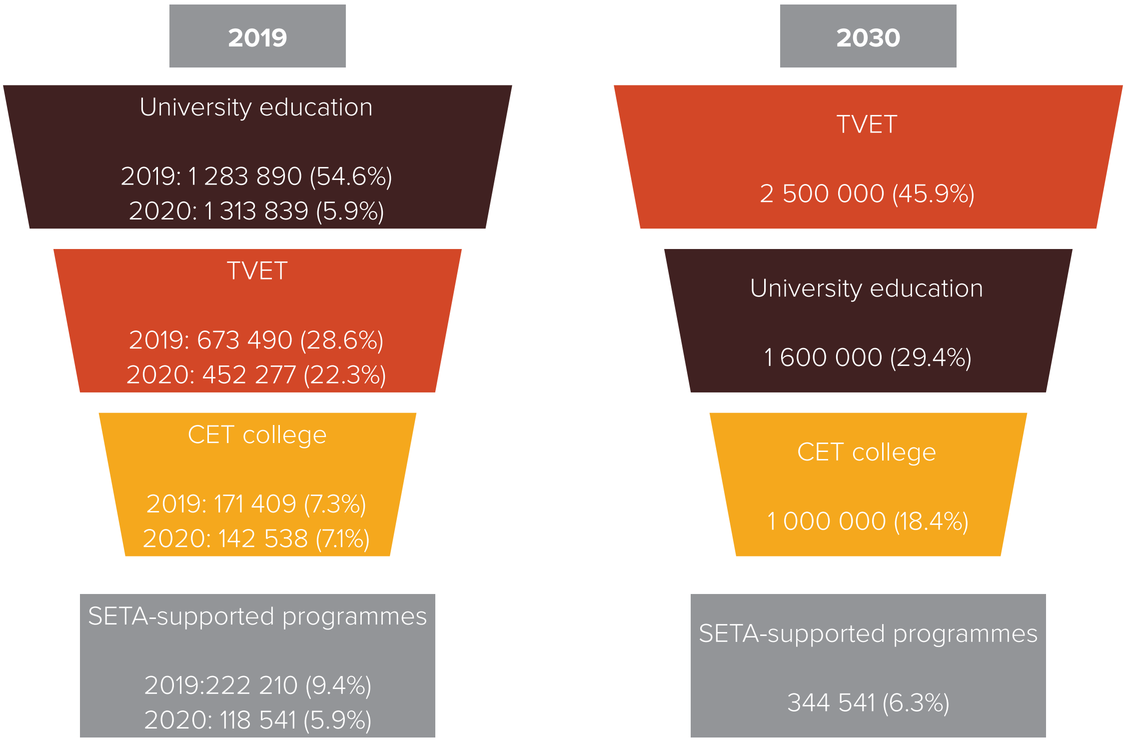
Figure 4.1: Enrolment in TVET colleges by type of qualification, 2010—20



Source: Statistics on PSET in South Africa 2020 (DHET, 2022).

In contrast to recent declines in enrolment, South Africa is targeting a significant expansion in the TVET system by 2030. The NDP (NPC, 2012) lays out ambitious targets for the growth of the PSET system, with TVET at its centre. This chapter assumes that these targets are South Africa's context specific operational targets derived from the TVET-related SDGs. Achieving the NDP's target of 5.4 million students enrolled in PSET by 2030 will require enrolment to increase 2.7 times from the 2.03 million students enrolled in 2020. Further, the NDP envisages a change in the structure of PSET enrolment, with TVET outgrowing other systems and replacing university education as the largest PSET sub-system (Figure 4.2).

Figure 4.2: PSET enrolment in 2019 and PSET White Paper's interpretation of NDP enrolment targets for 2030 by sub-system



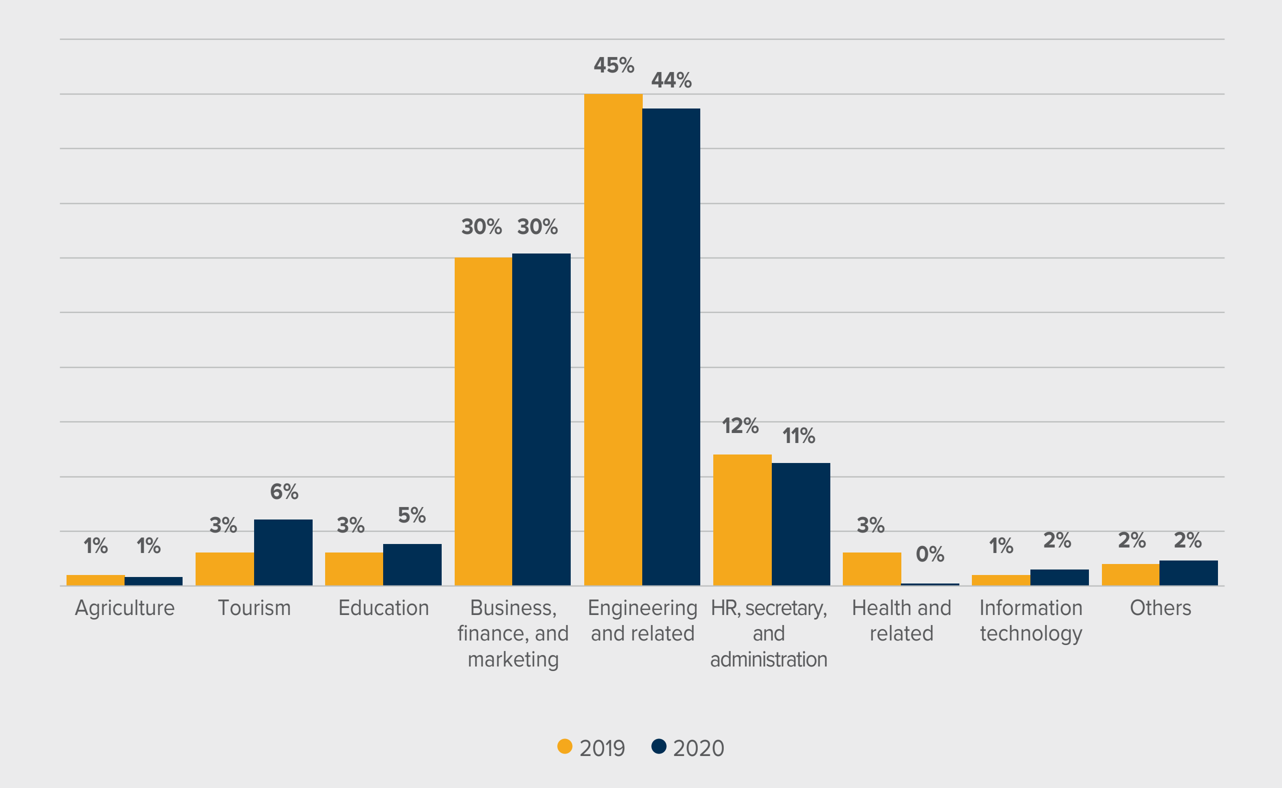
Source: PSET Monitor (Khuluvhe et al., 2021).
Note: CET refers to Community Education and Training; and SETA, Sector Education and Training Authorities

In the next few years, enrolments are unlikely to increase at the rate required to meet the PSET White Paper's interpretation of the NDP target, which is 2.5 million students enrolled in TVET programs by 2030, or even the target described by the NDP itself, which is 1.25 million students enrolled in TVET by 2030. Recognizing this, the DHET's revised 2020—25 Strategic Plan (DHET, 2021b) aims for a modest increase in enrolment to 620 000 by 2024. It cites inadequate funding as the main constraint to reaching the trajectory implied by the NDP's 2030 target. The Strategic Plan also establishes several other targets related to improving access to TVET, the quality of TVET services, and the outcomes of TVET students. When these targets are combined with the expansion of TVET enrolment that the NDP targets (or even a more modest version of that target), South Africa is aiming for both a massive expansion of the TVET system and a significant improvement in quality over the coming years.

System diagnostic

Most students in TVET colleges are enrolled in engineering, business, finance, and management courses. While this pattern of enrolment may appear, at first glance, to be aligned with labour market demand (see, for instance, National List of Occupations in High Demand (DHET, 2020)) the broad categorization of trades used conceals the prevalence of outdated courses and curricula that do not meet the significant demand for science- and technology-based occupations at the professional and technician levels (Figure 4.3).

Figure 4.3: Percentage share of enrolment in TVET colleges by categories of trades (2019 and 2020)



Source: Authors' categorization of trades based on data enrolment provided by the DHET.

Not enough data is available on students' background characteristics. DHET does not publish data on TVET college students' background characteristics, such as socioeconomic status and prior educational qualifications. However, there is some data to suggest that TVET colleges play a significant role in catering to groups who are traditionally unserved by PSET. For instance, black African students account for 92% of enrolment in TVET colleges (growing at 10% per annum since 2010), compared to 76% of enrolment in university education (growing at 4% per annum since 2010). Over time, more women than men have begun to enrol in TVET colleges. The gender parity index of enrolment rose from 0.9 in 2010 to 1.4 in 2019 (DHET, 2022). This trend, however, is not unique to TVET colleges and is observed in other PSET sub-systems as well.

Students' employment outcomes are mixed, with NATED programs outperforming NC(V) programs. There is no systematic data collection on employment outcomes. As a result, comparable data on the employment outcomes of TVET programs versus other PSET programs, or those of different TVET programs is not available. However, some tracer studies provide partial understanding of employment outcomes. The most recent tracer study (CBPEP & DHET, 2020) found only a 40% absorption rate into either wage employment, self-employment, or workplace-based learning for TVET graduates. The employability of TVET graduates is limited by a mismatch between the TVET curriculum and employer needs, gaps in training quality, and a lack of practical training.

The internal efficiency of TVET colleges is low, which increases per-completer costs and places additional demands on campus infrastructure. High levels of repetition and dropout mean that students do not complete programs in the expected timeframe. For instance, only 9.2% of students enrolled in NC(V) programs in 2016 completed the three-year program by 2018 (Khuluvhe et al., 2021). This is despite significant increases in pass rates in certification examinations for NC(V) and NATED programs over recent years, indicating that repetition and dropout prior to certification examinations rather than low passing rates in certification examinations are largely responsible for the low internal efficiency. Some of the potential causes of repetition and dropout are the low quality of training caused by poorly trained and unmotivated instructors who lack qualifications in TVET instruction and relevant industry experience (Green, 2018); low availability and quality of instructional facilities (Alexander & Masoabi, 2017); outdated programs and curricula (DHET, 2020); low private returns to TVET, especially when the training duration is long (World Bank, 2019); and students' financial constraints (World Bank, 2019). Repetition causes students to spend longer than expected on campus and places a high burden on campus infrastructure such as student accommodation, which is already in short supply (el Zayat et al., 2020).

The DHET establishes an 'assumed student fee' for each program and colleges can set fees up to 10% above this assumed fee (exceeding this limit requires permission from the DHET on a case-by-case basis). The assumed fee is set at a level that covers 20% of the program cost and the remaining 80% is, in principle, to be covered by DHET program funding (DHET, 2019). An increasing proportion of TVET college students receive financial aid from the National Student Financial Aid Scheme (NSFAS). However, recent increases in NSFAS spending, in response to the 'FeesMustFall' student protests in 2015—16, have prioritized the university education sub-system. As a result, per-student NSFAS aid to TVET students has not kept pace with the increase in per-student NSFAS aid to university students, which was approximately four times as high in 2019 (DHET, 2022). Inadequate financial aid, which often doesn't cover the full training duration, is one of the causes of the high rates of dropout from TVET programs because students are unable to fully fund their studies.

TVET colleges are funded through a combination of student fees, government funding (including programme funding from DHET), and employer contributions (via the skills development levy). Government funding for TVET colleges is based on the programmes offered by colleges, enrolment in each institution, the cost of delivery, and infrastructure needs. DHET funding to TVET colleges is expected to follow financing norms and standards,[1] but these are not fully implemented. In 2013—14, the Expenditure Performance Review (DNA Economics, 2016) found that allocations to TVET colleges were only 50% to 80% of the amounts implied by the norms. Further, this model for determining program funding from DHET and the model for determining student fees, which are based primarily on the cost of provision rather than indicators of quality, do not incentivize quality improvements. Non-staff funding is very limited. Of the DHET funding to TVET Colleges, 80% is allocated to cover staff costs, and only 20% is directly transferred to colleges to be used for goods, services, and operational costs (DHET, 2018). Therefore, TVET colleges have limited financial incentives to improve quality, funding for investments in infrastructure and quality improvements is insufficient, and internal efficiency is very low.

The lack of a planned expansion of infrastructure limits the expansion of high-quality TVET services. At the system level, the TVET sub-system has not had a planned infrastructure expansion program since the Recapitalisation Program, which ended in 2008. Since then, most infrastructure development at the college level has focused on refurbishing buildings or constructing a few extra buildings on existing campuses (DHET, 2020). An evaluation of the College Expansion and Capacity Development Program implemented by the DHET and the National Skills Fund between 2012 and 2015 found that poor infrastructure and inadequate funding for infrastructure investments, among other factors, hindered the envisaged expansion in access under the program (Southern Hemisphere, 2018). Alongside limiting expansion, poor infrastructure limits quality because of, for instance, poor instructional facilities. Further, while poor infrastructure is a consequence of inadequate funding, it also contributes to the lack of funding by limiting efficiency. For instance, the lack of information and communication technology on campuses prevents the adoption of alternate, cheaper modes of delivery. Efficiency is also limited by sub-optimal utilization of existing infrastructure. Space norms for the utilization of TVET campuses in South Africa (DHET, 2017) prescribe a lower utilization rate for classroom space (50%) than comparable norms in India (AICTE, 2021) and Australia (TEFMA, 2009) (70-75%). The system also lacks macro-level space norms (i.e., norms that support system-level planning by establishing broad ranges for the space required based on student headcount) and college-level space norms are outdated and do not reflect changes in pedagogy and technology use. The DHET currently lacks a systematic process to revise norms regularly based on observed good practices in TVET colleges and the evolution of international norms and standards.

1 Financing norms and standards contained in the Continuing Education Training Act 16 of 2006, revised in 2015.

Overall, there are several systemic constraints to achieving South Africa's TVET objectives. Systemic gaps in funding, infrastructure, instructor qualifications and competencies, management capacity, internal efficiency, and curriculum and training constrain the expansion of high-quality TVET services required to meet South Africa's objectives. These constraints are mutually reinforcing and policies and programs to address one constraint must consider the limitations imposed by the others. For instance, gaps in funding, such as inadequate student financial aid for long duration programs contribute to dropouts, which reduces internal efficiency. Conversely, low internal efficiency increases per-completer costs and limits funding available for student financial aid.

Methodological approach and scenarios

The analysis undertaken in this chapter is based on the World Bank's Beyond the Gap analytical framework (Rozenberg & Fay, 2019) and is anchored on the SDG 4 indicators adapted to the South African TVET policy context. Apart from the education specific context, the analysis considered different development trajectories in education until 2030, allowing the analysis to estimate the resources that are likely to be needed to address infrastructure backlogs and for new infrastructure.

The TVET infrastructure deficit is analysed in two main components. The first component includes the investments required to bring existing campuses and colleges to acceptable minimum standards, defined using a combination of the current space norms and standards for campus conditions derived from recent DHET projects. This component is predicated on assessments of more than 250 existing campuses. The quality of the facilities in these campuses are categorized as good, or fair, or poor condition, with each group being associated with a given unit cost for upgrading (based on condition and campus size). The second component is the expansion of the TVET system to accommodate new students based on the projected increase in the number of youth eligible to join TVET. These two components give the total TVET infrastructure investment needed between 2022 and 2030. In addition to infrastructure investment, the report also acknowledges that an expanded TVET system will need an expanded operational ecosystem, which is costed alongside infrastructure to have holistic assessment of funding needs.

For estimating the funding needs to expand the TVET system, the following three policy scenarios were assessed:

- **Business as usual (BAU) scenario:** This scenario maintains the status quo of TVET performance in terms of access, key quality inputs, and operational elements, keeping these performance levels to those seen in 2020:
  - The number of trainees per 100 000 population remains at 1126 throughout the period, similar to the 2020 levels. The capacity of the programs is retained at the same level as 2020. For instance, agriculture, education, and tourism had their capacities retained at 5700, 40 700, and 25 700 students respectively up to 2030.
  - At the operational level, the Full Time Equivalent (FTE) STR and the ratio between teaching and non-teaching staff is maintained at 2020 levels. Salary levels are kept constant at 6.2 and 4 multiples of per capita GDP for teachers and non-teachers respectively. Operational spending at the central (DHET) level is assumed to grow marginally by 4% to sustain the anticipated growth in staff and associated functions like the monitoring of TVET colleges, accreditation processes, capacity building, and provision of working tools for the staff at central level.
  - The share of students benefitting from the TVET students grant funding remains at the 60% recorded in 2020, with each student projected to continue receiving an average of R13 800 annually.[2] Other recurrent expenditures, which support operations in TVET colleges, remain at 130% of teacher salaries, implying that a future increase in the teacher wage bill would increase other recurrent expenditure.
- **PSET white paper scenario:** This is the PSET white paper scenario, which builds on the foundation laid in the BAU scenario. The following are the assumptions that differ with those under the BAU scenario:

2 This is the projected amount of support provided in 2020, calculated using National Treasury data from 2019.

  - The number of students per 100 000 population increases from the baseline of 1126 to 3700 by 2030 as envisioned in the PSET White Paper's (DHET, 2014) target of 2.5 million trainees in TVET by 2030. The capacity of agriculture, education, and tourism programs is ring-fenced to 15 000, 75 000 and 120 000 students respectively to adequately address demand for them.
  - Distance education offering begins in 2024, with 50% of trainees on distance education by 2030 (used as a proxy for the cost-saving effects of technology and alternate delivery models).
  - Twenty percent of additional students are housed in TVET institutions.
  - The STR (based on the FTE enrolments) improves from the baseline of 1:48 in 2020 to the desired Organisation for Economic Co-operation and Development average of 1:15 in 2030. The ratio between teachers and non-teaching staff is kept at 1:1.2.

- **NDP scenario:** This scenario is aligned with the NDP 2030 goal of having at least 1.25 million FTE trainees[3] in TVET by 2030. The following are the assumptions that differ with those under the PSET white paper scenario:
  - The participation rate doubles from 1126 students per 100 000 population in 2020 to 2250 in 2030. The fixed capacity programs are projected to increase two-fold, with agriculture increasing from 5700 in 2020 to 10 000 in 2030; education to 50 000 in 2030; and tourism, hospitality, and other related programs to 80 000 in 2030.
  - Distance education offering begins in 2024, with 30% of trainees on distance education by 2030.
  - The number of teachers in the expanded TVET system is driven by an improved teacher to student (FTE) ratio, from 1:48 in 2020 to 1:30 by 2030 in addition to a progressive move towards the desired balance between teaching and non-teaching staff, which improves from a factor of 1.2 teachers to non-teaching staff in 2020 to 1.3 in 2030.
  - Ten percent of additional students are housed in TVET institutions.
  - One hundred percent of the students in public campuses receive welfare support, each benefitting from an average of R14 000 annually.

The scenarios were analysed assuming the three socioeconomic pathways that were developed for this study and presented in the introductory chapter. This assesses the sensitivity of the findings to different population and GDP trajectories.

A simulation model was developed for estimating the funding needs for expanding the TVET system. The model estimates (a) the youth who will probably join TVET from the projected population in the country (given that access to TVET is measured as participation per 100 000 population), (b) the facilities that these additional youth would require for training, and (c) the associated capital investment required to establish these facilities. The simulation model also estimates the number of instructors that would be needed to sustain the existing and additional trainees, based on the capacity of different trades in the expanded TVET system. Leveraging historical data and the unit spending on instructors and trainees, the simulation model estimates the potential recurrent costs that will be required to sustain the expanded TVET system. The model accounts for the role of technology and alternate modes of TVET delivery by simulating different scenarios on the use of distance education. Distance education is used to demonstrate the relief that increased use of technology could have on the demand for additional infrastructure and equipment. The simulation model also estimates how student financial aid costs would evolve as the TVET system expands.

Closing the infrastructure gap in TVET

Upgrading TVET infrastructure

The cost of upgrading existing infrastructure in TVET campuses amounts to R6.2 billion. Out of the country's 254 TVET campuses only five were found to be in good condition; 120 in fair condition; while 130 were assessed to

3 The standardised number of students when part-time students' actual course loads are standardised against the normal course load of full-time students.

be in poor condition.[4] The unit costs of upgrading the campuses in each category were predicated on the size of the campuses (see Table 4.1) based on broad estimates from visits to 15 campuses. The cost of upgrading existing infrastructure in TVET campuses was estimated to be R14 million for campuses in relatively good condition, R2 billion for those in average condition, and R4.2 billion for those in poor condition.

Table 4.1: Upgradation of facilities in existing campusesa

	Condition of college facilities			
	Good	Average	Poor	All
Number of campuses				
<1 000	4	20	30	54
1 000-4 000	1	72	69	142
Above 4 000		28	30	58
Total	5	120	129	254
Unit costs (million rands)				
<1 000	2	5	10	
1 000-4 000	6	15	30	
Above 4 000	12	30	60	
Funding needs (million rands)				
<1 000	8	100	300	408
1 000-4 000	6	1 080	2 070	3 156
Above 4 000	-	840	1 800	2 640
Total	**14**	**2 020**	**4 170**	**6 204**

Source: Authors' estimates based on data provided by DHET.

Expanding the TVET system

The policy assumptions under each of the three expansion scenarios would see enrolment in TVET increase by nearly 100 000 to 762 300 students in 2030 under the BAU scenario, to 2.5 million under the PSET white paper scenario, and to 1.5 million under the NDP scenario, with varied annual increases (Table 4.2). The analysis further shows that distance education would see more than 200 000 students join the platform every year under the PSET white paper scenario and 73 000 under the NDP scenario, with the capacity peaking at 1.25 million and 457 000 in 2030 in the two scenarios respectively. The distance education pathway would require initial infrastructure setup to manage the teaching as well as teaching and learning resources in the pathway.

4 DHET provided subjective classification of infrastructure in the TVET campuses as: good (requires minimal renovation); average (requires considerable renovation and the current physical condition may adversely impact operations); poor condition (requires significant renovation and the current physical condition adversely impacts operations).

Table 4.2: Outcomes of policy assumptions in the expansion of TVET system

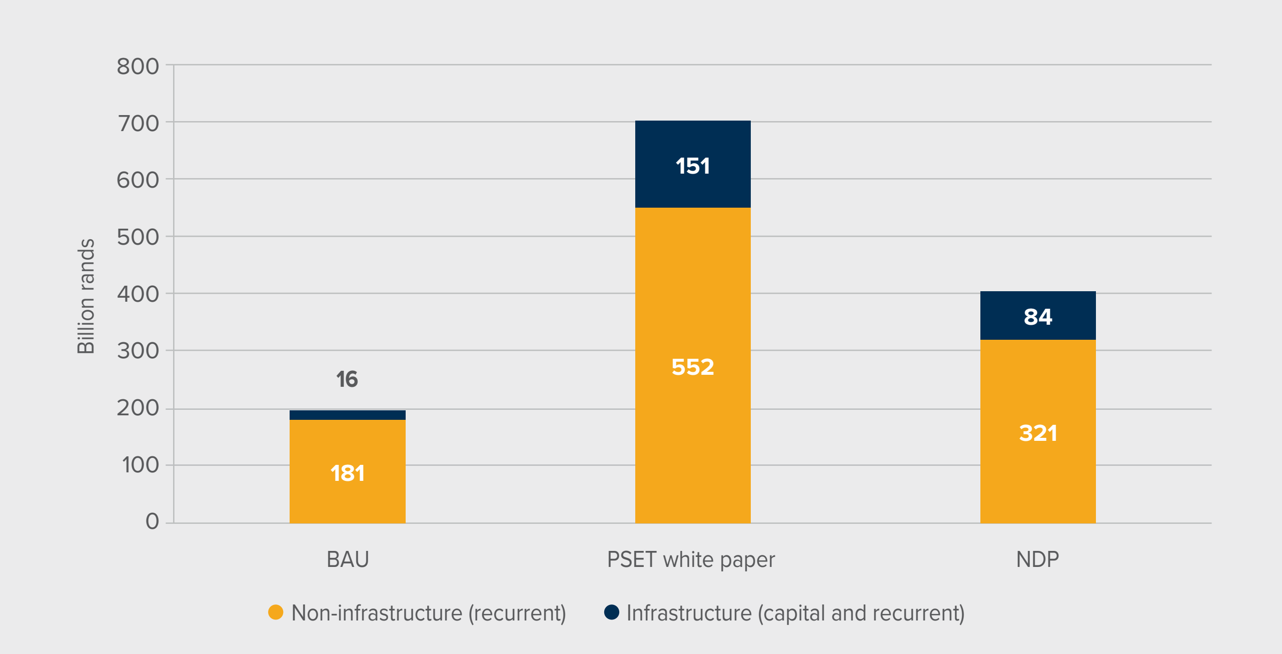
	Scenarios		
	BAU	PSET white paper	NDP
Total enrolment in public colleges			
Baseline (2020)	671 000	671 000	671 000
Projected for 2030	762 309	2 505 449	1 523 584
Annual increase	9 087	183 401	85 214
Enrolment in distance education			
Projected for 2030	-	1 252 724	457 075
Annual increase	-	204 279	72 884
Teachers			
Baseline (2020)	7 800	7 800	7 800
Projected for 2030	8 816	46 407	19 754
Annual increase	105	3 864	1 199
New Campuses for additional trainees			
Small (1 500)	16	114	51
Medium (5 000)	6	57	31
Large (8 000)	3	14	19
Total	**26**	**186**	**101**

Source: Authors' estimates based on data provided by DHET.

The additional students triggered the need for additional staff, with the need for nearly 1000 additional teachers demonstrated in the BAU scenario compared to the 39 000 and 12 000 in the PSET white paper and NDP scenarios respectively. The difference in the teacher needs in each scenario was driven by the differentiated increase in students under each scenario as well as the varied improvement in the teacher to student (FTE) ratio. The analysis further showed that the additional students would need 25 new campuses under the BAU scenario (16 small, six medium and three large); about 190 additional campuses under the PSET white paper scenario (114 small, 57 medium and 14 large); and 100 new campuses under the NDP scenario (51 small, 31 medium and 19 large).

The cost of expanding the TVET system ranges between R197 billion under the BAU scenario and R703 billion under the ambitious PSET white paper scenario (Figure 4.4). In all the three scenarios, the cost simulations showed that non-infrastructure recurrent costs would be the major driver, ranging from 92% in the BAU scenario (R181 million) to 79% in the two scenarios (R552 billion and R321 billion in the PSET white paper and NDP scenarios, respectively). The recurrent costs covered salaries for administrators; instructors and support staff; support to student welfare financing; and operation in the TVET system, with more than 90% of the recurrent costs slated for execution at the TVET campuses.

Figure 4.4: Total funding need for expanding the TVET system, 2022—30



Source: Authors' estimates based on data provided by DHET.

Infrastructure costs are driven by construction of additional campuses, expansion and upgrading of housing facilities, acquisition of equipment for distance education and training, as well as proper maintenance of facilities (Table 4.3). In the BAU scenario, infrastructure costs were estimated for construction of new campuses and maintenance only, the former taking up more than 70% of the cost. In the PSET white paper scenario, the total infrastructure cost was estimated to be R151 billion, with new campuses taking more than half of this cost (55%), construction of housing for the additional students taking 28%, while upgrading of existing hostels took up 13%. In the NDP scenario, construction of new campuses would take up about two thirds (65%) of the total estimated infrastructure cost (R84.2 billion), construction of additional hostels, 17%, and upgrading of existing hostels, 10%.

Table 4.3: Composition of infrastructure funding needs for expanding the TVET system, 2022—30, million rands

	Scenarios		
	BAU	PSET white paper	NDP
Construction of new campuses	11 664	82 642	54 513
Maintenance of facilities	4 496	4 496	4 496
Housing for additional students	-	41 955	14 140
Upgrade of existing housing facilities	-	19 680	8 722
Distance education infrastructure	-	2 314	2 314
Total	**16 160**	**151 087**	**84 185**

Source: Authors' estimates based on data provided by DHET.

The adoption of technology and alternate modes of delivering TVET could substantially reduce costs. The analysis assessed the introduction of distance education to demonstrate the impact of adoption of new training technologies (such as simulation-based training) and alternate modes of delivery (such as distance education and workplace-based learning). The analysis assumed that the recurrent per-student cost of TVET provision would be five times lower for distance education than for on-site training. If distance education were not considered as a delivery pathway in the PSET white paper and NDP scenarios, the funding needs in these scenarios would be R1155 billion and R535 billion, respectively, which is 64% and 32% higher than the costs with distance education (Table 4.4). While the exact efficiencies obtained through technology and alternate modes of delivery would depend on the specific technologies and modalities chosen, South Africa may not be able fund its TVET objectives without the widespread adoption of cost-saving training technologies and cheaper modes of delivery.

Table 4.4: Total funding needs for TVET system expansion with and without distance education 2022—30, billion rands

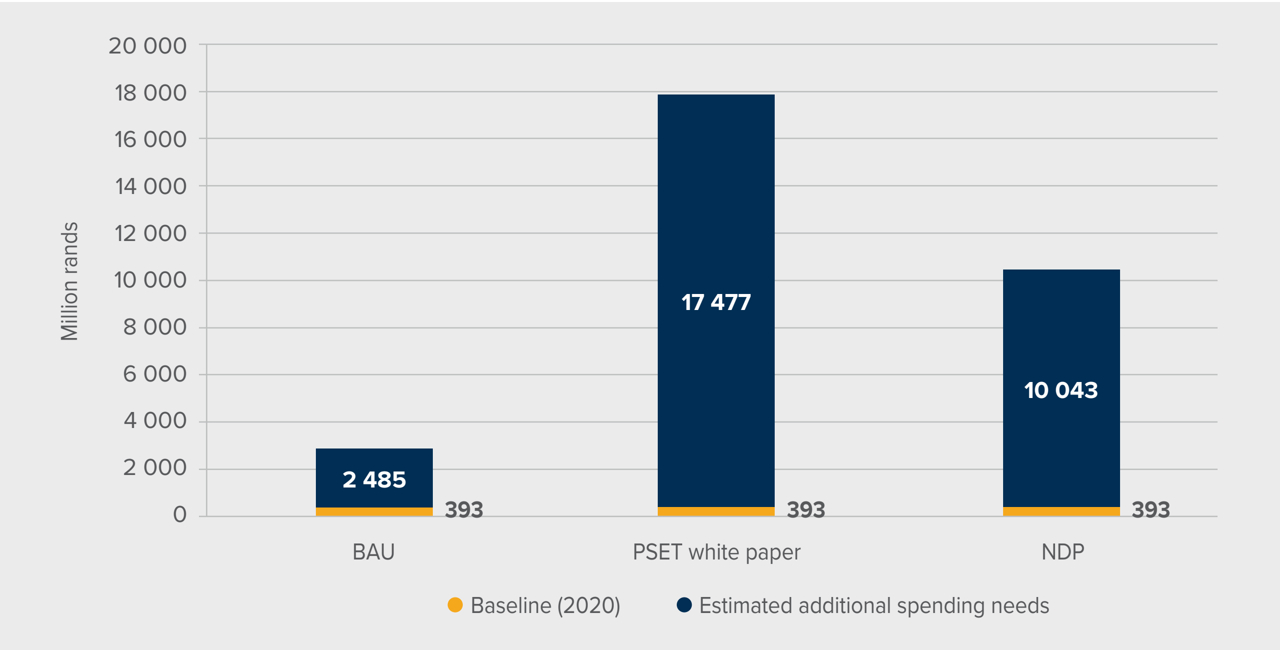
	Scenarios	
	PSET white paper	**NDP**
Without distance education		
Non-infrastructure	731	370
Infrastructure	424	166
Total	**1 155**	**535**
With distance education		
Non-infrastructure	552	321
Infrastructure	151	84
Total	**703**	**405**

Source: Authors' estimates based on data provided by DHET.

Expansion of the TVET system is likely to be constrained by the supply of qualified and trained instructors. The increases in enrolment and improvements in student-instructor ratios modelled in the NDP and PSET white paper scenario would require approximately 20 000 and 46 000 instructors in the public TVET system respectively by 2030. This would be a large increase from the approximately 7800 teaching staff in the public TVET system (based on DHET administrative data from 2020). This increase would be despite assuming that instructors who provide on-site training would also develop distance learning material and conduct classes for distance learning trainees, i.e., no additional instructors would be required for distance learning students. If the current delivery model for TVET were to continue, the number of instructors required would be much higher, for example, it would double under the PSET white paper scenario.

The construction of new campuses and student housing required to accommodate increased enrolment would require a many-fold increase in capital expenditure. In 2020, the government spent R393 million under the College Capital Infrastructure Efficiency Grant for the maintenance and upgrading of colleges. This would mean that the funding associated with interventions under any of the expansion scenarios would be an increase from this reference. The estimated annual infrastructure funding needs, if they were to be matched with commitment, would result in a 6-, 26- and 44-fold increase from the 2020 levels of capital expenditure (Figure 4.5). This increase would be driven mostly by the cost of constructing new campuses and student housing. A significant change in the composition of TVET expenditure would be required to meet these costs. The construction cost of new campuses was calculated assuming that the unit cost of construction would be unchanged in real terms and current norms for space utilization would prevail. While their effects have not been simulated because of a lack of data, more efficient construction methods and better space utilization would significantly reduce these costs.

Figure 4.5: 2020 infrastructure spending versus annual average infrastructure funding needs



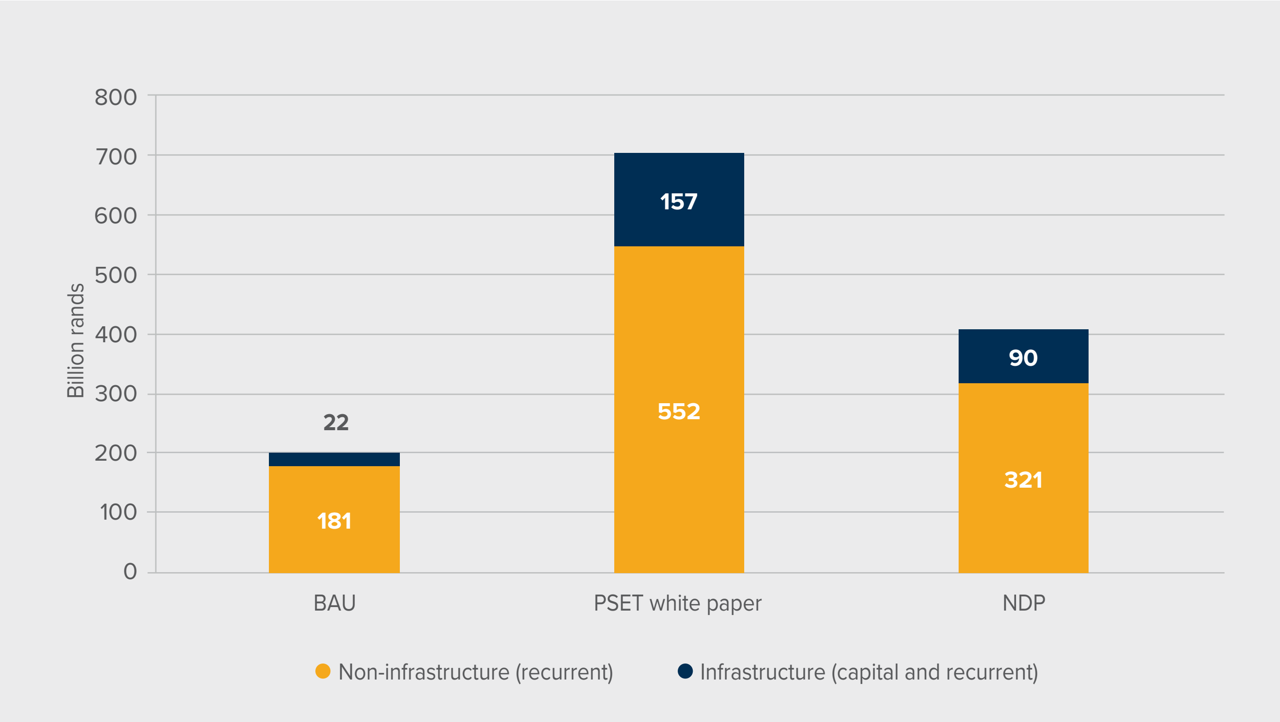
Source: Authors' estimates based on data provided by DHET.

Total funding needs for upgrading and expanding the TVET system

South Africa has set itself ambitious targets for the expansion of quality TVET services. The many-fold increase in funding necessary to achieve these targets is unlikely to be realised, particularly given the fiscal constraints South Africa faces. Nevertheless, given the critical need to address the youth employment crisis, increasing access to quality TVET must remain a priority. Under these circumstances, the NDP scenario, which sets a more modest target for TVET enrolment than the PSET white paper scenario, while still aiming for a significant expansion of TVET, is the preferred scenario.

The funding needs for upgrading existing facilities and expanding the TVET system under the preferred scenario is R411 billion for the period 2022—30. Total funding needs for upgrading existing facilities and expanding the TVET system under the more ambitious PSET white paper scenario amount to R709 billion, while the funding needs for the less ambitious BAU scenario amount to R203 billion between 2022 and 2030. The funding needs cover infrastructure and non-infrastructure costs, with the latter accounting for 79% of the total needs in the preferred NDP and PSET white paper scenarios and 89% in the BAU scenario. The infrastructure upgrading and expansion would cost between R22 billion in the BAU scenario and R157 billion in the PSET white paper scenario (Figure 4.6), with expansion taking the larger part (ranging from 72% in the BAU to more than 90% in the other scenarios). The non-infrastructure costs cover salaries for administrators, instructors and support staff, student welfare financing and TVET system operations, while infrastructure costs would cover construction of new campuses, construction of new hostels, rehabilitation or upgrading of existing hostels, installation of infrastructure for distance learning, and maintenance of facilities in the TVET institutions.

Figure 4.6: Total funding needs for upgrading and expanding the TVET system, 2022—30



Source: Authors' estimates based on data provided by DHET.

The average annual costs of expanding and upgrading the TVET system range between R23 billion in the BAU scenario and R79 billion in the PSET white paper scenario. The preferred NDP scenario is estimated to cost R46 billion annually. Here the total cost of upgrading (R6 billion) and the cost of acquiring infrastructure for distance education (R2314 billion) were spread equally over a nine-year period yielding R689 million and R257 million respectively (see Table 4.5). However, given the inequality arising from accessing the facilities with varied quality, upgrading the facilities in the short-to-medium-term would be the best option. Compared to the GDP, the annual funding needs for upgrading and expanding are 0.38% of GDP in the BAU scenario, 1.34% in the PSET white paper scenario; and 0.78% in the NDP scenario.

Table 4.5: Average annual funding needs for upgrading and expanding the TVET system, 2022—30

	Scenario		
	BAU	PSET white paper	NDP (preferred)
	Million rands		
Non-infrastructure			
Central level	914	914	914
In-person education	19 199	56 207	32 868
Distance education	-	4 172	839
Total	**20 112**	**61 292**	**35 621**
Infrastructure			
Upgrading	689	689	689
Expansion	1 796	16 787	9 354
Construction of new campuses	1 296	9 182	6 057
Housing for additional students	-	4 662	1 571
Upgrade of existing housing facilities	-	2 187	969
Infrastructure for distance education	-	257	257
Maintenance of facilities	500	500	500
Total	**2 485**	**17 477**	**10 043**
Total funding needs	**22 597**	**78 769**	**45 664**
	% of GDP		
Non-infrastructure	0.34	1.04	0.61
Infrastructure	0.04	0.30	0.17
Total funding needs	0.38	1.34	0.78

Source: Authors' estimates based on data provided by DHET.

Expansion of the TVET system would lead to large increases in the cost of student welfare support. By 2030, NSFAS expenditure will account for a third and a tenth of total recurrent expenditure in the NDP (where all trainees are assumed to receive NSFAS support) and the PSET white paper (which assumes that the current rate of approximately 60% of trainees receiving NSFAS support continues) scenarios respectively. This assumes that the current average amount of NSFAS support provided to TVET trainees is maintained in real terms, which is only a quarter of the amount provided to university students. Given the large funding needs arising from other aspects of the expansion of the TVET system, a targeted approach to trainee financial aid which provides support selectively to those most in need will be needed.

Recommendations

Create an enabling regulatory and funding environment for private providers. Closing the infrastructure gap would require diversification of financing sources. This would include greater support for private providers of TVET. The role of the private sector is acknowledged in South Africa's TVET objectives, with the NDP's target of 1.25 million TVET trainees by 2030 potentially comprising both students from public and private TVET colleges (Khuluvhe et al., 2021). However, the lack of data on private TVET colleges prevents the DHET from accounting for these colleges in its strategic planning processes. Enabling the private sector to contribute to the achievement of South Africa's TVET objectives would require a simplified and more responsive quality assurance mechanism, outcomes-linked government funding, and regular and comprehensive monitoring.

Encourage alternate modes of training, such as workplace-based training. In addition to crowding-in private providers of college-based TVET, there is significant potential to leverage the capacities and resources of firms through alternate training mechanisms such as workplace-based learning. To improve participation in workplace-based learning, enterprises must be prepared to engage and be capable of taking on learners. However, there are barriers that influence the preparedness of enterprises to engage (such as information failures and changes in the business and qualification environment) and barriers that affect their capability to take learners. Capability barriers include bureaucracy and procedures, high costs and limited incentives, and low training capacities (Franz, et al., 2022). Creating an enabling environment for workplace-based learning would require reducing the administrative requirements for workplace-based learning imposed on enterprises, incentivizing Sector Education and Training Authorities to increase their responsiveness to micro- and small-enterprises, facilitating intermediary models of micro- and small-enterprise participation in workplace-based learning, and fostering the development of demand-led programs and qualifications.

Use financial regulation to incentivise quality. More flexible fee ceilings could increase college income and incentivize quality improvements. Reforming the model for determining student fees and program funding from the DHET could also generate more income for higher performing colleges, where investments are most efficient. These reforms would entail a shift away from determining fees and program funding based solely on the cost of provision, to a model that directly incentivizes quality as measured by student outcomes. The state of Gujarat in India has implemented such a model for technical education, where institutes that are granted 'Centre of Excellence' status based on a set of quality standards, are exempted from government fee regulation (Government of Gujarat, 2013). In other models, while no institutes are exempted from fee regulation, higher performing institutes can charge higher fees. Such provisions must be accompanied by well-targeted student financial support to ensure equitable access to the best colleges.

Diversify the sources of income for public TVET colleges. Public TVET colleges should also diversify their sources of income. There is significant potential for TVET colleges to raise revenues from direct services provided to firms drawing on models from other countries. This has the benefit of strengthening linkages between colleges and local markets. For example, the Servicio Nacional de Adiestramiento en Trabajo Industrial (National Industrial Work Training Service, Spanish) in Peru derives nearly 60% of its income from the sales of goods and services, including training programs focused on high-demand areas such as environmental technologies, in-house training for employees of private firms, and manufacturing services (SENATI, 2018). Other potential sources of income are leasing land and equipment to firms when not in use and delivering services such as small-scale construction and repairs to local communities. While pursuing these sources of income, it is important to balance the emphasis on income generating activities with the core objective of providing high quality training.

Improve the internal efficiency of the TVET system. With limited fiscal space to increase the TVET budget, improved efficiency can create room for increased capital expenditure. Extremely low internal efficiency results in a considerable waste of resources due to repetition and dropout. Improving internal efficiency requires, amongst other measures, improved quality of instruction, sustained financial aid for long duration programs to reduce dropouts, better access to internships and industrial placement opportunities for students to meet the practical training requirements of their courses, and timely certification after examinations. Improved management and accountability at the system level is also needed to improve efficiency. This requires strengthened capacity to design and implement well-aligned policies, norms, and standards in areas such as quality assurance, financing, and infrastructure development. This is reliant on better monitoring and evaluation based on consolidated data systems to ensure compliance.

Use innovative mechanisms to fund the adoption of technology. The use of technology in TVET can be funded by leveraging emerging business models and funding sources. Digitizing TVET to respond to market demand and enable new delivery models requires additional investment. Digitization is dependent on the availability of digital infrastructure and the COVID-19 pandemic has highlighted the need for investment in digital infrastructure in the TVET sector. Compared to 80% of university students, only 40% of TVET students had access to any online learning during the pandemic (DHET, 2021c). While the government will have to invest in the enabling digital infrastructure, it can leverage the private sector to fund digital TVET platforms and content. Venture capital is driving investment in education technology globally. In 2010, for instance, venture capital investment in education technology was $500 million (R8 billion in 2020 prices), and by 2020 it had reached $16 billion (R242 billion in 2020 prices), including doubling in 2020 alone (HolonIQ, 2021). For South Africa to benefit from these investments, the government will have to develop a conducive policy and regulatory environment for private investment in education technology in TVET. To ease initial capital constraints, which are partly driven by high perceived risk, the government can provide startup capital to incubate locally grown solutions or to facilitate the entry and piloting of global technology solutions (World Bank Group, 2021). In addition, the government also has the unique role of providing accreditation and recognition to trainee outcomes from digital products, to encourage their adoption, facilitate recognition by industry, and overcome resistance from established providers.

Develop macro-level space norms and improve the norms for space utilization. Planned expansion of TVET infrastructure requires macro level space norms for TVET colleges. With no planned TVET infrastructure expansion since the Recapitalization Program of 2008, it is essential that the next phase of expansion is informed by careful strategic planning that accounts for both trends in enrolment and the trades to be taught. This requires an evolution of the current TVET space norms. The creation of higher-level norms that provide a broad understanding of space needed based on expected student load, will allow the DHET to identify future infrastructure funding needs. College level space norms can be revised to improve space utilization. Increasing the expected utilization of classroom space in the space norms from the current 50% of annual working hours to 75% will reduce the amount of classroom space needed by 33%. A 75% utilization rate is in line with other developing countries, such as India. This can be achieved by building multi-purpose classrooms that are not earmarked for specific trades or instructors and effective timetabling. Similarly, the utilization of workshops and laboratories can be increased by using each facility multiple times. This can allow these facilities to be designed for only a third or half of the student strength, significantly reducing the cost of construction and equipment.

Strengthen DHET capacity to develop and implement infrastructure norms and standards. The DHET's capacity to develop and implement standards and norms for TVET infrastructure should be strengthened. In addition, data and monitoring systems needed to ensure compliance must be developed. The DHET currently does not have a system to monitor the availability and condition of TVET infrastructure. Consequently, there is no data on existing TVET infrastructure and the extent to which it complies with the current norms. There are examples of education infrastructure monitoring systems in South Africa, such as the NEIMS for basic education, which can inform the development of a TVET infrastructure monitoring system.

Use technology for more efficient space utilisation. Technology can enable more efficient utilization of existing physical infrastructure. The use of technology, where the necessary digital infrastructure is present, can greatly reduce demands on physical infrastructure, particularly for space or equipment intensive activities. For example, at the Swiss Federal Institute for Vocational Education and Training, horticulture programs use virtual reality glasses to allow students to create and implement landscaping designs, including placement of trees, shrubs, and plants, and to simulate different seasonal effects for their virtual landscapes (UNESCO-UNEVOC, 2020). This eliminates or reduces the need for land to practice these skills. Similarly, online, or blended learning can reduce the need for classroom space. By simulating on-the-job training, these technologies can also help to bridge the gap between theoretical learning in the classroom and the skills needed to perform in professional settings. Space norms for TVET colleges must evolve in line with the adoption of these technologies. In addition, the effective use of these solutions will require teachers, trainees, and administrators to have the required digital skills.

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Chapter 5

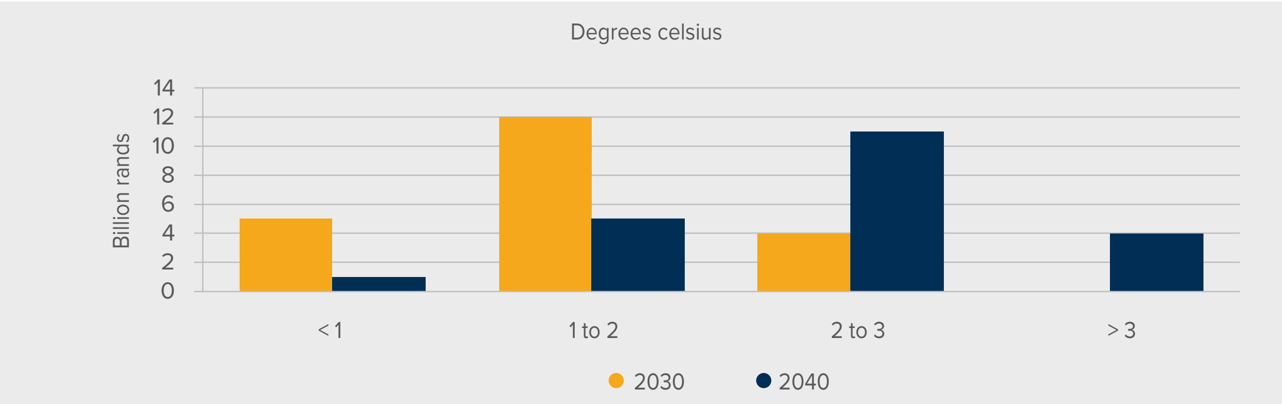
INFRASTRUCTURE RESILIENCE

Introduction

South Africa is exposed to a range of natural disasters that can damage its infrastructure assets and hinder growth. According to historical data, the country is at high risk of wildfires and river, urban and coastal floods, and at a medium risk of earthquakes, landslides, tsunamis, water scarcity, and extreme heat (GFDRR, 2022). The water emergencies in Cape Town in 2017 and Nelson Mandela Bay in 2022, and the unprecedented floods in eThekwini in 2022, are examples of the climate catastrophes that have already occurred in the country. As the World Bank's South Africa Country Climate and Development Report suggests, South Africa can deliver an effective response to climate change without undermining its socioeconomic goals by embracing a resilient transition as well as a low carbon and just transition (World Bank, 2022).

Climate change is increasing the frequency and severity of some of these hazards. South Africa is currently warming at twice the global average, and according to most models, extreme temperatures are projected to increase on average by two to three degrees by 2040 under the most extreme climate scenario (RCP8.5) (Figure 5.1). These changes in temperatures also come with (more unpredictable) changes in precipitation that can increase the severity of floods and droughts, water scarcity, and wildfire risks. The country is ranked 96th out of 182 countries in the Global Adaptation Index,[1] meaning that it is the 96th most vulnerable country based on exposure and readiness for adaptation.

Figure 5.1: Average increase in temperature 2030—40



Source: Authors' elaboration based on NASA Center for Climate Simulation (2019).
Note: Projected annual average increases in seven-day maximum annual temperature for the 2030 and 2040 decades. Ensemble results for all models under an RCP8.5 (21 models total).

Natural hazards and climate-related events can have significant impact on public and private infrastructure. Floods, earthquakes, and wildfires are hazards that have the potential to significantly damage infrastructure that is essential to public service delivery which includes road networks and water and sewer plants and distribution networks, amongst others. As public infrastructure is owned and managed by government, this results in a contingent liability to government for any repairs of the damaged infrastructure. These infrastructure damages not only are costly in terms of repair, but also create network disruptions that can affect households and firms. The most visible include transport and supply chain disruptions, halting of production lines because of electricity outages, and slowdown of processes where water is required because of water shortages. Disruptions delay the supply and delivery of goods, while incurring costs, as firms aim to mitigate the disruptions with backup power generation and water storage facilities. Potential disruptions have a long-term impact on how firms make decisions on strategic investments and growth potential (Hallegatte et al., 2019). In South Africa, the costs from sale losses caused by disruptions to the power system were approximately $3.7 billion in 2019 (1.36% of GDP that year) (Rentschler et al., 2019). These losses can in turn have additional indirect negative effects on public finances.

1 The Notre Dame Global Adaptation Index ranks 181 countries using a score that calculates a country's vulnerability to climate change and other global challenges, as well as its readiness to improve resilience. The higher the ranking, the lower the country's vulnerability and higher its readiness (World Bank, 2022).

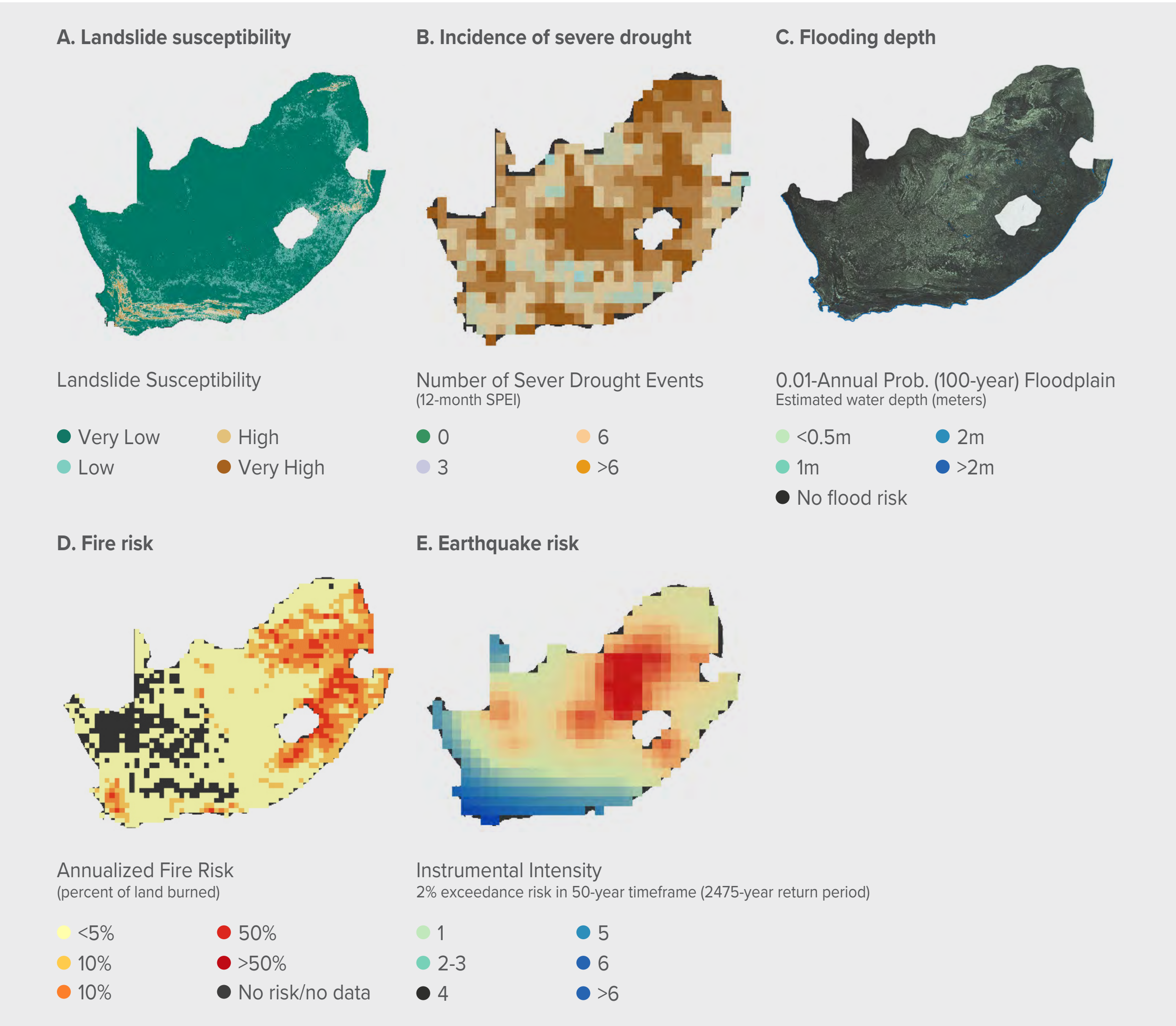
It is therefore important to ensure that future infrastructure assets be built in areas that are not exposed to natural hazards or, if this is not possible, to ensure that they are built according to standards that will make them resilient to future natural hazards. This chapter quantifies the exposure of South Africa's infrastructure assets to natural hazards and the cost to make future infrastructure more resilient to those hazards.

Exposure and risk assessment

Methodology

Individual infrastructure exposure was assessed for every natural hazard for which data was available. The hazards include drought, fluvial and pluvial flooding,[2] fire, landslide susceptibility, seismic events, and climate change projections for the 2030 and 2040 decades, including increases in extreme heat and intense precipitation events.

Map 5.1: Examples of natural hazards occurrence in South Africa



Source: Authors' elaboration based on Vicente-Serrano et al. (2010) for droughts, Broeckx et al. (2018) for landslides, Fathom (2021) for flooding, Giglio et al. (2013) for fires, and Ordaz et al. (2014) for earthquakes.

2 Fluvial flooding indicates depth of flooding due to high water levels in rivers exceeding bank heights, while pluvial flooding indicates the depth of flooding due to rainfall intensity that exceeds infiltration capacity.

Landslide susceptibility is considered high in the Western Cape and the Eastern Cape; Gauteng, KwaZulu-Natal, Mpumalanga, and Limpopo are high risk fire areas; and Gauteng, the Northern Cape, and the Free State are also subject to high earthquake risk (Map 5.1). Severe drought events are prevalent throughout South Africa, and while flooding data is limited it does indicate flooding events are also present throughout the country.

In order to assess the exposure of infrastructure assets to different levels of hazard intensity, the methodology employed by Koks et al. (2019) was used. Five levels of intensity were defined for each hazard ranging from 0 to 5. The intensity levels are depicted in Table 5.1, with '0' being no risk or unknown risk, '1' very low risk, '2' low risk, '3' moderate risk, '4' high risk and '5' extremely high risk.

These different levels of hazard intensity were then overlaid with maps of infrastructure assets. The infrastructure assets that were considered in the assessment for each sector include the road and rail networks, wastewater and water treatment plants and the water and sewer distribution networks, primary and secondary schools, and TVET campuses. The annexure provides the detail on the data description and sources for natural hazard and climate change data.

The risk caused by each hazard on infrastructure assets was also estimated, by calculating the expected present value of costs from natural hazards damages, between 2022 and 2050. Expected costs for the hazards impacts are calculated in each sector and for each asset class by multiplying the average construction costs for each asset by the percentage damage caused by an event (% of asset value) and by the annual probability of the hazard event, and then summing over all possible events and aggregating over time (using a discount rate consistent with macroeconomic projections). For the road network, construction costs per km are determined for primary, secondary, and tertiary roads, while for basic primary and secondary schools and TVET campuses the average cost to build the school or campus is used. For wastewater and water treatment plants the construction cost is determined in terms of their capacity, with treatment plants having lower unit costs as the capacity increases due to economies of scale. For piping (water and sewer distribution), the diameter strongly impacts the cost per km, with the larger diameter being more expensive and so when the diameter is unknown, a range of minimum to maximum costs have been determined.

The analysis of expected costs is limited by available input data. The cost data is the same used in chapters 1—4 and specific fragility curves (i.e., how an asset is expected to be damaged by a hazard at various intensities) are used for costing. Where data is not available on the fragility of the asset, but a fixed rate of damage is available, the latter is used. For the water and education infrastructure, a fixed rate of damage is used, while for the transport assets, flood depth fragility curves for the road and rail network have been applied. One limitation of the methodology applied for both fragility curves and fixed rate of damage is that it does not take into account the effect of the deterioration of an asset over time, as well as its initial condition which will modify its fragility. In other words, the analysis assumes that assets are always well maintained so that they retain the quality they had when they were first built throughout their lifetime. The rest of the analysis in the chapter focuses on flooding and seismic hazards because fragility curves or data on rate of damage are only available for those hazards.

Table 5.1: Hazard data reclassification summary and exposure assessment criteria

Hazard	Original data metric	Explanation of qualitative ranking classification	Score '0'	Score '1'	Score '2'	Score '3'	Score '4'	Score '5'
Flooding (fluvial)	Depth of projected flood inundation, based on modelling for the historical 0.01-annual probability event ('100-year event')	Depth of flood	No data OR no risk	< 25 cm	25-50 cm	50-100 cm	100-200 cm	> 200 cm
Flooding (pluvial)	Depth of projected flood inundation, based on modelling for the historical 0.01-annual probability event ('100-year event')	Depth of flood	No data OR no risk	< 25 cm	25-50 cm	50-100 cm	100-200 cm	> 200 cm
Landslide	Relative (quartile) risk ranking of susceptibility ('low' to 'very high' susceptibility)	Quartile ranking reclassified to meet five-tier scale	No data OR no risk	'Low' susceptibility	not considered	'Medium' susceptibility	'High' susceptibility	'Very High' susceptibility
Fire	Percentage of land burned annually (average value calculated from satellite data for preceding 19 years)	Classifications based on percentage of land burned	No data OR no risk	< 5%	5% - 10%	10% - 20%	20% - 50%	> 50%
Drought	Number of 'severe' drought events that occurred 1988-2018 using the 12-Month SPEI classification	Number of events	No data OR no risk	< 3 events	3-5 events	6-8 events	9-12 events	> 12 events
Earthquake	Expected ShakeMap Intensity and peak ground acceleration (PGA) resulting from 1/2475-year event, which corresponds to a 2% likelihood of exceeding design standards in 50 years	ShakeMap Intensity and PGA Value, reclassified using the Modified Mercalli Index (MMI)	No data OR no risk	< V intensity (<0.092g PGA)	VI intensity (<0.092g-0.18g PGA)	VII intensity (<0.18g-0.34g PGA)	VIII intensity (<0.34g-0.65g PGA)	> VIII intensity (>0.65g PGA)

Hazard	Original data metric	Explanation of qualitative ranking classification	Score '0'	Score '1'	Score '2'	Score '3'	Score '4'	Score '5'
Extreme Heat (Climate Change)	Increase, in degree Celsius, of average annual seven-day maximum temperature. Increase is the annual average across the decade (2030—40) relative to a thirty-year historical baseline	Increase in degrees	No increase	< 2 degrees	2-3 degrees	3-4 degrees	4-5 degrees	> 5 degrees
Intense Precipitation (Climate Change)	Increase, in percent, of total five-day maximum precipitation amount. Increase is the annual average across the decade (2030—40) relative to a thirty-year historical baseline	Increase in percent	No increase	< 20%	20-30%	30-40%	40-50%	>50%

Source: Authors' elaboration based on Koks et al. (2019).
Note: Qualitative ranking of hazard intensity is used only for the multi hazard exposure assessment. The not considered for level 2 under landslide stems from spreading the quartile ranking to the 5-category ranking for consistency purposes.

Main findings

Transport

Using the hazard classification as indicated in Table 5.1, for a level 2 or greater risk, the entire road and rail networks are exposed to severe drought events, while flooding only affects between 3% (fluvial) and 6% (pluvial) of the network. Fire with an intensity of 2 or higher can impact 37% of the primary and secondary road network, while the local road network exposure is 79% and rail network is 47%. Earthquakes of intensity 2 or higher can affect 49% of the highway, primary and secondary road network, with the risk to the local road network increasing to 75%. The rail network exposure for earthquakes is similar to that of the primary road network of 47%.

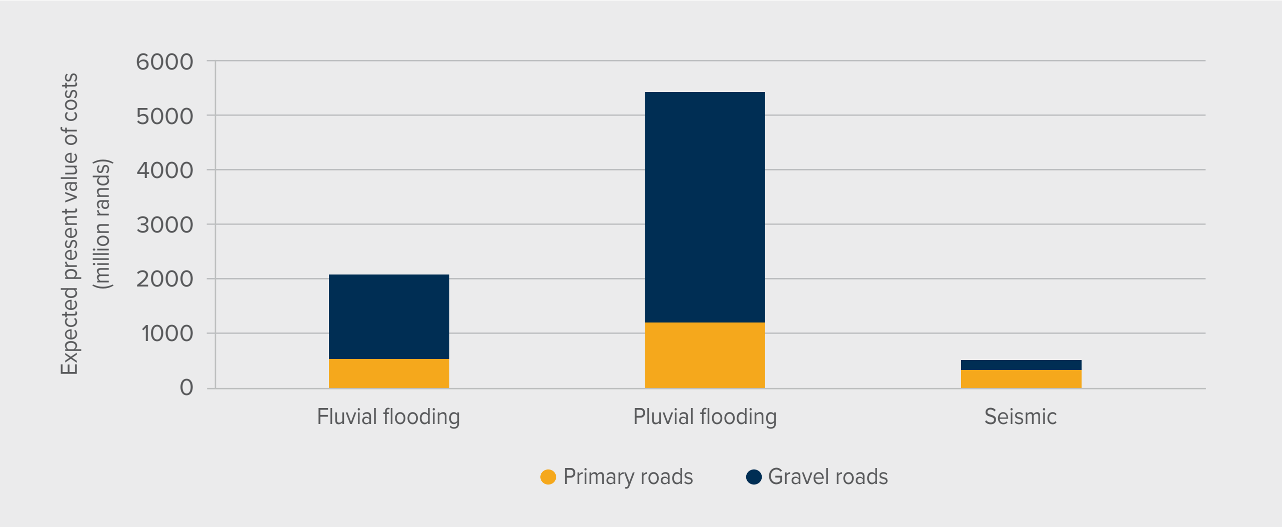
The national exposure of transport assets to changes in extreme heat and intense precipitation for the 2030 and 2040 decades was also analysed based on the RCP8.5 model (the most extreme climate scenario). Both the median and 95th percentile models were considered providing a range of asset exposure levels to heat and precipitation events.

For the 2030 decade, up to 60% of the primary and secondary road network is exposed to extreme heat with a level 2 or greater intensity, with local roads exposure increasing to 78%, while the rail network exposure is 64%. In the 2040 decade, exposure is increased to up to 87%, with local road exposure remaining the same, and the rail network increasing to 80%. Precipitation exposure in the 2030 decade ranges between 10% and 30% exposure for the road network and 12% and 37% for the rail network depending on the model applied (median vs 95th percentile). In the 2040 decade, the precipitation exposure increases to between 21% and 65% for the road network and between 20% and 40% for the rail network.

All roads have drought exposure, which can create visibility hazards and several issues for road safety particularly for unsealed or gravel roads. Drought increases the rate of erosion and dust emissions which then can create a visibility hazard. Significant portions of the road network are also subject to extremes of precipitation which increases erosion of unsealed roads. Extreme heat exposure is seen to be significant in the 2040 decade, and this is a risk factor for sealed roads and increases maintenance costs (Mollholland & Feyen, 2021). In the 2040 decade heat exposure is particularly high: greater than 80% for a level 2 intensity or higher. Extreme heat can cause buckling in railroad tracks, extreme precipitation can contribute to softening of railroad beds, and flooding can erode and undercut them (Rossetti, n.d.).

Figure 5.2 reflects the total expected hazard impact for flooding and seismic hazards nationally, split by road classification. Pluvial flooding is the highest risk, with the expected costs for primary and secondary roads driving most of the costs. Seismic risk has the second biggest impact, with most costs coming from the primary road network.

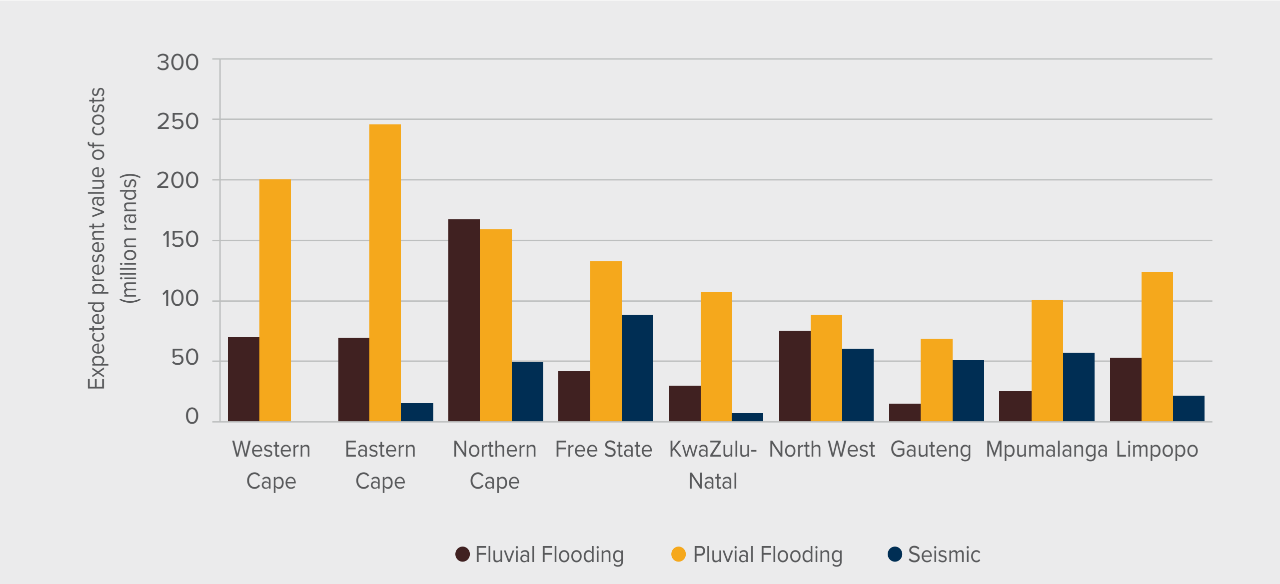
Figure 5.2: Expected hazard costs per asset class for road network



Source: Authors' estimates.

The expected costs due to flooding and seismic activity on the primary road network at the provincial level are presented in Figure 5.3. Flooding has the highest hazard impact on the primary road network, with the Eastern Cape reflecting the highest expected net present value (NPV) of costs from pluvial flooding and the Northern Cape from fluvial flooding. The expected seismic hazard impact on the primary road network is the highest in the Free State, followed by North West, and Mpumalanga.

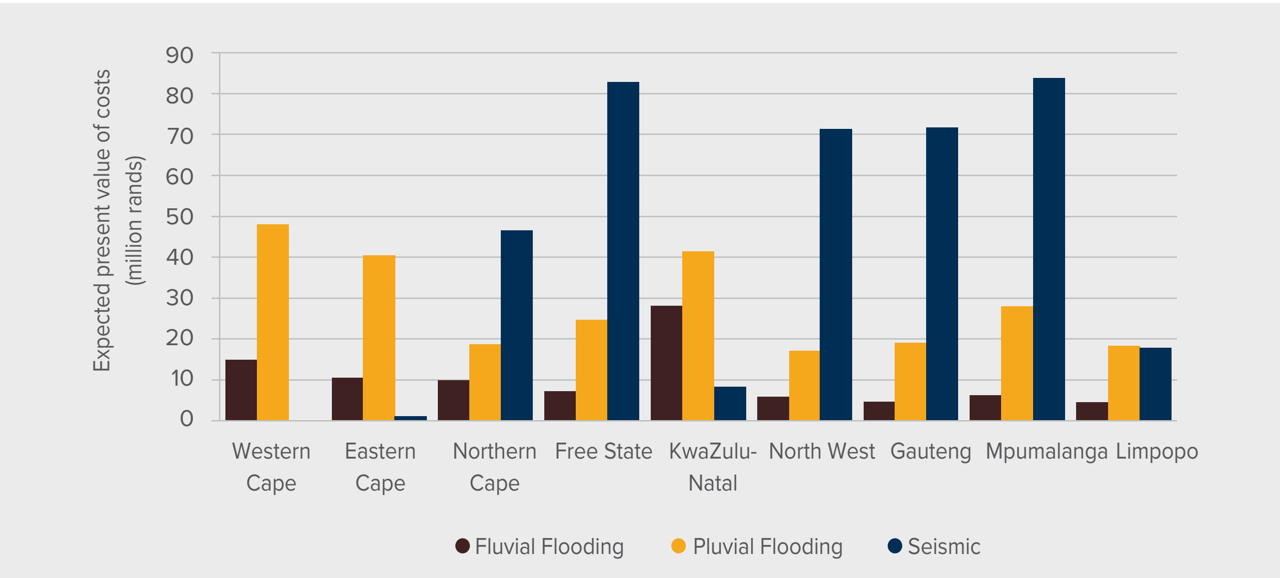
Figure 5.3: Expected hazard impact for the road network



Source: Authors' estimates.

The expected costs due to flooding and seismic activity on the rail network at the provincial level are presented in Figure 5.4. The highest expected costs are due to earthquakes in the Free State, North West, Gauteng, and Mpumalanga provinces, while flooding is the highest in the Western Cape, KwaZulu-Natal, and the Eastern Cape. Note that the costs are lower than for the road network, due to a smaller number of exposed assets.

Figure 5.4: Expected hazard costs for the railway network



Water and Sanitation

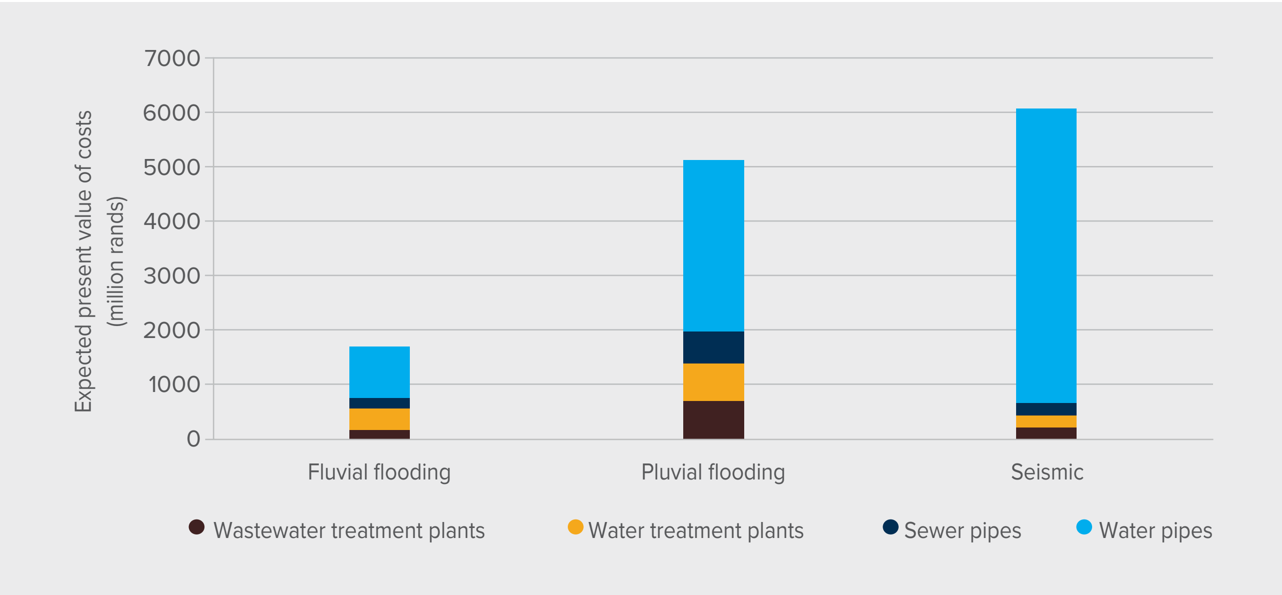
Using the hazard classification as indicated in Table 5.1, for a level 2 or greater risk, all water and sanitation assets are exposed to severe drought events, while flooding affects up to 13% of treatment plants and up to 17% of the distribution network. Exposure to fire ranges between 34% and 40% for treatment plants while it is at 62% for the distribution network. Earthquake exposure ranges between 34% and 45% for the treatment plants and could affect up to 50% of the distribution network.

For a level 2 or greater risk, the national exposure of water and sanitation assets to change in extreme heat and intense precipitation for the 2030 and 2040 decades was also analysed based on the RCP8.5 scenario. For the 2030 decade, up to 48% of the treatment plants and 66% of the distribution network is exposed to extreme heat, with this increasing to 74% and 90% respectively in the 2040 decade. Precipitation exposure in the 2030 decade ranges between 9% and 33% for treatment plants and 5% to 40% for the distribution network. This increases in the 2040 decade to a range of between 19% and 46% for the plants and between 20% and 53% for the distribution network.

The water and wastewater treatment plants are exposed to multiple hazards. More than 40% of water treatment facilities are in regions where more than 5% of the land experiences burns annually and this rises to more than 51% for water treatment facilities. Earthquakes are a particular risk for water transmission and distribution lines, and more than a third of facilities that they attach to have a 10% probability of exceeding a PGA VI event in a 50-year period. Half of the distribution network (sewers and pipelines) are exposed to some risk of earthquake, and between 10% and 20% are in location with landslide susceptibility.

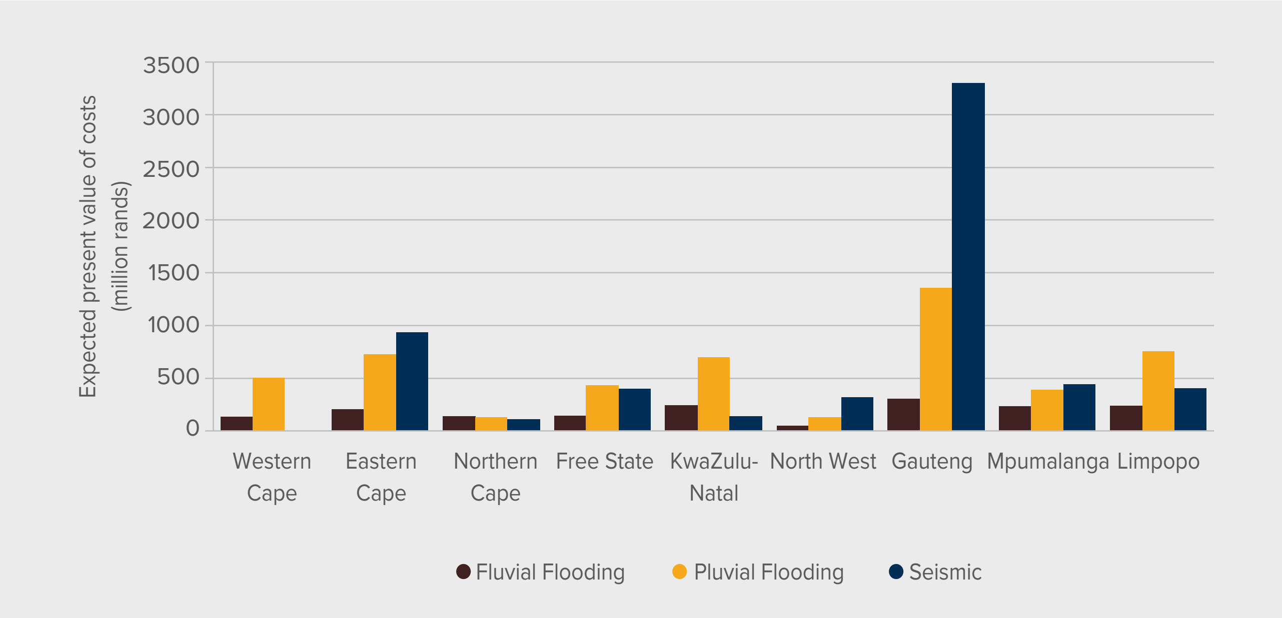
Seismic activity represents the highest expected hazard costs for water and sanitation assets, most notable on the water distribution network, at the national level (Figure 5.5). Pluvial flooding is another costly hazard. The provincial level analysis (Figure 5.6) shows that the highest expected costs from seismic hazards are in Gauteng and the Eastern Cape. These two provinces also face the highest expected costs from pluvial flooding.

Figure 5.5: Expected hazard costs per asset class for water and sanitation network



Source: Authors' estimates.

Figure 5.6: Expected hazard impact for water and sanitation assets



Source: Authors' estimates.

Education

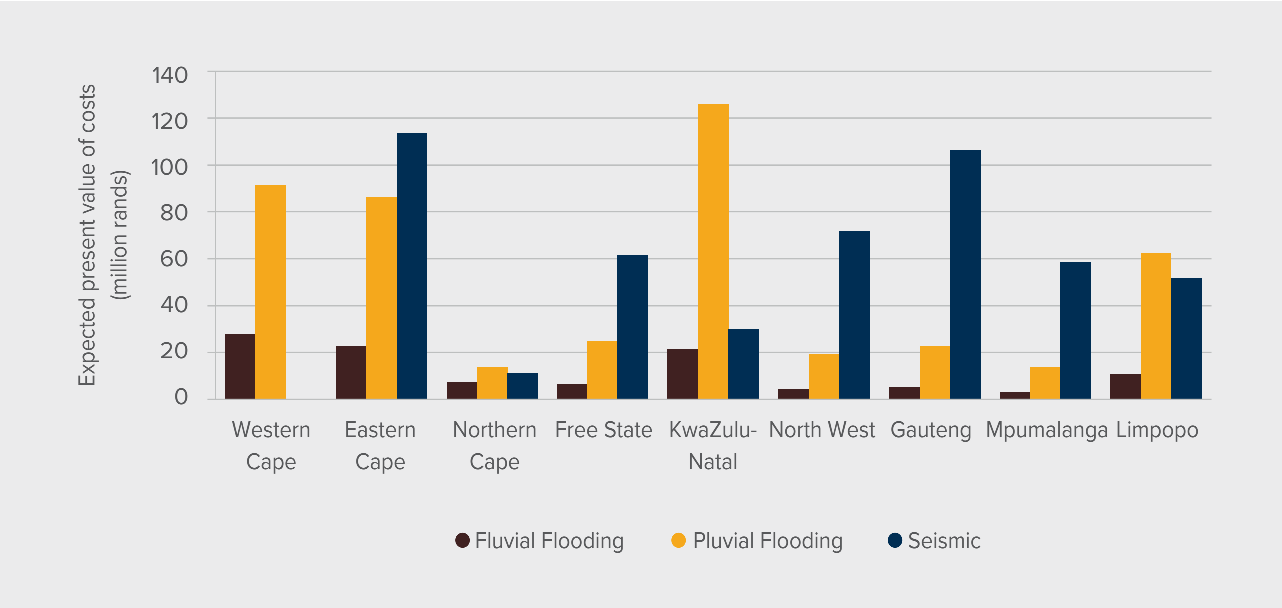
Using the hazard classification as indicated in Table 5.1, all primary and secondary schools and TVET campuses are exposed to severe drought events (level 2 or higher intensity), while only 2% of schools and 4% of campuses are exposed to flooding with level 2 or higher intensity. Fire has the potential to impact 58% of schools and 63% of campuses, while earthquake exposure could impact 41% of schools and 46% of campuses.

For a level 2 or greater risk, the national exposure of education assets to change in extreme heat and intense precipitation for the 2030 and 2040 decades was also analysed based on the RCP8.5 model. For the 2030 decade, 65% of schools and 69% of campuses are exposed to extreme heat, with this exposure increasing to 89% of schools and 80% of campuses in the 2040 decade. Precipitation exposure ranges between 5% and 35% for both schools and campuses, while increasing to between 22% and 47% in the 2040 decade.

All education assets are exposed to droughts, and more than 50% of these reside in regions where over 5% of land experiences burns annually. Flooding also presents a major source of risk, in particular for TVET campuses. In the 2040 decade, the majority of basic education schools and TVET campuses are expected to experience drought with extreme precipitation also posing a significant risk, especially as shown by the high-end climate model.

Analysis at a provincial level for the expected costs of the hazards impacts on the primary and secondary schools for flooding and seismic activity is reflected in Figure 5.7. Flooding represents a major risk in the Western Cape, the Eastern Cape, and KwaZulu-Natal most notably. Gauteng and the Eastern Cape also show a higher risk from seismic activity.

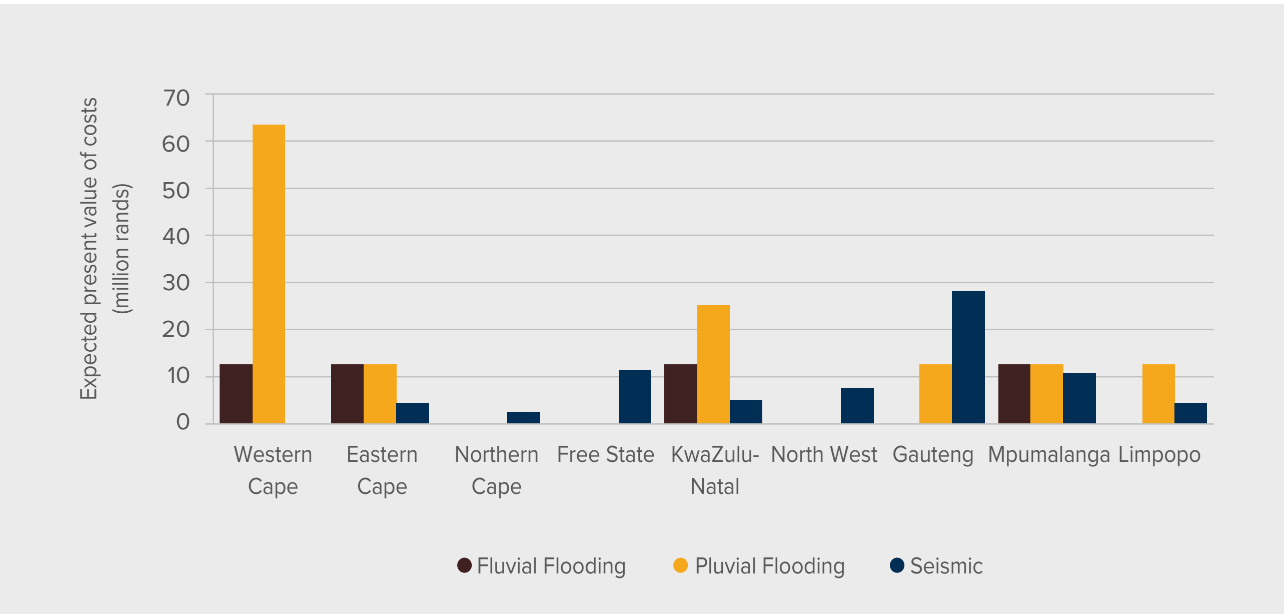
Figure 5.7: Expected hazard impact for primary and secondary schools (horizon 2050)



Source: Authors' estimates.

For TVET campuses, the expected costs for the impact of flooding and seismic activity are reflected in Figure 5.8. There is a larger expected cost in the Western Cape from flooding, but no cost due to seismic risks, which is the highest in Gauteng.

Figure 5.8: Expected hazard impact for TVET campuses



Source: Authors' estimates.

Adaptation assessment

Methodology

The adaptation analysis assesses first what fraction of the existing and future infrastructure assets would benefit from increased resilience (i.e., hardening) through typical measures (Table 5.2) The future assets are based on the investment needs identified in chapters 1—4. The analysis assesses whether it makes financial sense for assets to be upgraded to be more resistant to hazards (and thus avoid repair costs), or to keep them as they are and pay for repairs every time an asset is damaged. The analysis is done at the provincial level. An NPV of hardening at the 30-year horizon is used to assess the need to upgrade assets. Box 5.1 details the steps of the analysis adopted. Important to note is that the only benefits considered in the NPV are the avoided costs from direct asset damages. Indirect costs to users are not included in the assessments but would increase the number of assets that are worth hardening and could be funded through mechanisms to ensure users who benefit can share the cost of hardening. As a result, the estimates can be seen as a reasonable lower bound. Once all the assets that are worth hardening are identified, the study calculates the overall cost of making them more resilient to hazards.

Table 5.2: Typical hardening strategies

Asset	Hazard	Hardening strategies
Water and wastewater plants	Earthquake	Higher threshold seismic design
	Flooding	Elevation of equipment and floodproofing
	Landslides	Higher threshold for ground displacement
Sewers and water distribution	Earthquake	Equipment entourage retrofit
	Flooding	Elevation and barrier installation
	Landslides	Higher threshold for ground displacement
Primary roads	Earthquake	Compact the underlying material, earthquake resistant foundations
	Flooding	Provide barriers and improve drainage
	Landslides	Improve soil
Gravel roads	Earthquake	Compact the underlying material, earthquake resistant foundations
	Flooding	Provide barriers and improve drainage
	Landslides	Retaining wall, stabilize slope, soil nails
Railways	Earthquake	Bridge pier jacketing
	Flooding	Elevation and barrier installation
	Landslides	Drainage and drainpipe installation
Education buildings	Earthquake	Earthquake resistant foundations
	Flooding	Elevation and barrier installation
	Landslides	-

Box 5.1: Adaptation cost analysis

The analysis is completed in three steps: fragility assessments, yearly benefits analysis, and net present value (NPV) computation.

Fragility curves determine how an asset is expected to be damaged by a hazard at various intensities. The fragility functions are used to derive the fragility ratio for each asset, which is the ratio of repair cost to original cost. It is assumed that repair costs increase linearly with damages, so the repair cost is equivalent to the asset damage.

The yearly expected damage to an asset is computed using the fragility ratios, infrastructure exposure to hazards, and hazard likelihood and intensity. The expected damages are the percentage of damage from an event, times the asset value, times the probability of the event.

The NPV allows the assessment of the expected costs over a given period of time (30-year horizon). Using Ramsey's social discount rate, where a discount rate for every year is obtained (in this instance using the gross domestic product growth projections in the baseline socioeconomic pathway), the NPV can be determined by applying the discounting factor against the time horizon to determine the costs or savings as applicable for respective scenarios.

Because indirect costs to users, which are very hard to quantify, are not considered and such costs could justify the decision to harden an asset, the cost of hardening all exposed existing assets is assessed in a second step. This gives an upper bound to possible investment costs.

Main findings

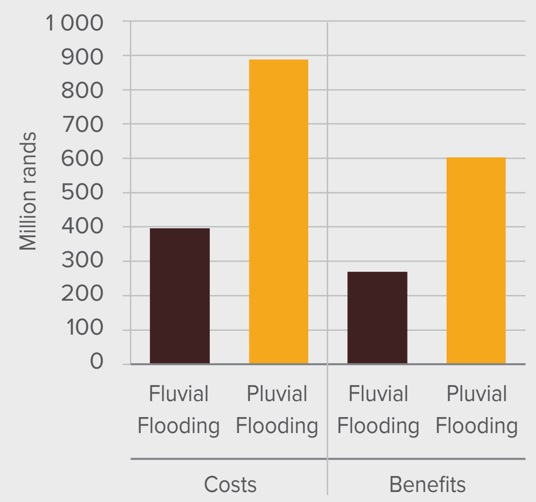
Transport

The analysis shows that for the road network, hardening makes financial sense (from a repair only perspective) when the 100-year expected flood depth hazard is 2.75 meters and up for paved roads. For the primary road network, a cost benefit analysis that only considers avoided direct damage to the roads does not justify hardening, since primary roads are already resistant to some level of hazards. However, primary roads can still be disrupted by large events, and they are critical for the functioning of the overall transport network. Therefore, the analysis quantified the costs and benefits of hardening all exposed primary roads, considering the extreme case where all exposed primary roads are critical from a social and economic perspective.

The highest hardening costs come from protection against earthquakes (Figure 5.9 and Figure 5.10), while the direct benefits from earthquake protection are limited. On the other hand, protection against flooding or landslides almost justifies the costs just based on avoided direct damages. If earthquake protection is excluded, the total cost of hardening all existing primary roads that are exposed to flooding or landslides would be R6.6 billion. Examples of resilience measures include the construction of retaining walls for landslide prone areas, and barriers and improved drainage to lower flooding impact.

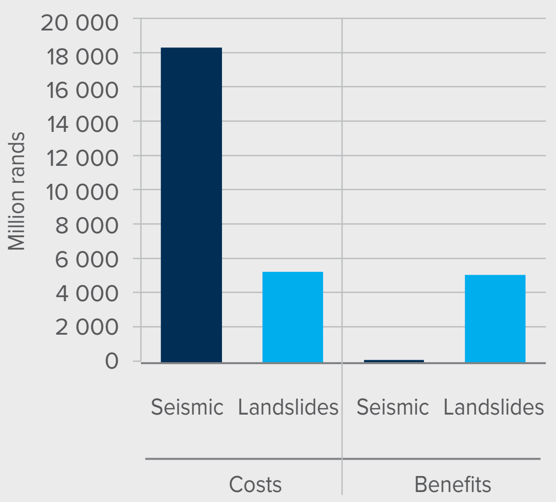
The investment costs required to increase the resilience of rural roads to floods depend on the policy for increasing rural access. If South Africa implements the policy of paving all rural roads as recommended in chapter 1, it will result in no additional costs for hardening of rural roads, as this is the most resilient technology. The policy of paving rural roads will yield an additional benefit in terms of the expected savings of not having to repair roads in high rainfall areas and flood zones after floods. The Eastern Cape and KwaZulu-Natal exhibit the highest additional benefit from a resilience perspective (Table 5.3).

Figure 5.9: Costs and benefits of hardening the primary road network against flooding



Source: Authors' estimates.

Figure 5.10: Costs and benefits of hardening the primary road network against earthquakes and landslides



Source: Authors' estimates.

Table 5.3: Additional expected NPV savings of rapidly paving high priority paved roads in high rainfall and flood regions (million rands)

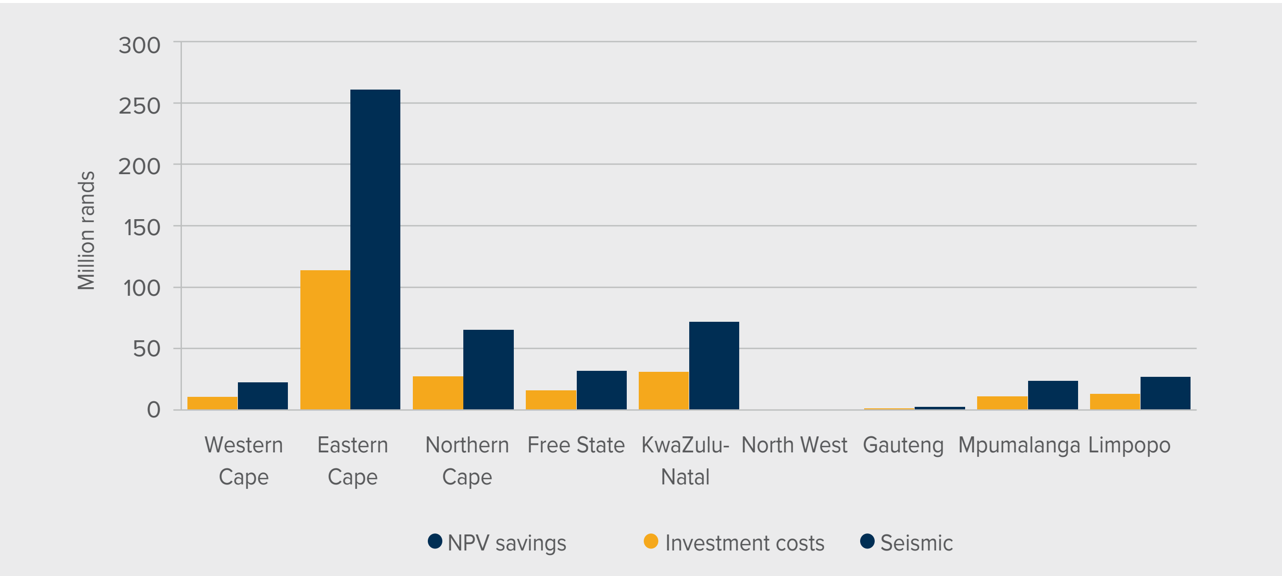
Province	Expected NPV savings at 30-year horizon (2051)	
	Fluvial	Pluvial
Western Cape	1.3	20.6
Eastern Cape	137.0	1 132.7
Northern Cape	-	12.8
Free State	7.4	78.5
KwaZulu-Natal	84.8	620.1
North West	-	0.2
Gauteng	64.9	8.2
Mpumalanga	7.8	61.0
Limpopo	5.9	94.1
Total	**244.0**	**2 028.3**

Source: Authors' estimates.
Note: Cost of upgrading is not included.

The analysis shows that hardening gravel roads makes financial sense (from a repair only perspective) when the 100-year expected flood depth hazard is greater than 50 centimetres depth. If South Africa decides to keep the current surface of rural roads, hardening only those roads that make sense financially will lead to an additional investment cost of R225 million. Hardening measures include construction of trenches to allow for more effective drainage, which would lead to halving the flood risk. The analysis assumes that hardening cost is 2% of the nominal gravel roads construction cost. It is important to note that the cost reflected is the capital cost only and does not include maintenance costs.

A ratio of saving (i.e., benefits) to costs in the order of two to three can be observed if the hardening is performed and targeted optimally. Figure 5.11 provides a comparison of investment costs and NPV of savings when applying targeted hardening against fluvial and pluvial flooding to exposed gravel roads at a provincial level. The Eastern Cape shows the largest potential savings from increasing resilience against flooding risks and investment costs, followed by KwaZulu-Natal and the Northern Cape.

Figure 5.11: Investment costs and NPV savings for targeted hardening against flooding of exposed gravel roads



Source: Authors' estimates.

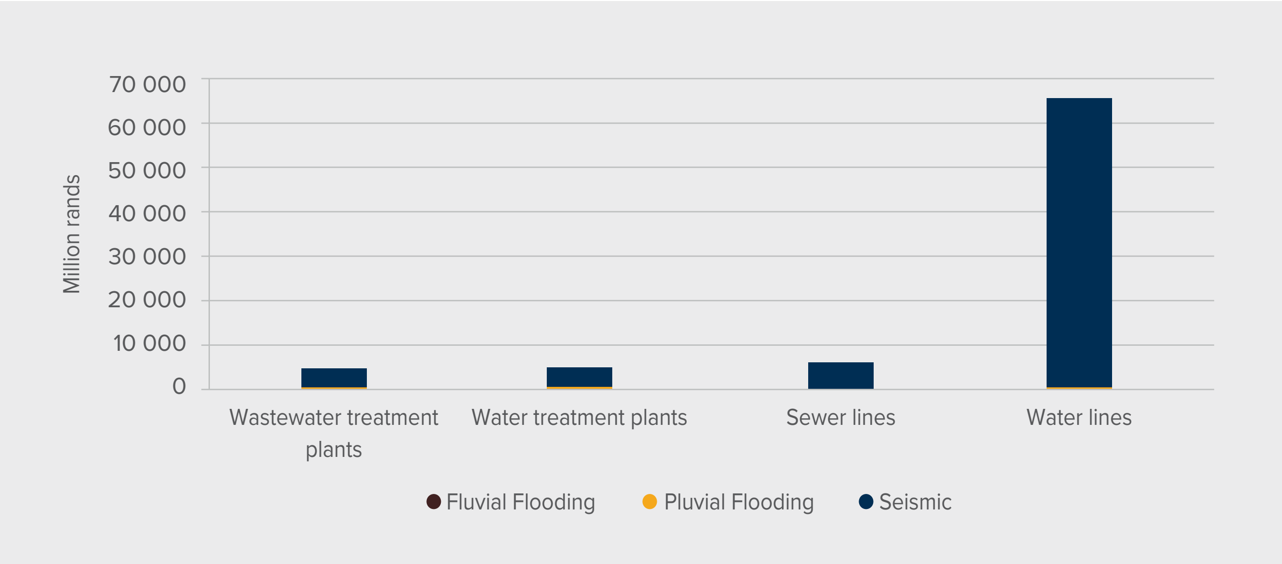
For the railway network, about 500 kms are found exposed to significant fluvial flooding (greater than 25 centimetres), and about 1500 kms to pluvial flooding. However, hardening is found not to be financially beneficial for railways as their increased resistance through elevation and barrier installation does not justify their hardening costs. The hardening costs, which are 45% of baseline costs, result in a reduction to 10% of the baseline expected damages (Miyamoto International & World Bank Group, 2019). The analysis shows that if the hardening costs are lowered to 7.5% of baseline costs, financial benefits start to emerge, but with the data available it is not possible to identify engineering solutions for hardening that are below this cost.

Past work on transportation infrastructure disruptions has shown that aggregate economic costs of disruptions can be 15 to 30 times higher than direct damages (Hallegatte et al., 2019). Accounting for this, one can justify railway upgrades if cascading economic losses from disruptions reach five to ten times the direct damages costs (for very high expected flood depth) and up to 30 times the direct damages for more moderate floods (more than 100 centimetres). This indicates that localized interventions in high-risk areas could be very appropriate economically. The results show that if the indirect losses are 15 to 30 times higher than potential direct damages from flooding only, upgrading the all-weather gravel rural roads with a low-volume sealant and drainage structures, or the railways with defence adaptation, would be economically beneficial in the medium to long-run.

Water and sanitation

The investment cost for hardening the exposed existing wastewater and water treatment plants, and sewer and water distribution pipes against flooding and earthquakes is close to R82 billion (Figure 5.12). The water distribution network represents the highest cost because of its relative size and its significant exposure to seismic risk. The assessment is based on a fixed rate of damage because fragility curves are not available. The investments costs for hardening of water and sanitation assets are based on Miyamoto International & World Bank Group (2019).

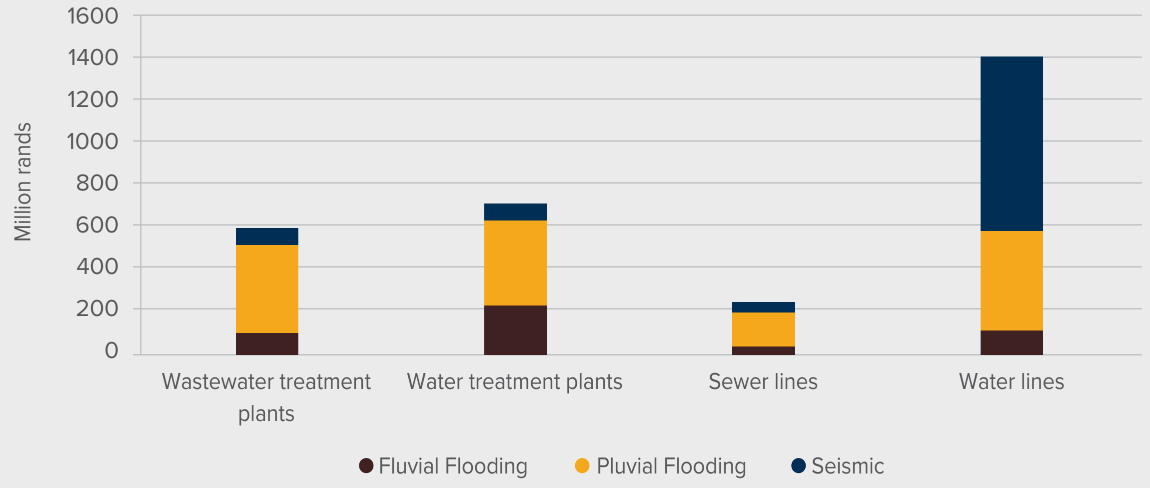
Figure 5.12: Investment costs for targeted hardening of water and sanitation assets



Source: Authors' estimates.
Note: The values reflected in the figure are based on the mid-point unit capital costs for water and sewer pipes.

The expected savings from the targeted hardening of the assets is presented in Figure 5.13 for all water and sanitation assets. The most significant saving is seen with the water distribution network based on its extent.

Figure 5.13: Expected savings from targeted hardening of water and sanitation assets



Source: Authors' estimates.
Note: The values reflected in the figure are based on the mid-point unit capital costs for water and sewer pipes.

A cost benefit analysis based only on avoided direct damages would not justify the hardening investments. The savings for wastewater treatment plants is 12% of the investment costs required and for the water treatment plants the savings equate to 13% of the investment costs. But targeting exposed assets with hardening strategies can yield consequential dividends when accounting for the value of service and costs of disruptions on various economy sectors. And while the cost of retrofitting existing assets is high, it is cheaper to increase the resilience of new assets when they are being built.

Education

The investment required to harden existing primary and secondary schools and TVET campus exposed to flooding and earthquakes ranges from R348 million for fluvial flooding to R41 billion for earthquakes (Table 5.4). The analysis is based on a fixed rate of damage, as fragility curves were not available. As the actual costs for adaptation strategies for school buildings and TVET campuses is not known, the assumption applied is that the adaptation cost is 12% of the construction cost for flood and 20% of the construction cost for earthquake defence.

Table 5.4: Investment for hardening of exposed existing basic education schools and TVET campuses (million rands)

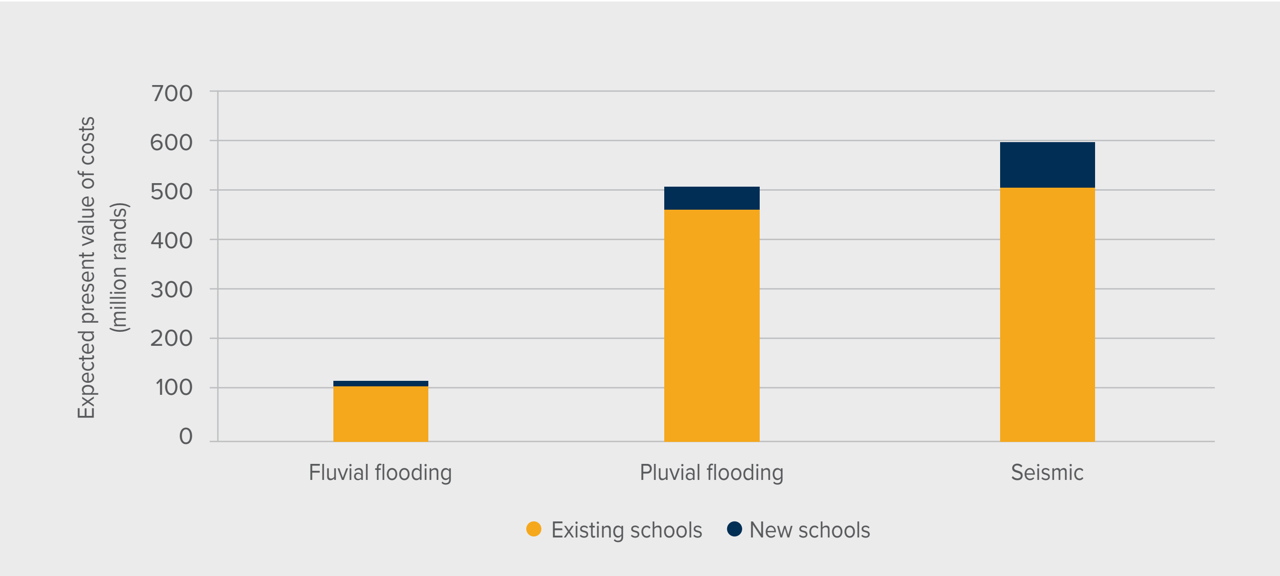
	Fluvial flooding	Pluvial flooding	Seismic
Primary and secondary schools	238	999	36 125
TVET campuses	110	303	5 366

Source: Authors' estimates.

A cost-benefit analysis based on avoided direct damages only would not justify the costs presented in Table 5.4. However, the primary reason why one would want to harden schools is to prevent disruptions in learning, which can cause economic damages much higher than direct infrastructure damage on schools. The negative economic and social impacts of students not being able to physically attend schools were notably seen during the COVID-19 pandemic in multiple countries, including South Africa (Ardington et al., 2021). Physical damage from natural hazards would result in a similar disruption for sets of students.

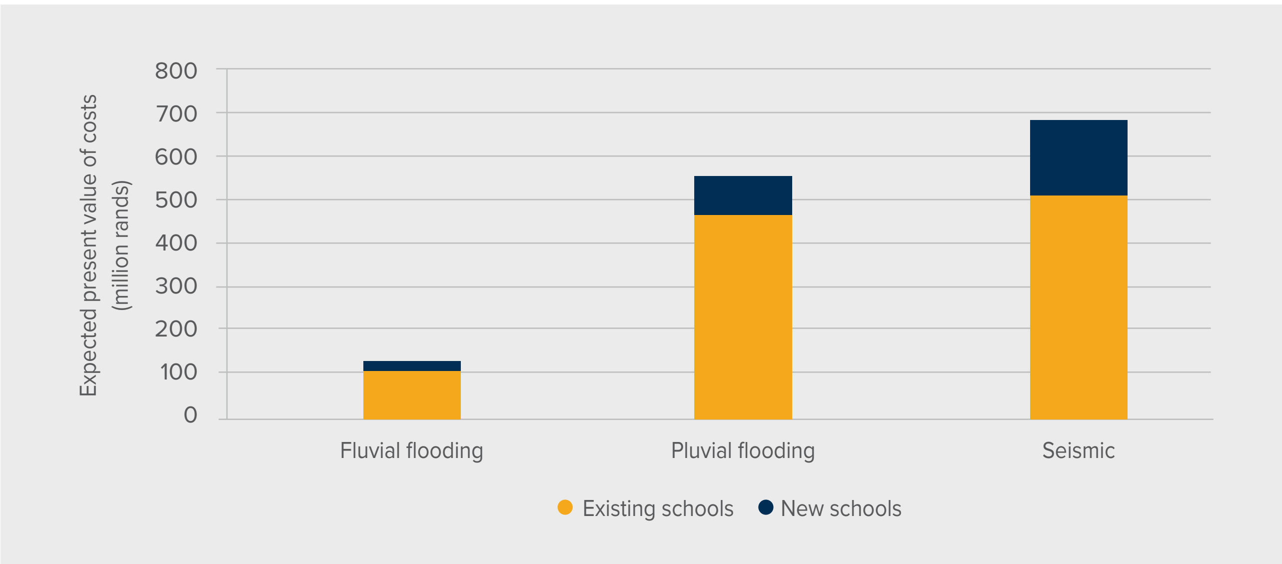
For primary and secondary schools, the three expansion scenarios (i.e., BAU, full access, and full access with efficiency) considered in chapter 3 have been analysed to understand the hazard impact on future schools. Figures 5.14—5.16 reflect the expected hazard cost for the existing and future schools per scenario. Exposure to earthquakes present the highest expected costs for each scenario with pluvial flooding as the second highest expected cost. In all cases the largest share of costs comes from existing schools.

Figure 5.14: Expected hazard impact for basic education schools under BAU scenario



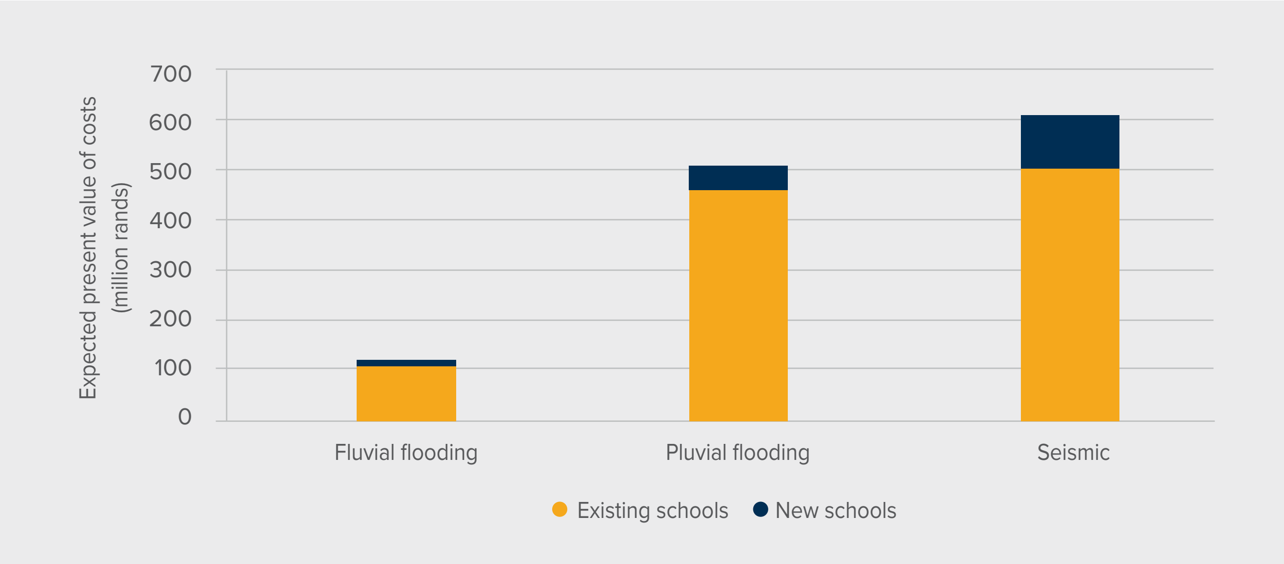
Source: Authors' estimates.

Figure 5.15: Expected hazard impact for basic education schools under full access scenario



Source: Authors' estimates.

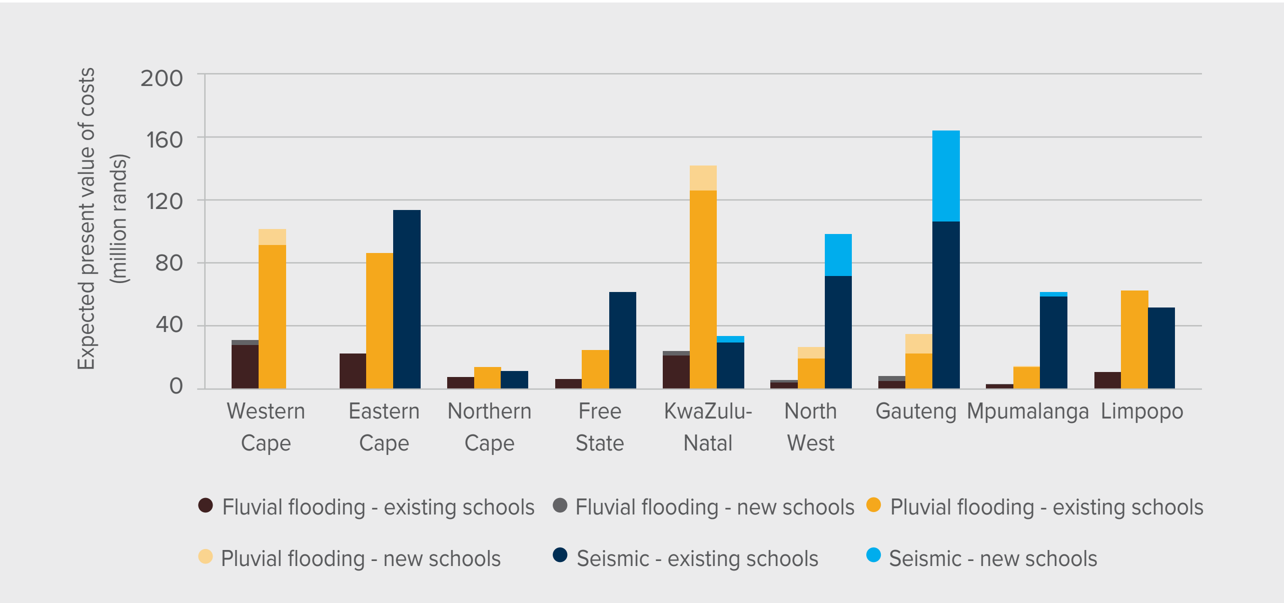
Figure 5.16: Expected hazard impact for basic education schools under full access with efficiency scenario



Source: Authors' estimates.

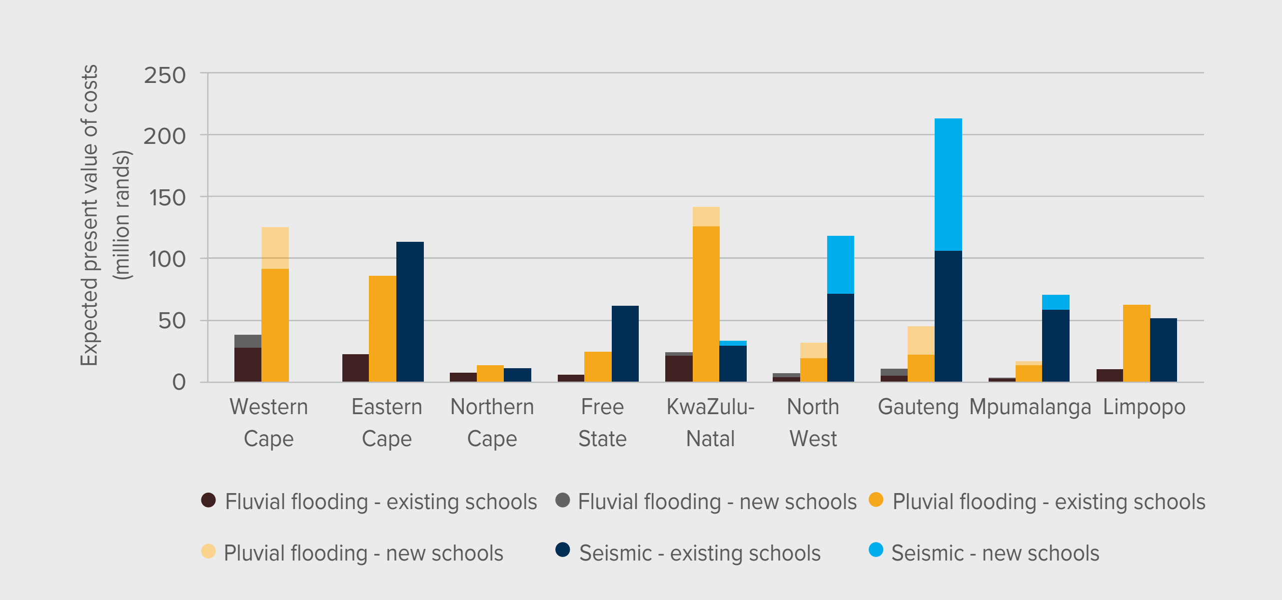
Figures 5.17—5.19 indicate the expected hazard costs at a provincial level. The expected costs from hazard exposure are highest under the full access scenario, as expected because the number of schools increases. Gauteng faces the largest expected costs from hazards, particularly seismic, in all three scenarios, followed by KwaZulu-Natal (pluvial flooding), the Western Cape (pluvial flooding), and the Eastern Cape (seismic). In the case of Gauteng, the large number of new schools plays an important role in driving the expected costs.

Figure 5.17: Expected hazard impact for basic education schools – BAU scenario



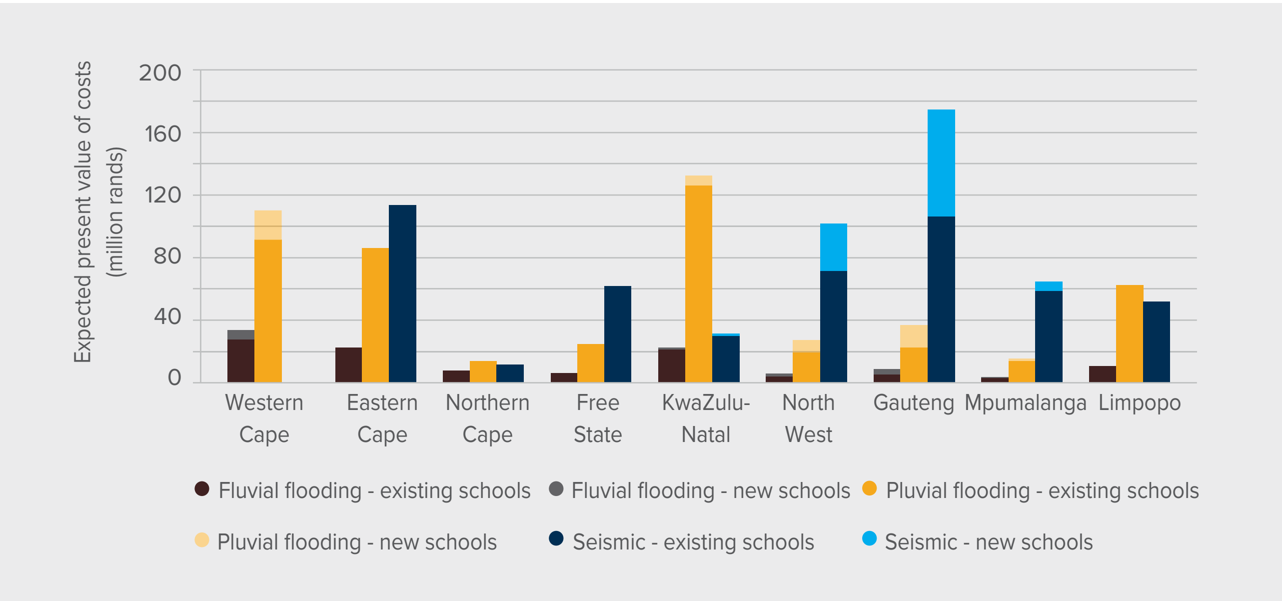
Source: Authors' estimates.

Figure 5.18: Expected hazard impact for basic education schools – full access scenario



Source: Authors' estimates.

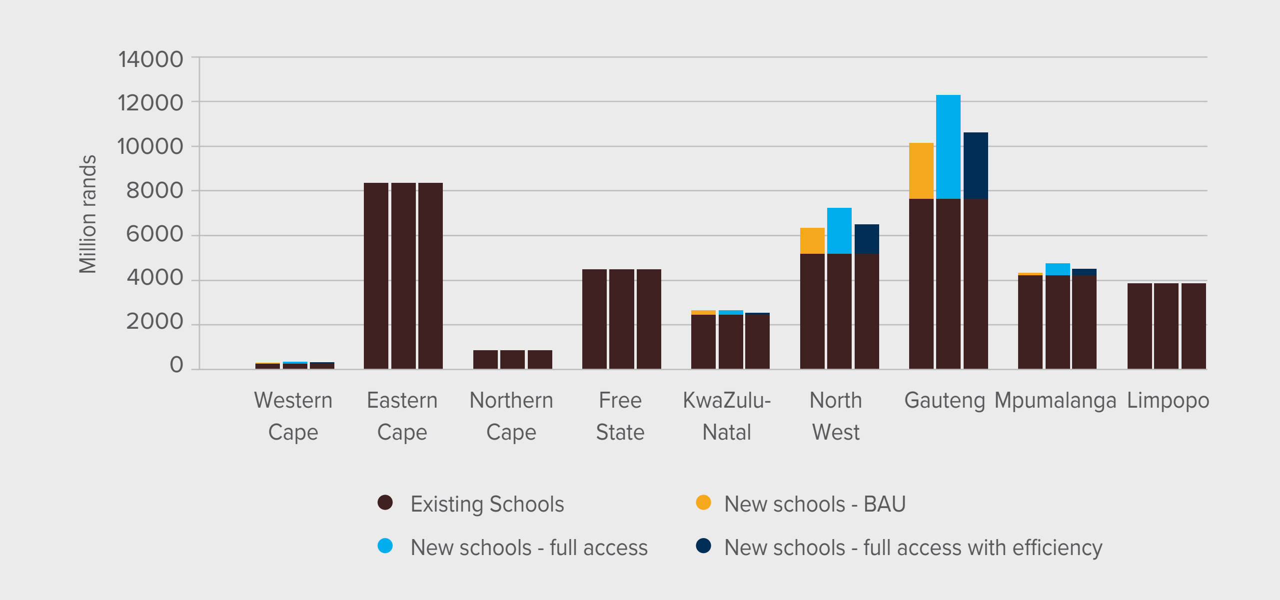
Figure 5.19: Expected hazard impact for basic education schools – full access with efficiency scenario



Source: Authors' estimates.

The investment required for targeted hardening of basic education schools with a focus on flood and earthquake defence ranges between R41 billion and R44.8 billion depending on the scenario selected with the hardening of existing schools making up the bulk of the cost of R37.4 billion. In all provinces most of the cost comes from the hardening of existing schools (Figure 5.20). In Gauteng between 28% and 38% of the total cost is for strengthening future schools, while in North West the share ranges between 18% and 28%.

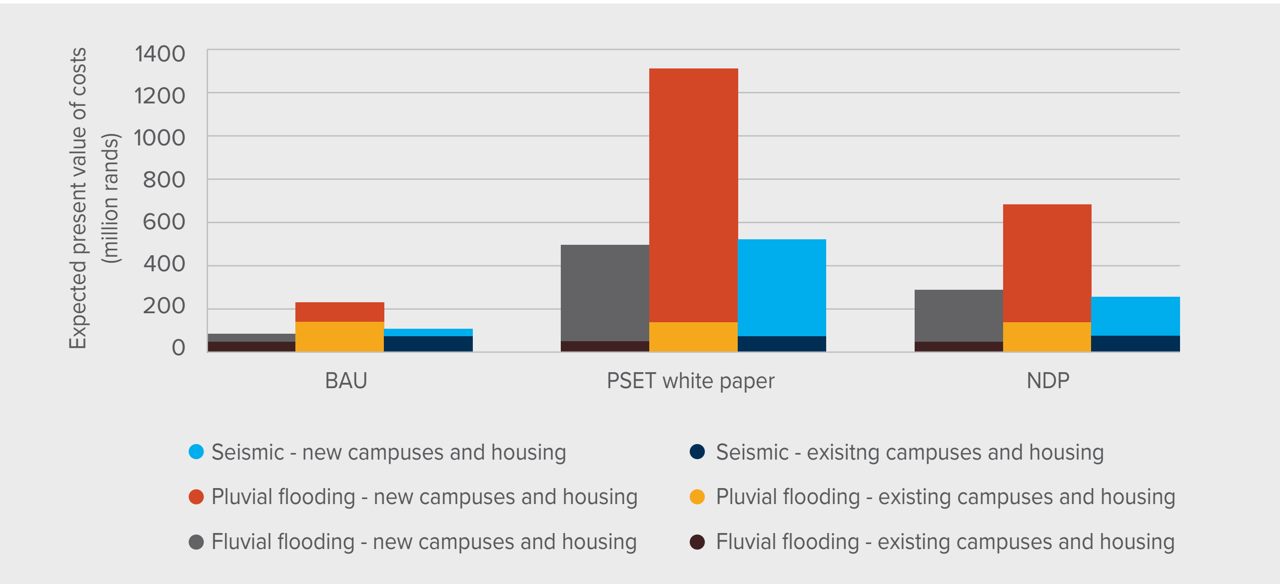
Figure 5.20: Investment costs for basic education schools for all scenarios



Source: Authors' estimates.

For TVET infrastructure, the three scenarios considered in chapter 4 have been analysed to understand the hazard impact on current and future TVET campuses.[3] Pluvial flooding presents the highest expected cost in all three scenarios, with fluvial flooding as the second high expected cost (Figure 5.21), with the expected costs for new campuses and housing representing the majority of the costs in the PSET white paper and NDP scenarios.

Figure 5.21: Expected hazard impact for TVET campuses, by hazard, type of infrastructure, and scenario

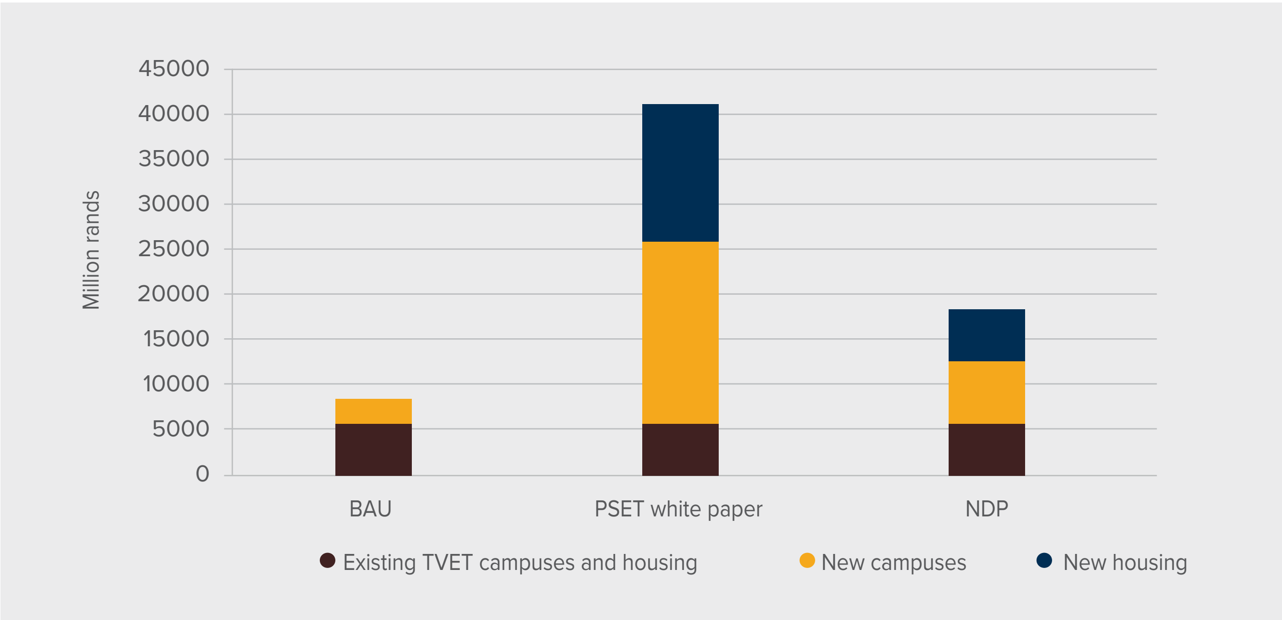


Source: Authors' estimates.

3 The new campuses and housing were distributed across provinces in the same proportion as the current campuses.

The investment required for targeted hardening of TVET campuses ranges between R8.6 billion in the BAU scenario and R41.3 billion in the PSET white paper scenario (Figure 5.22). The PSET white paper scenario represents the highest investment cost as it has the highest number of new campuses and associated housing. In the preferred NDP scenario, the investment costs are R18.5 billion, with the hardening of existing and new TVET campuses representing 31% and 38% of the cost, respectively.

Figure 5.22: Investment costs for hardening exposed TVET campuses for all scenarios



Total funding needs for infrastructure resilience

South Africa's high risk exposure to natural hazards coupled with climate change make it imperative that its infrastructure assets are made resilient to future hazards. While the NPV savings for the investment in infrastructure resilience measures alone do not justify the cost (except for gravel roads), the hardening of exposed assets can yield consequential dividends when accounting for the value of service and costs of disruptions on various economy sectors. The strategic importance of assets for service delivery and the indirect cost savings on service continuity must be factored in when considering funding options as the cost to the economy due to disruption in service often runs into the billions, as can be seen with disruptions in the power sector already.

The total investment costs for infrastructure resilience measures for targeted assets in all four sectors range between R59 billion in the minimum spending scenario and R95 billion in the maximum spending scenario, with the investments required in the preferred scenario amounting to R69 billion (Table 5.5). The minimum spending, preferred, and maximum spending scenarios are those that have been identified through the sectoral analyses in chapters 1—4. If the funding needs were annualized over the 2022—30 period, they would represent 0.10%, 0.12%, and 0.17% of GDP, respectively.

Table 5.5: Total capital cost for infrastructure resilience measures per sector

	Scenarios		
	Minimum spending	Preferred	Maximum spending
	Billion rands		
Transport (primary roads)	7	7	7
Water and sanitation	2	2	2
Basic education	41	42	45
TVET	9	18	41
Total	**59**	**69**	**95**
	% of GDP (2022—30)		
Total	**0.10**	**0.12**	**0.17**

Source: Authors' elaboration.
Note: The projected GDP under the baseline socioeconomic pathway was used.

For the transport sector, all scenarios include the investment needs to increase the resilience of targeted primary roads to flooding. In the case of water and sanitation infrastructure, the investment needs also only cover measures to protect the infrastructure against flooding. In the case of education assets, both basic education and TVET, the investment needs include the costs of hardening against flooding and earthquakes as the seismic risks is significant.

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Annexure

Table 5.A.1: Details of the data and metrics on the natural hazards used in the assessment

Data Type	Description	Data Processing (as applicable)	Source
Drought	The number of 'severe' drought incidents occurring 1988-2018 using 12-month Standardised Precipitation Evapotranspiration Index	Severe events are calculated as events less than -2 with a duration exceeding three months	Vicente-Serrano et al., 2010
Landslide	Qualitative quintile ranking	None	Broeckx et al., 2018
Flooding	Depth of inundation expected from 0.01-annual probability historical event ('100-year' flood) for fluvial and pluvial flooding	None	Fathom, 2021
Fire		Annual average land burned (percent of total) calculated over entire period	Giglio et al., 2013
Earthquake	Estimated PGA from 2 percent likelihood of exceedance in 50-year event ('2475-year event')	PGA converted to estimated MMI categories	Ordaz et al., 2014
Climate Change	Annual decadal increase in average 7-day maximum daily temperature; Annual decadal increase in average 5-day maximum precipitation total	Daily data (1970-1999, 2026—45) processed for average annual values for each time assessed	NASA Center for Climate Simulation, 2019

Chapter 6

MACROECONOMIC IMPLICATIONS

Introduction

Transport, water and sanitation, and education infrastructure is necessary for the functioning of modern economies and the wellbeing of populations. However, more infrastructure in these sectors might not bring more growth. There might be constraints in other parts of the economy, for example, in energy supply, availability of human or private capital, or in the quality of institutions. Infrastructure is expensive to build and maintain, as shown in chapters 1—4, and much of it is financed through costly and often distortive taxation, which might dampen growth. In a country like South Africa where public finances remain in a difficult situation, increased spending can further exacerbate fiscal problems and limit growth.

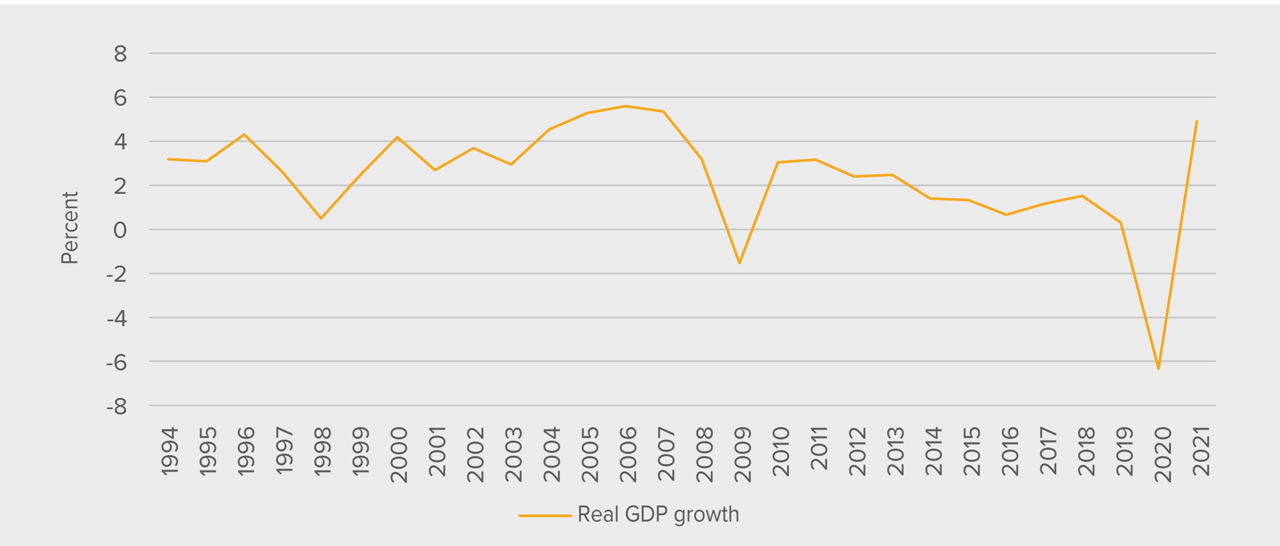
The economics literature tends to find a positive causal relationship between infrastructure and growth, but the magnitude varies widely. The elasticities of output with respect to infrastructure range from −0.06 to 0.52 in studies covering developed and developing countries (Holmgren & Merkel, 2017), which means that infrastructure investments sometimes have a slightly negative impact on growth and sometimes have a significantly positive impact.

As a result, the macroeconomic implications of the infrastructure spending proposed in chapters 1—4 are not straightforward. This chapter aims to shed some light on this through the use of a computable general equilibrium (CGE) model. The chapter begins with a brief overview of the South African macroeconomics, which is followed by a non-technical presentation of the CGE model used for the analysis. The chapter ends with the discussion of the macroeconomic implications of the different scenarios considered.

The South African macroeconomics

South Africa's GDP was R6192 billion in 2021. With a population of more than 59 million, this corresponds to a per capita GDP of R104 264 (World Bank, 2023a). The country displayed relatively high growth until the 2008 crisis, but after the crisis the growth path has been lower (Figure 6.1). As a consequence of COVID-19 the GDP growth rate fell in 2020. The recovery from COVID-19 may come with a delay. The economy is projected to grow at 1.4% in 2023, and 1.8% in 2024, which is low compared to the 3.4% and 4.1% projected for emerging market and developing economies in 2023 and 2024 respectively (World Bank, 2023b). The adverse impacts from the war in Ukraine and the KwaZulu-Natal floods are the most imminent factors related to a potentially slow growth in the coming years.

Figure 6.1: South Africa annual GDP growth



Source: Authors' elaboration based on Stats SA (2022b).
Note: GDP at constant 2015 prices.

The structure of the economy has been evolving in favour of the services sector. The share of value added created by services has been increasing since the 1980s and reached 63% in 2021 (World Bank, 2023a). This change has been at the cost of shrinking shares of industry (including construction) and manufacturing sectors. The transformation of the South African economy has recently been associated with business focused services, such as finance and communication, government services, and wholesale and retail sales (Bhorat et al., 2018). With the Ukraine war's impact on natural resource prices, South Africa is expected to benefit from increasing industrial mineral and precious metal prices (World Bank, 2022a). But the country continues to suffer from infrastructure constraints that hamper economic prospects.

Inflation in South Africa had been in the single digits for almost all the years in the 2000 to 2021 period, with the exception of 2008 when 10% inflation was observed (World Bank, 2023a). Consistent with the inflationary pressures of 2022, monthly inflation was high in the first half of the year. But recent monthly data shows a smoothing of the inflation (Stats SA, 2022a). The annual inflation is reported to have fallen from 7.6% in October 2022 to 7.2% in December 2022.

According to data from Stats SA, the labour force participation rate in South Africa was 58.3% in the third quarter of 2022, with male and female labour force participation being 64% and 52.6%, respectively (Stats SA, 2022b). The unemployment rate was 32.9% in the third quarter of 2022; 35.1% for women and 31% for men (Stats SA, 2022b). For the 15—24 age group, the unemployment rate was 59.6% in the third quarter of 2022. Youth unemployment has been structurally high for decades. The 14—25 age group's unemployment rate has been fluctuating around 50% in the 2010s and has exceeded 60% as of 2020 (Stats SA, 2020; Stats SA, 2022b).

Such adverse labour market outcomes are reflected in the poverty outlook. The October 2022 Poverty and Equity Brief of the World Bank on South Africa (World Bank, 2022b) highlights that half of the country is living below the national poverty line. Referring to the 2016 survey data, the United Nations Development Programme and Oxford Poverty and Human Development Initiative (2022) report that 18.7% of the population in South Africa lives under the purchasing power parity adjusted $1.90 a day poverty line.

The total consolidated expenditure budgeted for the 2022/23 fiscal year was R2157 billion (National Treasury, 2022). Of this, 34% was budgeted for transfers and subsidies and 59% for current payments. Most of the funds allocated for transfers are for households or municipalities. Most of the current payments are for the compensation of employees, followed by interest and rent on land and purchases of goods and services. Debt service costs represent 14% of total budget.

Additional spending will be limited by the fiscal situation. The consolidated government budget has been running deficits around 3.6% to 3.7% of GDP between 2013—14 and the 2017—18 period (National Treasury, 2017; National Treasury, 2019). In later years the deficit exceeded 4%, and temporarily reached 10% in the COVID-19 crisis years of 2020—21. But it is expected to fall back to 4.2% of GDP by the 2024—25 period after an expected 6% of GDP in 2022—23 (National Treasury, 2020; National Treasury, 2021; National Treasury, 2022).

Methodological approach and scenarios

The analysis in this chapter is based on the South African General Equilibrium model (SAGE) (Alton et al., 2012). The model has been constructed and developed in collaboration between the National Treasury, the University of Cape Town, and the United Nations University World Institute for Development Economics Research. SAGE represents, for the current study's objectives, the most suitable and recently calibrated, and readily available CGE model for South Africa. Box 6.1 presents a description of the model.

Box 6.1: South African General Equilibrium model

The model is formulated around consumers with their demand decisions, producers with their production related decisions, the public sector, and international connections. Production side of the model is able to account for the coexistence of the production activities undertaken in 77 different sectors. Input variation in the form of labour types with different education attainment levels and capital is possible through nested optimization problems with constant elasticity of substitution and transformation (CES-CET) functional forms. Labour can be primary educated, middle educated, secondary educated or tertiary educated.

There are ten household types referring to different income percentiles. These account for the consumption activities in the model via demand functions. The demand functions are the results of nested optimization problems that typically have utility maximization at the top nest and minimization problems at lower nests. The variety of the households enables the identification of different income percentile groups in the economy. Being the owners of the factors of production in the economy, households finance their consumption activities through the generated income and transfers from institutions depicted in the model. The model has an endogenous labour supply specification. The supply of labour is modelled through upward-sloping labour supply curves.

The model includes a government that consumes goods and services and collects taxes. Taxes in a CGE model can be expanded to cover production related taxes, factor income taxes, and taxes on international trade flows. If the model accounts for the creation of emissions, taxes can be introduced on emissions as well.

The economy is assumed to be a small open economy. Thus, the economy is a price taker, i.e., domestic prices of tradable goods are given and are impacted by the exchange rate and the related tariff parameters. Following the Armington specification, consumers are able to differentiate domestic and foreign varieties of goods. Also, producers are able to differentiate domestic and foreign markets. The imperfect substitution between domestic and foreign variations is through CES functions adopted in nested optimization problems.

Equilibrium conditions determine prices. Prices at different stages of economic activities are differentiated by tax wedges. Thus, by impacting relative prices, policies focused on tax rates have the potential to impact behaviour and the macroeconomic aggregates.

The model is run recursively for the desired time periods. This numerical exercise takes the time path of some exogenous variables, most notably: (i) population dynamics and (ii) the evolution of the total factor productivity (TFP) growth. The accumulation of capital in the energy sector is based on the energy model scenario inputs (Marquard et al., 2021; 2023). Consistent with the climate policy ambitions of South Africa the scenario used for the present analysis follows the policy and technology assumptions of case 22 in Marquard et al. (2021), which assumes that the integrated resource plan 2019 is implemented alongside planned demand-side policies (Hughes et al, 2020). In non-energy sectors, capital accumulation is related to the sector's share in previous capital stock and capital's profitability such that capital responds to higher capital price and follows higher profit margins.

The analysis has three basic steps. First the model is calibrated and solved numerically to replicate the current macroeconomic situation, which will be referred to as the baseline. Then each of the scenarios of interest are translated to changes relative to the calibration of the baseline, that is changes relative to the status quo. Then the model is re-run under the assumptions of each of the scenarios. Finally, the results for each scenario are compared to the results under the baseline.

The analysis in chapters 1—4 presented three scenarios, that is the minimum spending, preferred, and maximum spending scenarios, for transport, water and sanitation, basic education, and TVET sectors. The aggregation of the sectoral funding needs yields the aggregate funding needs in each scenario, which range from 8.72% to 11.22% of GDP (Table 6.1).

Table 6.1: Average annual funding needs as % of GDP

	Scenarios		
	Minimum	Preferred	Maximum
Transport	1.68	2.26	2.54
Water and sanitation	1.97	2.17	2.49
Basic education	4.69	4.73	4.85
TVET	0.38	0.78	1.34
Total	**8.72**	**9.94**	**11.22**

Source: Authors' estimations.

These scenarios are translated to the CGE model as numerical shocks. These numerical shocks are introduced in the form of changes in TFP and government expenditures. The TFP changes are introduced to all the sectors but not to coal mining, gold mining, refineries, green hydrogen production and electricity production.[1]

The TFP paths correspond to annual changes for the 2022—30 period (Table 6.2), which are based on findings from the economic literature (Bloom et al., 2019; Bhorat & Kimani, 2017; Fedderke & Bogetić, 2009; Ntombele et al., 2017; Prüss-Ustün et al., 2014). For example, the improvement in transport infrastructure under the preferred scenario will increase TFP by 0.44% per year between 2022 and 2030. The infrastructure investment in the water and sanitation, basic education, and TVET sectors will lead to 0.13%, 0.06%, and 0.04% additional increases in TFP in the scenario, respectively.

Table 6.2: Additional TFP change by sector and scenario, 2022—30

Scenario and sector	TFP change (%)	Annual average TFP change (%)
Minimum spending	**3.92**	**0.43**
Transport	2.43	0.27
Water and sanitation	1.11	0.12
Basic education	0.30	0.03
TVET	0.08	0.01
Preferred	**6.16**	**0.67**
Transport	4.07	0.44
Water and sanitation	1.19	0.13
Basic education	0.53	0.06
TVET	0.37	0.04
Maximum spending	**6.30**	**0.68**
Transport	4.24	0.46
Water and sanitation	0.78	0.09
Basic education	0.53	0.06
TVET	0.75	0.08

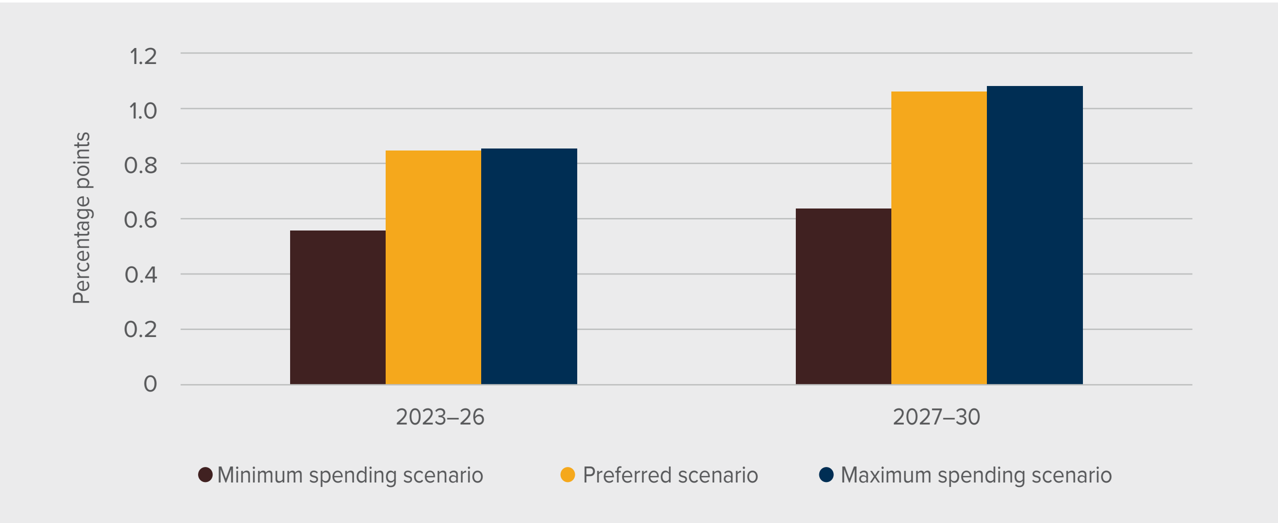
Source: Authors' estimations.

1 The production functions, productivity, and growth of these sectors is controlled by inputs coming from the energy model.

Growth and employment implications

In order to assess the growth implications of the scenarios, GDP growth rates were calculated for the 2023—30 period. Then the difference of growth rates between the baseline and each scenario were used to calculate the additional growth implied by each scenario. The minimum spending scenario yields the lowest additional GDP growth, followed by the preferred scenario and the maximum spending scenario. In terms of the annual average growth rate for the 2023–30 period, the preferred and maximum spending scenarios yield additional 0.95 and 0.97 percentage points of growth, respectively, while the minimum spending scenario yields 0.60 percentage points of additional growth. Growth picks up in the second half of the 2020s, particularly under the preferred and maximum spending scenarios (Figure 6.2).

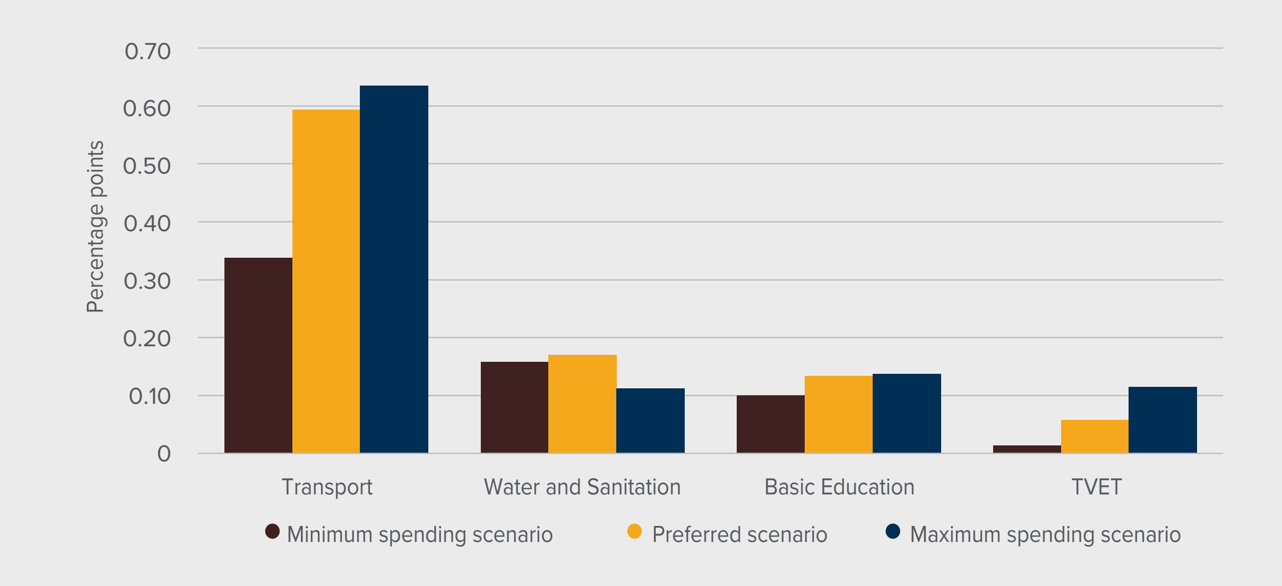
Figure 6.2: Projected additional average annual GDP growth by scenario



Source: Authors' estimations.

The aggregated results discussed above are driven by the additional spending in each sector. The additional average GDP growth in the 2023—30 period is largely driven by the spending to improve transport access and safety, followed by the spending on water and sanitation, and education (Figure 6.3). The expansion of primary, secondary and TVET education will take time in leading to the increase in the education and skill levels of the labour force. This is consistent with the notion that returns to investment in education are realized in the medium to long run, rather than the short run. Therefore, the higher growth from additional spending on education will materialize after 2030. The differences between transport and water and sanitation are largely the result of the differences in TFP gains between the sectors during the period of analysis.

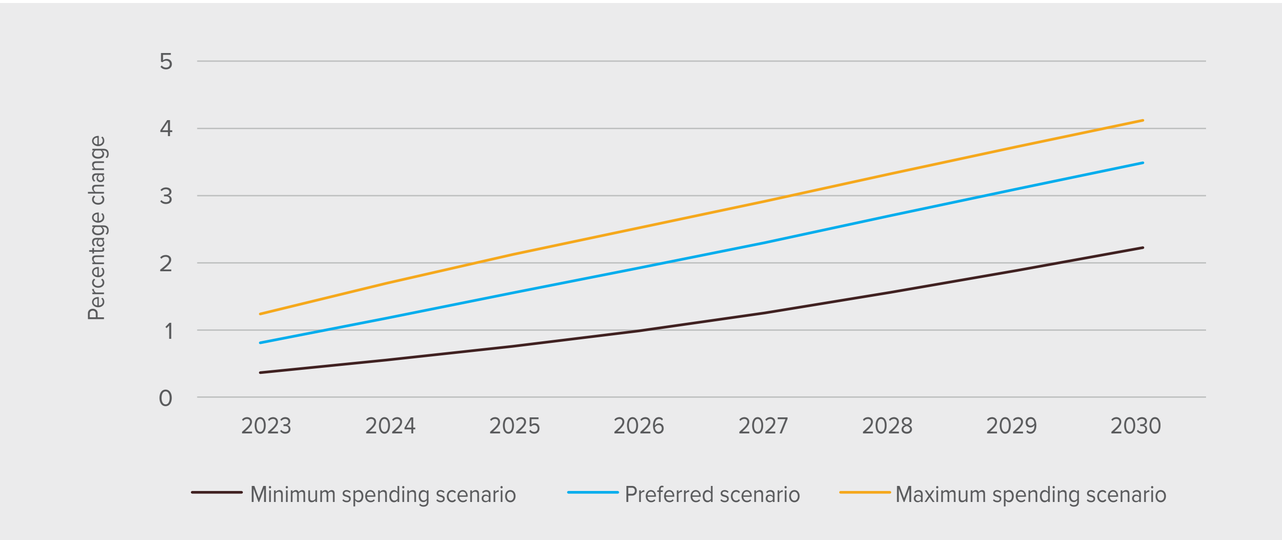
Figure 6.3: Projected additional annual average GDP growth in 2023—30, by sector and scenario



Source: Authors' estimations.

The additional spending on transport, water and sanitation, and education yield slightly improved employment outcomes in the 2023—30 period. In 2030 labour force participation will be between 2.2% and 4.1% higher than in the baseline (Figure 6.4). Unemployment is also predicted to decrease thanks to the investments and recurrent spending in the sectors. By 2030 the unemployment rate will be 8% lower under the preferred scenario than under the baseline. The employment impacts are expected to be larger after 2030 because the increased enrolment in basic and TVET education will take a few years to yield an increase in the number of graduates entering the labour market.

Figure 6.4: Percentage difference in labour force participation relative to baseline



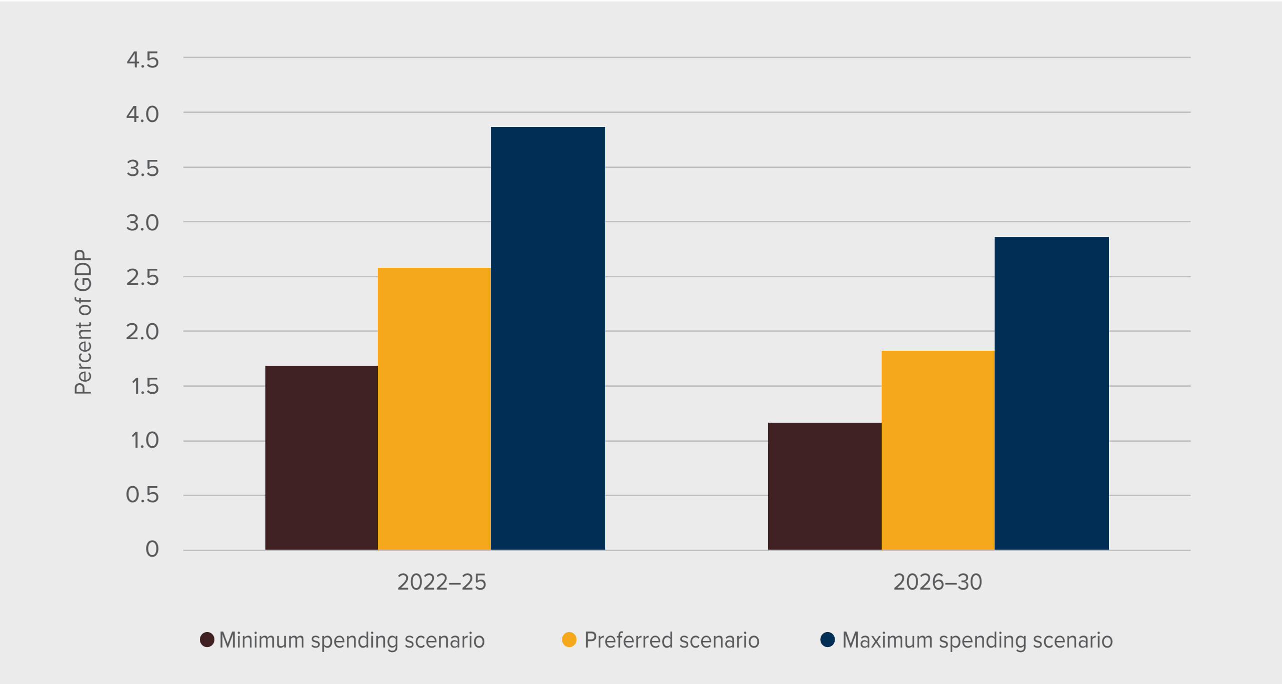
Source: Authors' estimations.

Fiscal implications

South Africa needs to spend on average between 8.7% and 11.2% of GDP per year until 2030 on transport, water and sanitation, basic education, and TVET to achieve the relevant SDGs, as discussed in chapters 1—4.[2] In addition, South Africa will need to spend between 0.1% and 0.17% of GDP per year until 2030 to increase the resilience of infrastructure in these sectors, as discussed in chapter 5. At the same time, South Africa is facing important fiscal constraints, with a deficit predicted to reach 6% of GDP in 2022—23 (National Treasury, 2022). This poses a significant challenge to the government, because even though the spending will support higher growth rates, as discussed in the previous section, it will take time to materialize. The funding needs presented here are not entirely additional spending, that is some of it can be covered with the existing resources in the sectors, though possibly a reorientation of budgets would be required to align budgets with the capital and recurrent spending proposed in the sectoral analysis.

The funding available to meet the expenditure required until 2030 is a combination of operational and capital grants, user charges, development charges, and national government funding towards each of the sectors analysed. The funding available differs per scenario, as grants and user charges vary with the level of ambition. The analysis assumes the public resources allocated to the sectors remain constant as % of GDP at the 2020/21 levels,[3] except for the funds for recurrent spending on basic education that are assumed to decrease from 4.5% of GDP in 2020 to 4% of GDP in 2030, and the revenues from user charges follow their latest trends until 2030.

Figure 6.5: Projected average annual funding gap, by scenario and period

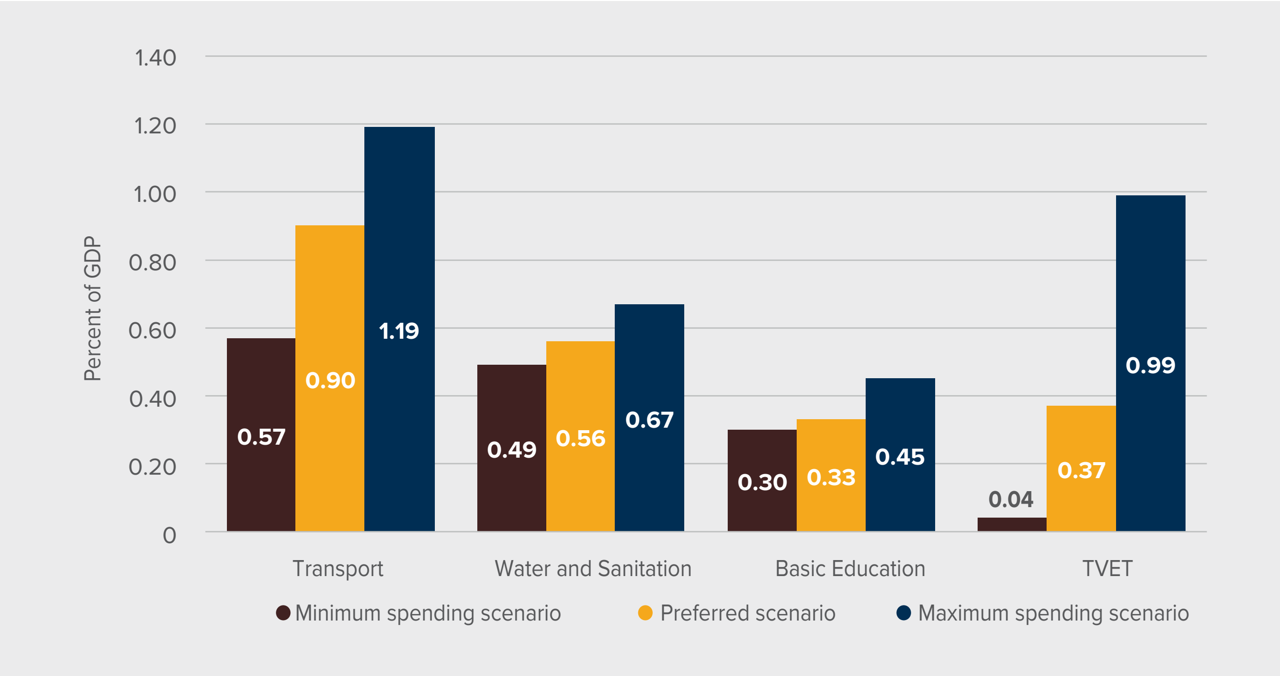


Source: Authors' estimations.

2 South Africa spent about 8% of GDP per year at the beginning of the 2020 decade in the sectors and subsectors covered in this report: 1.1% in rural and urban transport, 1.7% in water and sanitation, 4.8% in basic education, and 0.4% in TVET. These figures do not include spending on road safety because there is no available data at the required level of disaggregation.

3 The analysis assumes that there is no current funding available for road safety. In the case of urban rail, the analysis assumes the available funding as % of GDP remains constant at the pre-pandemic levels and according to the level of ambition. In the case of BRTs, the analysis assumes the yet to be built BRTs have not received any grants, as those are not included in the baseline budget.

Figure 6.6: Projected average annual funding gap, by sector and scenario



Source: Authors' estimations.

The available resources fall short of the funding needs. The average annual funding gap for the four sectors over the 2022—30 period will be 1.4%, 2.2%, and 3.3% of projected GDP in the minimum spending, preferred, and maximum spending scenarios. The annual gap will be the highest in the first few years and decrease over time as GDP growth picks up and relative prices change. The average annual funding gap in the preferred scenario would decrease from 2.6% of GDP in 2022—25 to 1.8% of GDP in 2026—30, with similar patterns in the minimum and maximum spending scenarios (Figure 6.5).

The largest funding gap in the preferred scenario is in the transport sector, followed by the water and sanitation sector, TVET and basic education sectors (Figure 6.6). In the maximum spending scenario, the order is almost the same except that the funding gap in TVET is slightly larger than in water and sanitation. In the case of the minimum spending scenario, the largest funding gap is in transport, followed by water and sanitation, basic education, and TVET.

The government will have to decide how to close the funding gap. It will have to choose how much will be funded through taxes, user charges, or reduction in spending in other sectors. The government will also have to decide on the timing of these changes. For example, it could decide to increase taxes less than proportionally in the first few years and more in the future and borrow the difference in domestic and foreign capital markets.

GDP growth triggered by the additional spending in transport, water and sanitation, basic education, and TVET sectors will lead to an increase in tax revenues. As a starting point, government could allocate the entire additional tax revenues to these sectors. As a result, the average annual funding gap for the 2022—30 period would be 0.9%, 1.2%, and 2.3% of GDP in the minimum, preferred, and maximum scenarios, respectively.

Conclusion

Investing, operating, and maintaining the transport, water and sanitation, basic education, and TVET infrastructure required to achieve the SDGs in these sectors will have significant impacts beyond the specific sectoral SDGs in terms of increase in labour force, reduction in unemployment, and higher GDP growth. However, significant public resources are needed to close the infrastructure gap and the projected resources are not enough. As a result, the government will need to make important decisions and will face trade-offs which are highlighted throughout the report.

First, the government will need to decide the level of ambition and the investment and policies to achieve its goals in each sector, which will determine the funding needs, the potential growth implications, and the size of the funding gap. The government will need to decide how to close the funding gap, which can be done through additional tax revenues, revenues from user charges—including service fees—and by shifting resources from other sectors. The government will also need to prioritize among the investments in the sectors covered in the report, but also across other important sectors such as energy and health, among others. Finally, the government will have to decide how much current and future generations will contribute to closing the gap by deciding how much of the funding gap will be financed through the different options available to South Africa. These are all decisions that need to be made at the highest level of government to achieve sustainable development.

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