SAICE 2022 Infrastructure Report Card

for South Africa

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SAICE House, Block 19, Thornhill Office Park, 94 Bekker Road, Vorna Valley, Midrand, 1686
Private Bag X200, Halfway House, 1685
T: +27 (0)11 805 5947 | **E:** civilinfo@saice.org.za
W: www.saice.org.za

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About SAICE
The South African Institution of Civil Engineering (SAICE) is the industry body for civil engineering professionals in South Africa. Our aim is to promote growth, excellence and sustainability in the industry. Through our divisions, branches and committees we aim to advance professional knowledge and improve the practice of civil engineering in South Africa. Our purpose is to provide members with opportunities for professional development through continued learning opportunities and industry networking.

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SAICE 2022 Infrastructure Report Card for South Africa

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Message from the South African Institution of Civil Engineering

Infrastructure is at the centre of public and economic wellbeing. This Infrastructure Report Card (IRC) is the fourth report produced by the South African Institution of Civil Engineering (SAICE) since 2006. More than any other set of professionals, civil engineers are entrusted by society to conceive, design, build and maintain the nation's portfolio of infrastructure assets. They are the custodians of the built environment. It is appropriate, then, for the Institution to prepare this assessment of the condition of public infrastructure as a public service. No sponsorship or grant was received for the commission of this work – it was funded entirely from the subscriptions of SAICE's 15 500 members.

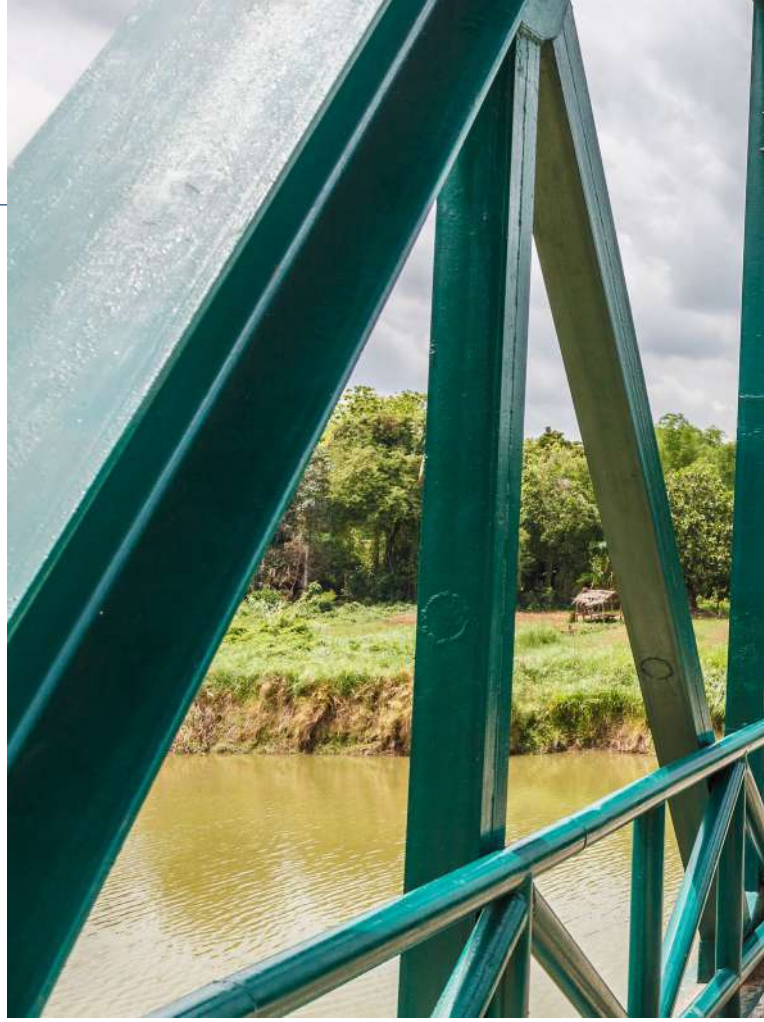
SAICE was established in 1903 as a not-for-profit learned society. It is a voluntary association of graduates and professionals in civil engineering whose members are individuals (not corporates) drawn from the public sector, state-owned companies (SOCs), consulting firms, academia, contractors and suppliers from the private sector. They are bound by a Code of Ethics and a Mission Statement which advocate the advancement of professional knowledge and improvement of the practice of civil engineering in the service of society. SAICE strives to enable its members and the greater engineering industry, through consultation and accountability, to provide society with environmentally and economically sustainable infrastructure. We believe that the IRC is the most effective tool the Institution has to uphold and advance the professional ethics of the civil engineering profession.

In the years before the next IRC, SAICE is committed to expanding the scope and detail with which it examines the state of infrastructure in each sector, and the reasons for its changing condition. We will make ourselves available to government and the public to discuss the findings in this report and to engage on finding the best solutions.

We congratulate the IRC team on the latest edition of the SAICE Infrastructure Report Card and thank them for their efforts.

2022 SAICE President
Prof. Marianne Vanderschuren CEng

Message from the IRC team



Since its inception in 2006, the IRC has become a reference document on the state of the broad range of infrastructure that facilitates economic and social activity for the nation. Universities and schools use it for discussion and orientation. Civil society, non-governmental bodies and decision makers in government refer to it as a baseline for engagement. International observers and commentators find its content useful to understand South Africa's infrastructure capabilities and challenges.

The number of countries that publish reports on the condition of their infrastructure continues to grow. In 2018, SAICE produced the *Infrastructure Report Card Guide 2018* in conjunction with the Federation of African Engineering Organisations to assist developing nations to prepare their own reports. The impact of this initiative has been impressive. Many African nations including Ghana, Nigeria, Rwanda, the Democratic Republic of the Congo and Kenya have since published their own IRCs and others are in the process of doing so. The concept of evidence-based report cards is clearly gaining traction in Africa.

The IRC team analysed large volumes of detailed information and followed a rigorous process in preparing this document. The report is brief, considering that it covers so much of the country's infrastructure, and the grades understandably average the large variations in condition and performance that exist across the country. For the sake of brevity we have only touched upon the external factors that affect the provision and care of infrastructure assets and the critical matters that must be addressed to improve their condition. This report is primarily a condition and performance assessment and does not prescribe remedies. However, SAICE is committed to publishing detailed bulletins on specific subjects, elaborating on this overview report and exploring recommendations before the next IRC is issued. Indeed, this process has already begun with recent articles on pipelines and fire engineering published in SAICE's monthly magazine, *Civil Engineering*.

In each IRC, SAICE has progressively widened the scope of its scrutiny. In this report we introduce fire engineering, information and communication technology (ICT), oil and gas pipelines, and coastal infrastructure, and reintroduce fishing harbours to the portfolio. Our comments also touch upon the impact of global warming and other environmental factors on infrastructure. There remain sectors that escape grading simply because relevant data is insufficient or inaccessible for us to do so credibly.

Our hope is that the report will inform and influence all South Africans about the importance of protecting and enhancing the physical infrastructure that is so critical to daily existence and our common prosperity. We hope that it contributes to the improved use of infrastructure funding, especially for preventative maintenance. We expect that it will stimulate debate on the matters raised herein by the professionals who grapple daily with meeting the infrastructure needs of a nation.

The rest of the report is organised as follows:

- **Section A: The infrastructure scorecard**: A snapshot is presented of the current condition and performance of infrastructure in the form of a traditional report with grades within each sector. The change in condition over the past 16 years is presented graphically, showing the trend over time. A thumbnail comment accompanies the grades for each sector.
- **Section B: The public asset**: The context within which infrastructure assets operate in a functional State is

described. External influences, such as climate change and the Covid-19 pandemic, and behavioural impacts of both the State and the public are discussed.

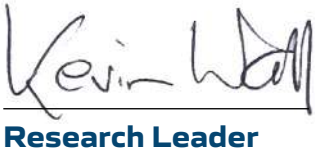
- **Section C: Matters of critical importance**: The theme of previous IRCs is retained: the essential triad of appropriate skills, comprehensive data and robust institutions that must be in place for effective infrastructure delivery and use are examined in the South African situation.

- **Section D: Condition assessments by sector:** The scorecard grades provided in Section A have the effect of smoothing significant variations in condition between localities. To elaborate, a more detailed discussion of each sector is provided, describing its extent, condition and particular challenges.

In previous years we were fortunate to have received research support from the Council for Scientific and Industrial Research (CSIR). For this report, SAICE undertook all the research itself with the assistance of volunteers from SAICE's technical divisions, sister institutions and civic-minded experts. We extend our sincere thanks to the South African Institute of Electrical Engineers (SAIEE) for the sections on electricity and ICT and to the South African Academy of Engineering (SAAE) for the section on oil and gas pipelines. The IRC team thanks participants from the SAICE technical divisions for their intense debate and comment, and the members of the advisory group and review panel for their guidance, especially the core team that drafted the report and managed this process. All of them displayed admirable qualities of civic and professional duty as volunteers. Acknowledgement of contributors is contained at the end of this report. We must note that many contributors chose not to be identified personally, and we thank them too.

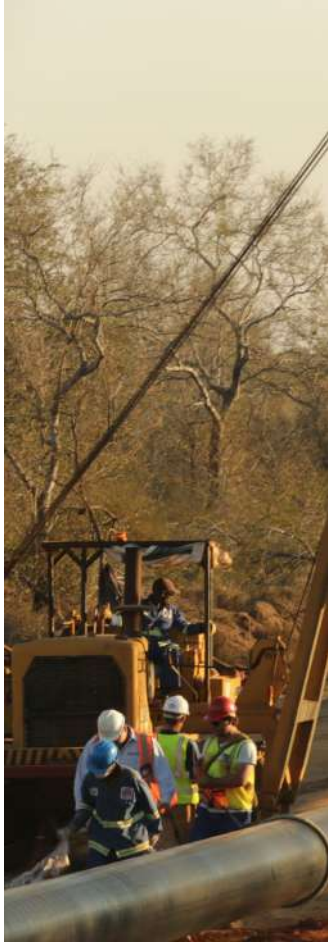
This report is based on the best information available to us at the time of writing. While we are grateful for the assistance received from many quarters, the views expressed are those of SAICE alone. The Institution welcomes engagement on the findings.

Convenor
Sam Amod Pr Eng



Research Leader
Dr Kevin Wall Pr Eng

Section A: The infrastructure scorecard



Understanding the grading

The IRC scorecard is based on a simple five-point scale ranging from A (world class) to E (unfit for purpose). Although it is a snapshot of the current condition and performance of infrastructure, it reflects the impact of past policy and management decisions, both good and bad. With a few exceptions (pipelines and ICT), only infrastructure that is owned by the public sector is included. This includes SOCs, e.g. Eskom, and concessions, e.g. toll roads.

At one extreme of the grading scale (A) is infrastructure comparable to the best in the world and capable of enduring pressure from unusual events, e.g. an influx of visitors for an international event or the ability to withstand a lengthy drought. At the other end (E) lies infrastructure in a state of disrepair or failure, exposing the public to possible health and safety hazards. The middle point, a C grade, represents a condition in which performance is satisfactory except during times of peak operating pressure when a slight drop in performance might occur. In some instances, a + or - symbol is used to suggest that the score is robust (+) or fragile (-) within that condition.

In the pages that follow, assessments are presented for 32 subsectors of infrastructure (up from 29 in 2017). Each grade is plotted in a coloured bar that represents the full range of possible scores. If a grade has changed since it was first reported upon in 2006 (or later), a lighter zone represents these shifts in score. These changes in condition over time send a powerful message because they signal the direction in which we are heading.

The condition of infrastructure

Sixteen years ago, the first IRC gave South Africa's infrastructure an overall grade of D+. The next IRC (2011) noted that the heavy investments in new infrastructure for the 2010 Soccer World Cup had elevated the overall grade to C-. We cautioned that this apparent improvement was not cause for complacency. In the following years, it became evident that the poor attitude to maintenance had continued, and this was reflected in the downturn in the subsequent grade to D+ in 2017.

In 2022, the overall grade for South Africa's public infrastructure declines further to D, the lowest grade ever recorded by SAICE, which is of great concern.

From the advent of democracy in 1994, South Africa made great strides in improving the quality and distribution of both economic and social infrastructure. However, these gains have not been effectively sustained. Since our first report in 2006, the condition of infrastructure has been in steady decline. For the current period, only three subsectors show improvement while 12 have deteriorated. Of the 13

Table 1 Grading definitions

A: World class	B: Fit for the future	C: Satisfactory for now	D: At risk of failure	E: Unfit for purpose
Infrastructure is comparable to the best internationally in every respect. It is in excellent condition and well maintained, with capacity to endure pressure from unusual events.	Infrastructure is in good condition and properly maintained. It satisfies current demands and is sufficiently robust to deal with minor incidents.	Infrastructure condition is acceptable although stressed at peak periods. It will need investment in the current Medium Term Expenditure Framework period to avoid serious deficiencies.	Infrastructure is not coping with normal demand and is poorly maintained. It is likely that the public will be subjected to severe inconvenience and even danger without prompt action.	Infrastructure has failed or is on the verge of failure, exposing the public to health and safety hazards. Immediate action is required.

subsector grades that remain unchanged, 10 were already at risk of failure or worse. When examined in the aggregate, much of our infrastructure is edging closer to failure. Of course, there are pockets of excellent and well-managed infrastructure of every type. But these are no longer the norm. The grades awarded to South Africa's infrastructure, and the downward trend in its condition, reveal a failure to manage and maintain existing assets.

It must be noted that no single sector of infrastructure operates in isolation – all of them are interconnected. Energy generation requires water for cooling and ports require roads and rail connectivity to serve the economy. So, while we grade sectors separately, there is a tightly woven interdependency between all these facilities. When rail services are inadequate, commerce shifts to the roads, even at a cost premium. When taps run dry, entrepreneurs will supply water in tankers. And some will resist a return to the previous modes of operation, even though the replacement modes are inefficient or inappropriate. Consequently, when public infrastructure is inadequate or unreliable, the resulting disruptions occur at a net cost to the fiscus and weaken the developmental role of the State.

Broadly speaking, it is evident that, with the exception of energy generation, economic infrastructure remains in a satisfactory condition – even those assets that have deteriorated, such as heavy freight rail and airports, maintain grades of B or C. However, the further degradation of social infrastructure paints a dismal picture of the plight that ordinary people face to access basic services of water, sanitation, health, education, public transport and electricity.

Altogether, the situation cries out for urgent and sustained attention.

Economic infrastructure makes business activity possible and includes, among others, communication, bulk transport and energy supply systems.

Social infrastructure meets basic needs and includes drinking water, sanitation, hospitals, schools and public transport.

The scores and an abbreviated commentary

Water

Bulk water resources

Supply in the major urban areas

Supply for all other areas

South Africa has an average rainfall of 465 mm, which is half the world average, and water scarcity is a serious threat. The national bulk water resources infrastructure system includes dams, abstraction works and water transfer schemes. Although ageing and in need of more maintenance, the system has been reasonably effective in meeting demand. There have been no major structural, mechanical or electrical failures.

Dam safety reports have not been published since 2016/17. It is therefore unclear whether all major dams conform to safety regulations, or if all the electrical-mechanical components for operation of the dams are in sound working order.

The quality and reliability of water supply systems continue to decline in small towns and rural areas. In some urban areas the water supply systems have been operated at full capacity and will not be able to meet growing demands unless proactive measures are taken to decrease consumption, refurbish critical components of the systems, and expedite key bulk water augmentation projects that have been delayed.

In 2022 the Department of Water and Sanitation rated 34% of 1 186 water supply systems as being at high to critical risk of failure. Regarding water quality, just 40% of systems achieved microbiological compliance and only 23% chemical compliance. Slightly less than 41% of treated water is lost to leaks and illegal connections. Spending on repair, maintenance and rehabilitation of water supply systems remains inadequate. Damage due to increased theft, vandalism and service delivery protests diverts funding from maintenance and expansion budgets, exacerbating the problem. Given this, as well as continually growing consumption, supply reliability is decreasing.

Sanitation (including wastewater)

For major urban areas

All other areas

Access to improved sanitation (flush toilets and on-site sanitation) has increased from 61.7% of households in 2002 to 84.1% in 2021.

However, the quality of wastewater treatment is declining. In 2022 the Department of Water and Sanitation published the first Green Drop assessment of every wastewater system (excluding on-site sanitation) in nearly a decade. The results clearly indicate that standards have dropped during the period of slackened regulatory supervision. Of the greatest concern is the extent to which substandard final effluent is discharged, raising the risk of disease transmission to communities downstream.

Out of 995 sanitation systems, only 22 Green Drops were awarded, compared to 60 in 2013. Municipal systems rated to be in a critical state have increased from 29% to 39% over the same period.

Some 16% of households still do not have access to improved sanitation, but make use of simple pits, convenient open spaces or other ad hoc arrangements.

Solid waste management

Waste collection in the major urban areas

Waste collection in other areas

Waste disposal in the major urban areas

Waste disposal in other areas

The collection, processing and disposal of solid waste material is an important local government task.

A lack of solid waste collection services may lead to disease, blockage of drainage systems and a general unsanitary appearance of the urban and rural landscapes. There has been a slight reduction in the provision of refuse collection services in metropolitan and larger urban areas, while rural and smaller municipal areas have experienced a large increase in indiscriminate dumping. Significant differences in service levels were also noted between the nine provinces.

Less than 45% of general landfill sites for disposal of solid waste are estimated to be licensed, and there is insufficient planning or construction of urgently required landfill capacity in most areas of the country. The situation with hazardous waste landfill sites is somewhat better – these are mainly operated by the private sector.

Although there are good industry recycling efforts in some sectors (e.g. paper, glass and metals), there is limited progress in others (e.g. e-waste and tyres).

Excellent legislation and policy documents are in place; however there are still many challenges in the implementation and policing thereof.

Roads

National roads

Paved provincial roads

Paved roads in the major urban areas

Other municipalities' paved roads

Provincial and municipal unpaved roads

South Africa's road network is approximately 750 000 km long, making it the tenth longest in the world. About 160 000 km of the network are paved. SANRAL manages 21 403 km of this paved network (13% of these are toll roads), with the balance shared between provinces and municipalities.

The proportion of the national road system in poor or very poor condition is below 7% thanks to SANRAL's strong maintenance and expansion regimen, which is excellent by global standards. By contrast, the secondary and tertiary road network is experiencing accelerated rates of deterioration, compromising both road safety and the efficiency of moving freight.

Most provincial and local road authorities do not regularly undertake or publish assessments of the condition of their road networks, and repairs are therefore typically reactive, e.g. fixing potholes rather than conducting regular preventative maintenance. Moreover, maintenance and improvements are generally underfunded, and the future negative consequences of this trend on the longevity of roadways are rarely assessed.

With the exception of the Western Cape, the condition of most paved provincial roads is substandard. There is a risk of further deterioration due to increased vehicle overloading, poor maintenance and the steady reduction of skilled personnel in roads departments. In major urban areas the condition of paved roads has also continued to deteriorate. While obtaining reliable road condition data for smaller municipalities was not possible, their roads generally suffer from significant and increasing maintenance neglect.

Provincial and municipal authorities share the country's gravel roads approximately equally. Gravel roads constitute nearly 80% of the country's road network, but few of them are in a satisfactory condition due to lack of capacity and insufficient funding.

Most South Africans (73% of the population) depend heavily on public and non-motorised transport. Around 20% of workers walk all the way to their place of employment. All public transport users also require pedestrian infrastructure for their first/last kilometre, as well as stops, stations and ranks. Statistics on infrastructure conditions for these modes are mostly unavailable, often due to a complete lack of services. This not only creates inefficiencies in public transport services, but also contributes to an extremely high road fatality rate (12 577 persons in 2021), of which over 40% are pedestrians.

Airports

ACSA-owned facilities

The nine major airports owned by ACSA enable more than 80% of South Africa's international and domestic commercial air travel. ACSA pays close attention to its infrastructure in order to comply with the requirements of regulatory authorities. The devastating impact of Covid-19 on revenue streams resulted in deferral of some maintenance and expansion work as the focus shifted to safety and efficiency. Overall, aviation infrastructure remains in good condition.

Ports

Commercial ports

Fishing harbours

Transnet owns nine commercial ports, namely Saldanha Bay, Cape Town, Mossel Bay, Port Elizabeth, Ngqura, East London, Durban and Richards Bay, and the much smaller Port Nolloth.

Well-developed standards and regulations govern infrastructure condition assessments and the maintenance, repair and rehabilitation regimen. As a consequence, infrastructure in all the commercial ports is generally in a good condition, still performing well in meeting safety and operational standards. However, the dry docks at the ports have been relatively neglected in both maintenance and staffing.

A major refurbishment of the 12 proclaimed fishing harbours in 2007 was followed by a period of neglect. Recent extensive rehabilitation and repair (not yet complete) has reversed the degradation and they are now in a generally good condition once more.

Oil and gas pipelines (new)

About 50 large-diameter oil and gas pipelines link strategic centres in the country and short-distance offshore facilities, such as between the Durban single buoy mooring and the shore. Of the approximately 4 600 km of onshore pipelines, Transnet Pipelines has the largest network and carries the largest volume of product.

Recognising that service interruptions hit revenue, the pipeline owners ensure that the pipes are inspected and maintained as rigorously as their (largely underground) location permits.

Rail

Heavy haul freight lines

General freight lines

Branch lines

PRASA passenger lines

Gautrain

Over the last 70 years freight rail traffic has grown by a factor of five (driven by the export of coal and iron ore), while passenger transport has largely disappeared.

The condition of the coal line (graded C+) has deteriorated, primarily due to management capacity shortcomings, maintenance practice deterioration, ageing signalling infrastructure, vandalism and theft. This has in turn caused a 20% reduction in the tonnage carried between 2017 and 2022. The iron ore line (graded B+) is prone to similar challenges but is currently in better condition.

The existing general freight network is in a fair condition. This is despite significant deterioration brought about by constrained maintenance practices and the ongoing need to replace or repair stolen or vandalised equipment. Declining condition is reflected in reduced volume and safety performance. The most important corridor, between Durban and Gauteng, was severely damaged by floods in April 2022 and is still a long way from being fully repaired.

The branch lines are in a very poor condition and only a small percentage is operational – some lines are no longer used.

The general condition of the commuter rail network is very poor. Safety and security on the rail network have deteriorated, and fewer and fewer trains are dispatched each year due to infrastructure, process, and systems challenges. Operational issues include outdated equipment, theft, arson, and vandalism. Many mainline passenger services have collapsed and are now almost non-existent.

The Gautrain system is in good condition, although track geometry has deteriorated since the line was built. Sound maintenance practices are in place and the system is still deemed world class.

Electricity

Eskom generating infrastructure

Eskom transmission network

Local distribution

Eskom owns and operates 15 thermal coal power stations. Some of them are more than 50 years old and have been operated without sufficient maintenance and refurbishment. The consequent decline in energy availability has increased the severity of national grid loadshedding and forced greater usage of emergency diesel-powered open cycle gas turbines.

The condition of electricity generating infrastructure weighs heavily on the national economy. Peak demand for Eskom electricity, while fluctuating, has been on a slow decline over the last 10 years. Although influenced by the state of the economy, this is linked to the decline in the condition of Eskom infrastructure and the consequent increasing unreliability of Eskom supply. Increasing tariffs and the increasing availability of alternative sources of electricity are further influences.

The national transmission system consists of 33 000 km of high-voltage overhead lines and 446 power transformers. Although its average age is nearly 40 years, diligent refurbishment of switch gear, instrument transformers and power transformers have contained any deterioration in performance.

The Eskom distribution grid consists of 351 000 km of overhead lines, nearly 8 000 km of cables, and 391 000 power transformers. Performance is measured by the number of disruption events and their duration. Both indicators have remained steady over the last decade.

Given the paucity of data on municipal distribution networks, they have been excluded from the grading.

Healthcare

Hospitals

Clinics

There are nearly 4 200 health facilities, including 394 hospitals, in the country. In response to the outbreak of Covid-19, a significant amount of funds have been diverted to related emergency infrastructure.

Data on the condition of health infrastructure is difficult to obtain. However, it appears that most provincial health departments and their associated public works departments do not place enough emphasis on maintenance. Inadequate budgets, shortages of suitable staff, and supply chain and administrative issues often result in poor infrastructure condition.

Fire (new)

While a grading for fire infrastructure is not deemed appropriate at this stage, the following concerns must be noted:

- Too many of the public sector's buildings are not compliant with fire safety regulations.
- Municipal fire protection services are often inadequate.

Education

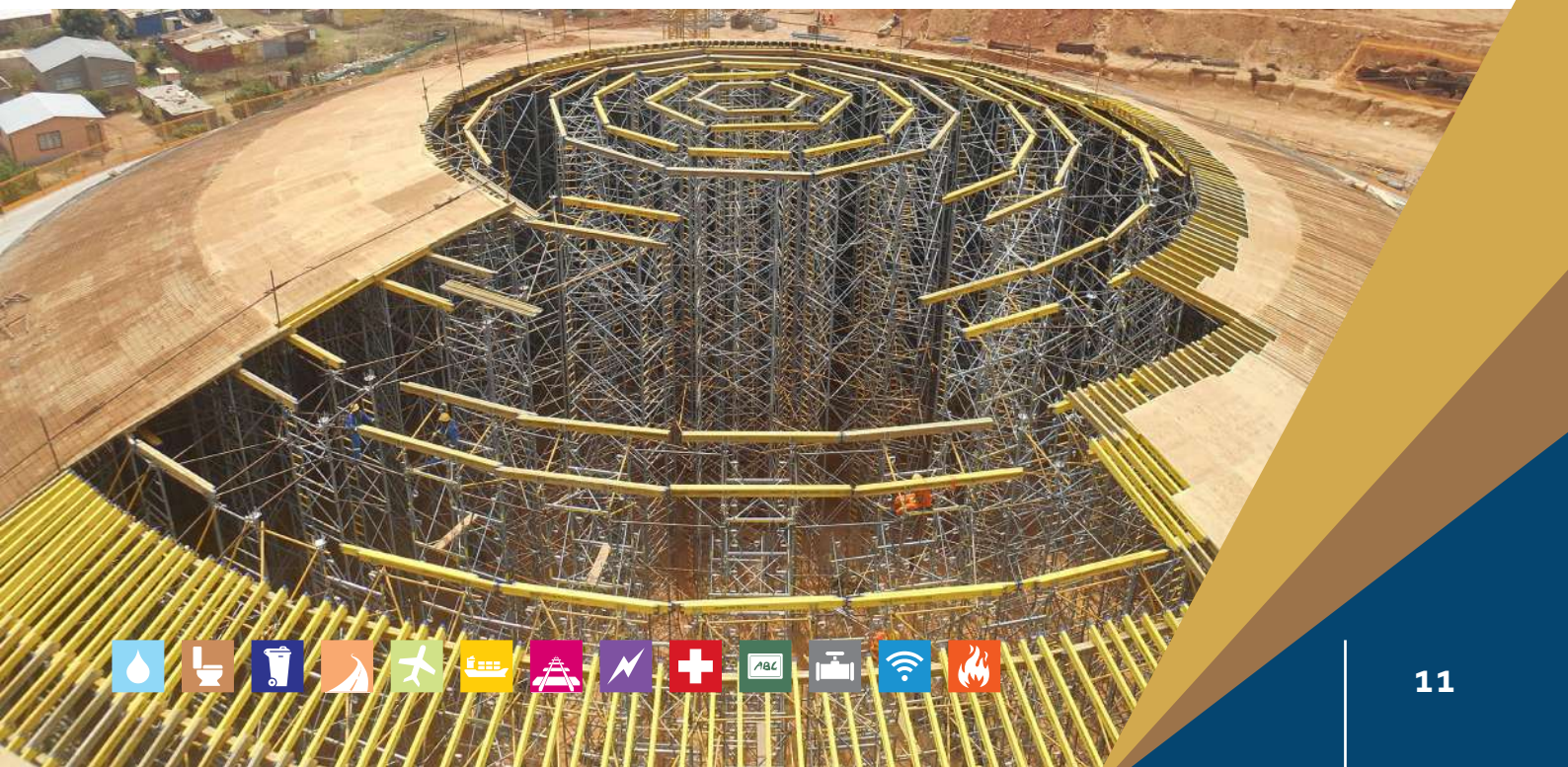
Public ordinary schools (D)	There are 22 740 public schools with infrastructure that varies from very good in the more affluent locations to barely fit for purpose in impoverished communities. The total number of schools is decreasing due to the closing of smaller schools. In Gauteng and the Western Cape the school number is growing due to urban migration. While some progress has been made on improving school facilities, many are not well maintained and are out of order. Improvement programmes routinely miss targets and available budgets are not fully utilised. Reliability of water and electricity supply in schools remains poor. Theft, malicious damage to property and arson remain significant threats to overcoming the backlogs in both public schools and higher education centres.
Universities (C+)	The 26 public universities, mostly located in major urban areas, host 1.1 million students. The 50 public TVET colleges have 700 000 students on 364 campuses spread across various towns and cities. Each province also has a Continuing Education and Training college with satellite centres. The steady increase in student intake places a severe burden on infrastructure at institutions of higher education. However, well-funded infrastructure support programmes introduced by the Department of Higher Education from 2017 are bearing fruit, evidenced by the improved condition of existing infrastructure, and the addition of new facilities, especially student accommodation.
Technical vocational education and training (TVET) colleges (D+)	The Covid-19 pandemic had a major impact on higher education institutions, delaying infrastructure maintenance and expansion and redirecting funds to ICT requirements.

Information and communication technology (new)

(B)	Most businesses and households depend on information and communication technology (ICT) infrastructure. In 2020, 74.1% of households had access to the internet. ICT infrastructure, although dependent on some public infrastructure sector services (particularly electricity supply), is almost exclusively owned by the private sector. Dependent as they are on this infrastructure for their income stream, the owners have every incentive to strive for it to be functioning at all times. This condition is supported by high maintenance standards and a continual cycle of investment.

Overall grade

(D)	**With the notable exception of energy generation, South Africa's economic infrastructure remains in a satisfactory (or better) condition. However, social infrastructure continues to deteriorate. Crime and non-payment for services as well as weak institutions lacking appropriate skills and accurate data have contributed towards a further decline in the overall condition of infrastructure since the last SAICE Infrastructure Report Card.**



Section B: The public asset

Responsibility for infrastructure

South Africa's growth, productivity and competitiveness as a global entity relies heavily on its economic infrastructure – from the national level through to provinces and down to the local level. Good social infrastructure provides opportunities for social mobility while improving the length and quality of human life.

The provision of public infrastructure is a core responsibility of a functional and thriving State, and its responsible use is a corresponding duty of citizens. The overall grade of D indicates that South Africa's existing infrastructure, taken in aggregate, is unsatisfactory and generally at risk of failing to serve its purpose.

The condition of public infrastructure is largely dependent upon the allocation of appropriate budgets and the development and implementation of sound maintenance systems, policies and processes. But it can also be buffeted by external factors, such as the Covid-19 pandemic and climate change, that go beyond the ability of the State to direct or influence. The end-user also exerts strong influence on the longevity and utility of infrastructure assets through their careful or abusive, and sometimes even destructive, behaviour.

Investment

A nation's portfolio of public infrastructure is its most valuable physical asset. It grows over the decades through investment, maintenance and renewal. Since 1994 the stock of public infrastructure has grown significantly, if not sufficiently to serve a growing population. Investment in infrastructure is a crucial pillar in Government's proposed economic recovery plan. And yet, investment continues to decline. After peaking at 22% of GDP in 2008, capital investment had dropped to 13.7% by 2020, of which two thirds are attributed to the private sector. This is less than half the targeted 30% of GDP called for by the National Development Plan. To achieve its target, National Treasury estimates that between 2020 and 2030 investment in infrastructure must increase significantly, from 3.9% to 10% of GDP for the public sector and from 9.8% to 20% of GDP for the private sector.

Weak economic growth and the additional financial bailouts provided to struggling SOCs have constrained Government's ability to invest in new infrastructure. This, combined with habitual underspending of infrastructure budgets, has pushed Government to consider blended finance partnerships with the private sector. Such a collaborative approach to funding and implementation will, of course, require Government to take measures to boost investor confidence. In contrast to the attention given to new projects, relatively little attention is placed on the upkeep of existing assets.

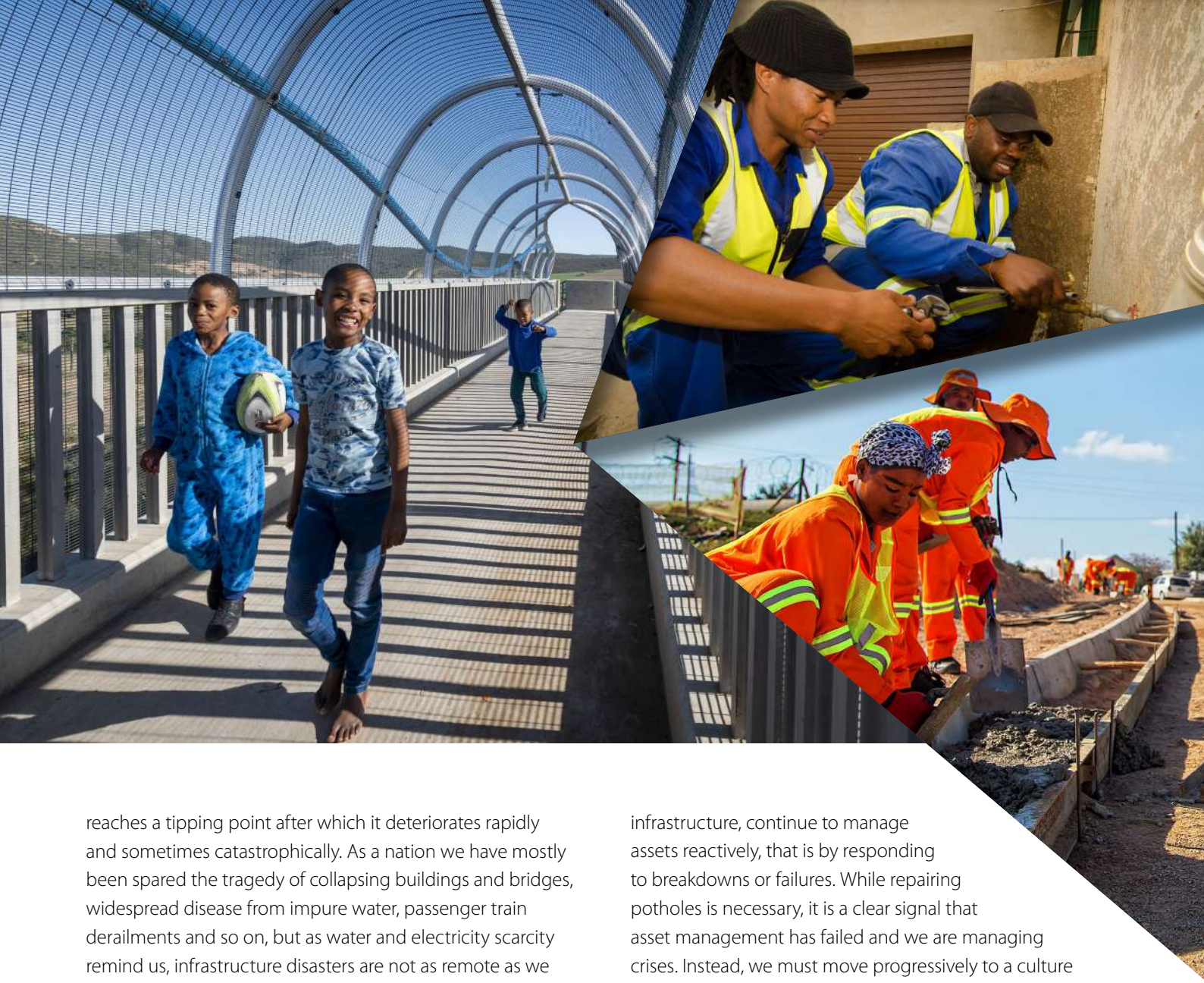
Electricity loadshedding is a complex issue but its devastation of the economy and the lives of ordinary people is undeniable. Resolving the crisis will not be easy, but it is worth remembering that the origin of the problem lay in the unwise delay in investment in new generation capacity, whether these be powered by fossil fuel or renewable energy. More broadly, the delayed investment in maintenance places the entire portfolio of public assets at risk of dysfunction.

> It is estimated that every day lost to Stage 1 loadshedding (loss of 1 000 MW) costs the country R235 million. In mid-September 2022 Eskom was at Stage 6 loadshedding with approximately 23 000 MW of generating capacity unavailable.

The preservation of the public asset

Much of the actual infrastructure that serves us is concealed from public view. The strength of a road lies beneath the visible surface, although that surface will often reflect the weaknesses below. The leaking tap is not the cause of the greatest water losses – much more is lost through leaks in buried pipes (in many municipalities over 40% of purified water simply leaks into the ground). The quality of drinking water is also not evident from its smell alone. Unless these assets are properly operated and managed, it is difficult for the casual observer to gauge their true condition and how close they might be to failing.

The condition of well-designed and -built infrastructure does not change rapidly, at first. With neglect, however, it



reaches a tipping point after which it deteriorates rapidly and sometimes catastrophically. As a nation we have mostly been spared the tragedy of collapsing buildings and bridges, widespread disease from impure water, passenger train derailments and so on, but as water and electricity scarcity remind us, infrastructure disasters are not as remote as we might think.

National Treasury suggests that 8% of the book value of infrastructure assets be targeted for maintenance every year. But this would actually reduce maintenance budgets as the equipment gets older. It also assumes that the infrastructure is in a satisfactory condition to start with. The international norm is to target between 1.1% and 2.6% of current replacement cost, which would also impose the crucial discipline of tracking the condition of all assets, something not widely practised at present. For most of our infrastructure neither of these targets is remotely achieved. Far too often even meagre maintenance budgets are appropriated for other "more pressing" needs. Increasingly, these monies are used for unscheduled repair of infrastructure damaged through criminality.

Neglect of maintenance is the most persistent problem encountered in all four IRCs to date. We have found that the majority of municipalities, and even provincial owners of infrastructure, continue to manage assets reactively, that is by responding to breakdowns or failures. While repairing potholes is necessary, it is a clear signal that asset management has failed and we are managing crises. Instead, we must move progressively to a culture of scheduled (preventative) maintenance and ultimately to predictive maintenance based on real-time data, in other words a focus on reliability.

The opportunities maintenance offers

Most infrastructure is built to last 30 years or more and it must be maintained for its entire lifetime. It only takes a fraction of that time to build it. Therefore, the employment created during operation and maintenance is of much longer duration than for the initial construction. Moreover, unlike greenfield construction, once trained in maintenance, the skills reside in that local community and may spill over into local enterprises. Conversely, if maintenance is poor, it is likely that the inevitable breakdowns or failures will be repaired by contractors from outside the area.

South Africa is faced with chronic unemployment and widespread poverty. The resulting dissatisfaction frequently

manifests in community demands for employment when constructors arrive from outside to do work in their area. Contractors on capital intensive infrastructure projects are of necessity nomadic, and these demands ultimately increase the price that the State pays. Employment in maintenance activities offers continuous employment, skills development and significant savings in the long run.

Climate change and environmental factors

In recent years the integrity of infrastructure has been threatened by global events such as climate change, regional conflict and the Covid-19 pandemic. Extreme and variable weather patterns, rising commodity prices and the loss of revenue negatively affect priorities and disrupt maintenance protocols.

Climate-related hazards can result in direct physical damage to existing infrastructure. Indirectly, there is increased pressure on infrastructure as demand for the service it provides is increased, or as its efficiency is reduced. It is predicted that South Africa's climate will change drastically, with temperatures projected to increase by between 1.5 to 2 times the global rate. These changes in weather patterns are more likely to cause droughts, fires and extreme rainfall events, causing flooding and geohazards like sinkholes and mudslides.

The risk is aggravated by town planning that does not account for high rates of urbanisation, poorly managed surface water drainage (e.g. blocked stormwater drains and culverts) and the drawdown of groundwater caused by the rapid increase in the number of boreholes to alleviate drought conditions or for mining activity. The floods in April 2022 destroyed primary infrastructure to the value of R25 billion in KwaZulu-Natal alone. The impact, especially on vulnerable communities, is devastating.

The changes required to tackle climate change, e.g. a transition from fossil fuels to renewables, affect our infrastructure choices and will impact on livelihoods that are tied to those offending technologies. New strategies must take advantage of the opportunities offered by the movement towards environmentally and socially sustainable development while accounting for those affected by the transition. Holistic assessment of risks is required.

Since 2020 the world has faced the daunting challenge of the Covid-19 pandemic. In the early stages, the entire world was in economic shock. Although developing nations were

especially hard hit, the later lockdown during the Omicron spike was devastating locally, because the rest of the world was entering recovery while the restart of South Africa's already wounded economy was delayed. As discussed later, this second setback also exacerbated the country's loss of critical engineering skills.

Two years of disruption and lockdown caused revenues to plummet for many SOCs. Budgets for maintenance consequently suffered more than usual. There was also a discontinuity in an already deficient data management regimen which became glaringly obvious in the preparation of this report.

All these external threats to infrastructure require specific design and construction responses, including a move towards greater resilience.

User behaviour and crime impacts

The South African Constitution enshrines progressive socio-economic rights around access to infrastructure and basic services that are offered without charge. The demands for better service delivery and anger at the unequal provision of infrastructure are understandable, but they should not be advanced through the destruction of the existing infrastructure. All too often dissatisfaction turns to destruction of property or causes lengthy delays in construction activities, and both are unaffordable. If the responsibility for providing and maintaining infrastructure is a core duty of the State, then there is a corresponding duty on citizens for its responsible care and use and payment for the services rendered.

At a basic level, conservation of resources is such a duty. In 2018 Cape Town became the world's first major metro to be on the brink of running out of water. The response of the city management in collaboration with residents to avert "Day Zero" shows the power of user engagement

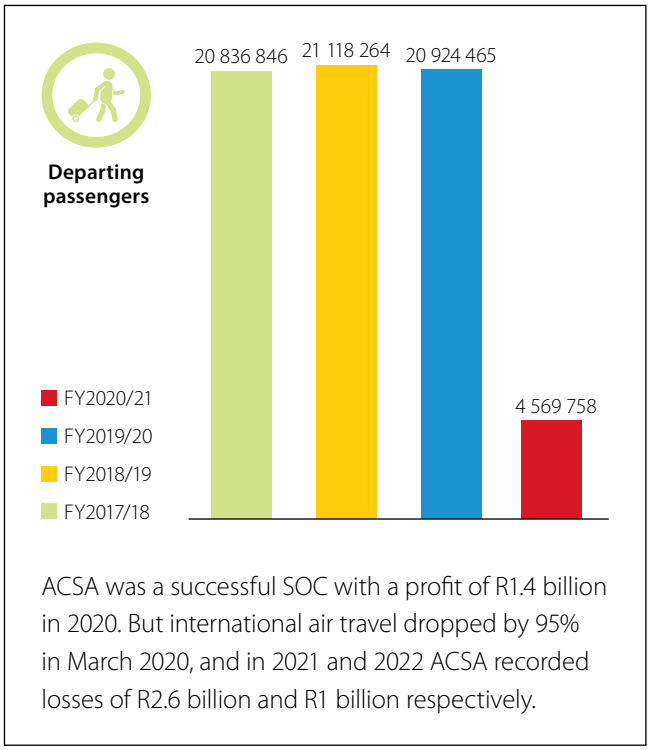
and responsible behaviour. Now Nelson Mandela Bay faces a similar crisis and it is likely that in the future others will follow. Water and electricity shortages will be with us for the foreseeable future and our usage behaviour must adjust to these realities.

Illegal connections and non-payment for services by residents are endemic, leading to a vicious cycle of municipal default and lost income to water boards, Eskom and the like, with disastrous consequences for maintenance and renewal. For example, even while the number of households with access to water increased by 46% between 2006 and 2019 – an admirable achievement – the proportion of households that paid for water services declined by 31%.

In September 2022 National Treasury reported that municipalities owed creditors (primarily Eskom and water boards) just under R90 billion, and that the municipalities themselves were owed R255 billion by their customers.

Most alarming, though, is the dramatic increase in arson, theft and malicious destruction of public property by criminals and protestors. These were highlighted in the 2011 and 2017 IRCs and have worsened since then. Theft of copper cables, aluminium guardrails, steel manhole covers and rail tracks results in personal tragedy, deprivation for legitimate users and disruption of commercial activity on an unprecedented scale. The prevention of theft and vandalism has become a major budget consideration for SOCs. In addition to the direct costs, the resulting instability causes indirect costs through inefficiencies, e.g. the shift of heavy freight from rail, to which it is best suited, to roads.

For some years now, the construction sector has been plagued by a peculiar form of extortion known as the "construction mafia". Under the guise of transformation, gangs posing as "business forums" have disrupted construction projects by demanding inclusion for little or no added economic value.



ACSA was a successful SOC with a profit of R1.4 billion in 2020. But international air travel dropped by 95% in March 2020, and in 2021 and 2022 ACSA recorded losses of R2.6 billion and R1 billion respectively.

Figure 1 ACSA passenger movements (ACSA IAR, 2021)

It is also not unusual to find communities in the vicinity of construction work disrupting those projects unlawfully with the intention of obtaining employment, economic participation or a change in the contractual scope of work. These actions cause distortions to the risk allocated between the contractor and employer (government) which ultimately increases the cost of providing infrastructure. In some cases contractors have abandoned the works with legal and abortive costs to all parties to the contract.

Government is charged with creating and operating infrastructure for the benefit of society. It fails too often in its duty. But users of infrastructure and the services they deliver are also duty-bound to protect those facilities and to use them with care. Too often they fail in their duty, with disproportionate costs to the fiscus and disadvantage to other users.

In the rail sector, security-related incidents overtook operator-related incidents in 2014 and now constitute over 80% of all reported incidents. The resulting losses amount to hundreds of millions of rands.

Section C: Matters of critical importance

Introduction

There can be little doubt of the importance of infrastructure to any meaningful renewal exercise in South Africa. And yet, as the low overall rating given in this report suggests, the problem of dysfunction remains stubbornly pervasive across most sectors.

Previous IRC reports drew attention to three key factors that influence infrastructure condition:

- **People and relationships**: having sufficient numbers of the appropriate skills in the right places, entrusting them with their responsibilities and a collaborative approach between the public and private sectors.
- **Institutional robustness**: clear mandates with corresponding accountability, effective policies and governance systems to carry these out efficiently, and a proactive approach to pursue excellence.
- **Data and information**: on the age, condition and performance of current assets, backlogs and future needs and innovative solutions.

All three of these factors, individually and in combination, remain crucial to addressing the infrastructure challenge. If any one of them is weak, asset management becomes critically unstable. For example, for corruption to be rooted out, competent and ethical executives must operate in institutions with strong governance and management systems. Likewise, for effective planning those same people must have up-to-date data and information. With accurate data institutions can make decisions that are evidence-based rather than being guided by the loudness of popular opinion.

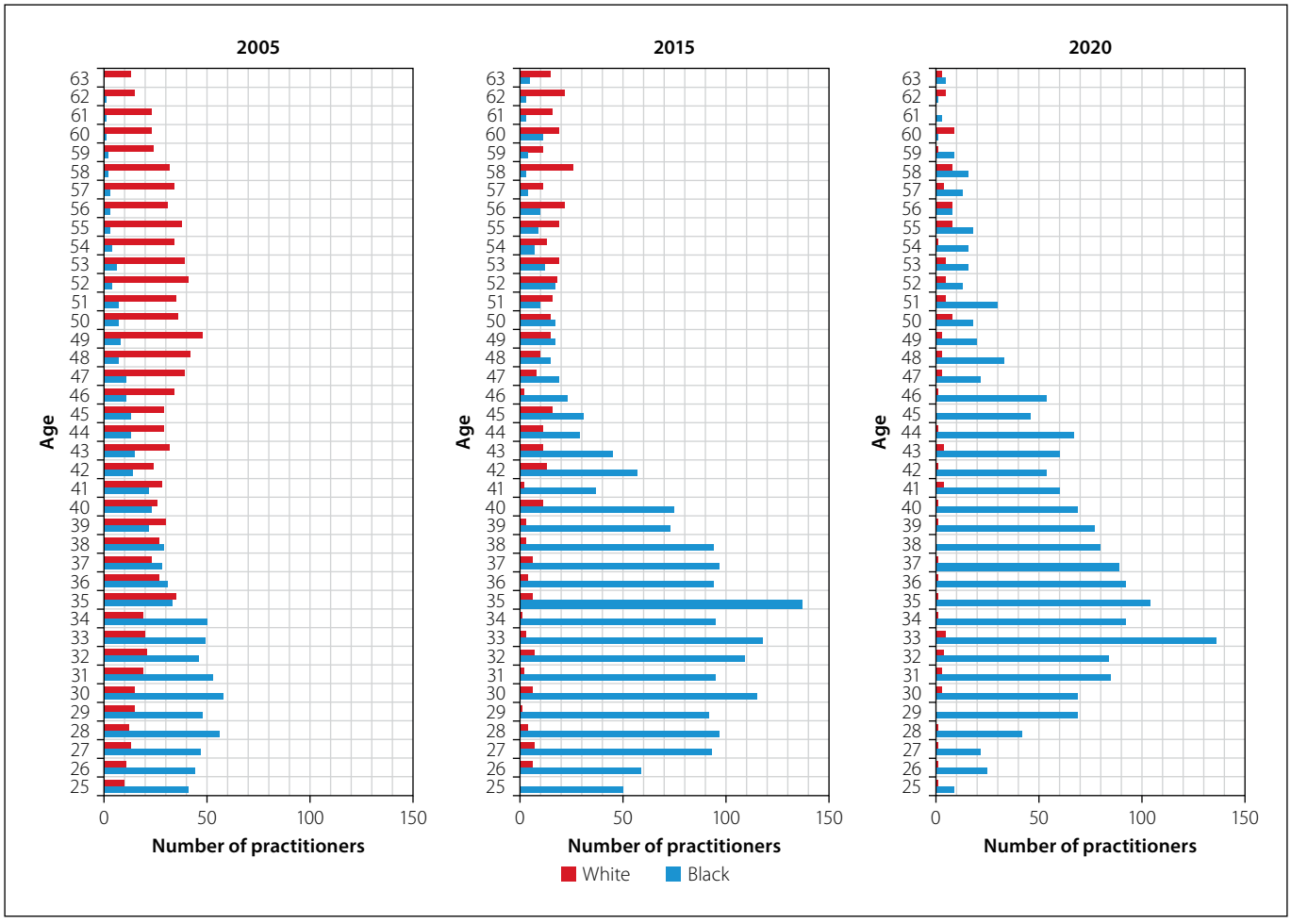


Figure 2 Engineering practitioners in local government by race (Numbers and Needs, 2005, 2015; and LGSETA WSP, 2020)

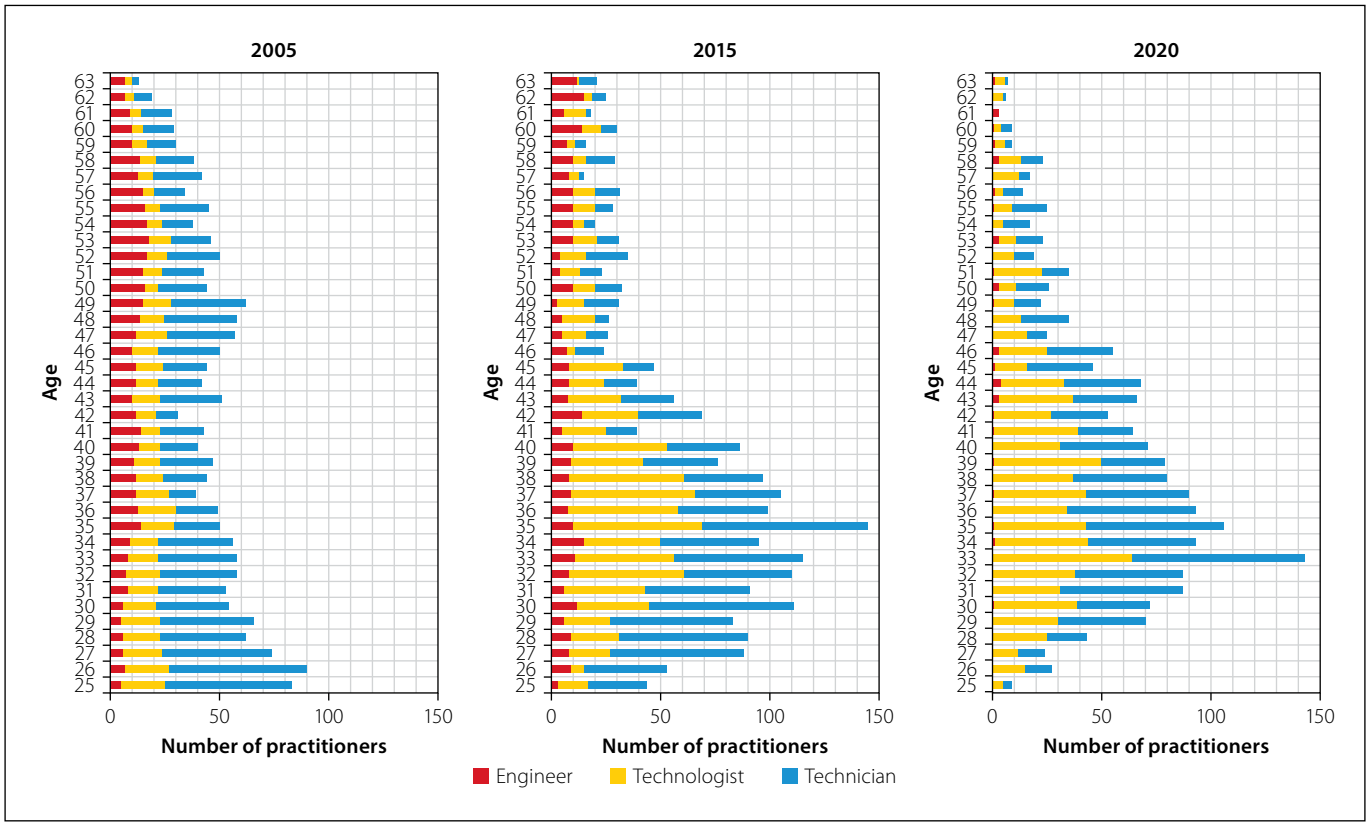


Figure 3 Civil engineering practitioners in local government by qualification (Numbers and Needs, 2005, 2015; and LGSETA WSP, 2020)

Consequently, programmes to capacitate defaulting institutions must address management and leadership shortcomings at the same time as technical incompetence and data analytics. Otherwise they will continue to have very limited success.

People and relationships

South Africa, and especially its public service, faces a debilitating shortage in engineering skills. It is rare to find a municipality that is blessed with a full complement of qualified and experienced personnel in its technical organogram. The human capacity to monitor, inspect and maintain the current infrastructure, and to plan for renewal and replacement, has not grown at the same high rate as the portfolio of public assets. Constrained budgets and inattention to the development of skills have worsened the situation.

Operation and maintenance activities are complex and require a cadre of skilled technical professionals if we are to avoid compromising the lifespan of assets through neglect. Most municipalities are desperately understaffed in these crucial positions or staffed by people who do not have the required training or experience. At the level of leadership, engineering professionals are under-represented in the boards of SOCs and senior management in all spheres of government.

Since 2005 SAICE has closely tracked the profile of engineering expertise in the public service. As discussed later, accurate data is hard to come by. Figures 2 and 3 are constructed from SAICE research in 2005 and 2015 as well as the 2020 LGSETA workplace skills plan (WSP). The trends in engineering capability are revealing. For example, in local government the dramatic increase in the number of black and female practitioners since 2005 is heartening, although there has been a slight decline since 2015 (Figure 2). This is a real South African success story for which institutions of learning and the industry in general must be congratulated.

It is concerning, however, that this achievement was accompanied by a displacement of their older and white counterparts, for two reasons. Firstly, as can be deduced from the corresponding graphs of qualifications (Figure 3), too many of those who left were engineers and their depletion has disrupted the profile of skill sets that are required for effective service delivery. Secondly, their exit leaves the incoming cadre of bright and eager candidate engineers, technologists and technicians without the mentorship essential to develop engineering judgement and wisdom – something that can only happen through guided practice.

The nomenclature of engineering qualifications can be confusing and misleading to those outside the profession,

such as non-technical human resource departments. But put simply, problem-solving skills and depth of knowledge differ from engineers to technologists to technicians. Infrastructure departments require the correct balance of all three of these professional categories to function well. In reality, the proportions of those employed in local government are alarmingly skewed towards the narrower-skilled technicians. As a result, most departments, and especially municipalities, do not have satisfactory technical capacity even when they have increased the technical headcount. Many programmes to increase the capability of the public sector have consequently failed.

In a survey of SAICE members, the following reasons were given for a reluctance to work in the public service:

- Political interference with the core work of infrastructure departments
- The diminished decision-making roles of technocrats
- The lack of systems, processes and structures for efficient administration
- The lack of training, development and career paths
- Unwarranted interference of human resource and finance divisions in the work of infrastructure engineering professionals.

An unintended effect of attempts to curb corruption has been the withdrawal of discretionary powers from even those professionals with integrity, rendering them powerless (or fearful) to exercise their judgement developed over years of practice. It is encouraging that the bill on professionalising the public sector echoes many of these concerns. The recent adoption of the Municipal Staff Regulations, which include competency frameworks for mainstream occupations, is a move in the right direction.

It is important to note that developed economies are targeting infrastructure development as a catalyst for growth in the wake of the Covid-19 pandemic. These countries must supplement their technical human resources for this surge and South Africans, being generally well trained and hardworking, become attractive targets for recruitment.

While the shortage of skilled professionals is a major challenge, the overall capability of the State to undertake the routine and complex tasks that encompass asset management requires strengthening.

Effective asset management requires the integration of processes and systems (financial, management, engineering, operating and maintenance) to gain the best use from physical assets over their lifetime – from conception to disposal.

Institutional robustness

Local government and SOCs provide many of the services that citizens use in their daily social and economic activities. This responsibility is matched by their large share of the infrastructure budget allocation. And yet the condition of South Africa's infrastructure is below satisfactory and deteriorating. To a significant extent, these are attributable to institutional failures in capacity and governance that extend beyond the realm of asset management.

The Auditor General (2022) is scathing in her description of local government as "characterised by accountability and service delivery failures, poor governance, weak institutional capacity, and instability." In September 2022, National Treasury reported that, of the 257 municipalities, 151 are insolvent of which 43 are in crisis and require rescue. A major reason given is "revenue management failures" that both administrative and political leadership have been unable to remedy. Of course, revenue cannot be generated if services are not delivered.

The utter scale of corruption has been exposed as a major blight on the public service, much of it related to infrastructure procurement. The Commission on State Capture has had at least two important outcomes in this regard. Firstly, it exposed the massive amounts devoted to infrastructure provision that were wasted, meaning that the amount of spending is not reflective of the scope or quality of assets obtained by the State. Secondly, the public perception of SOCs and government procurement generally has been dealt a credibility blow, which will have a lingering impact on its behaviour, e.g. on demand side management of electricity and water usage or on the non-payment for services.

The State has budgeted about R812 billion for infrastructure over the 2022 Medium Term Expenditure Framework period. This is a powerful tool for development and upliftment, but it is also an attractive reservoir for the criminally crafty to devise schemes of extraction. The Commission on State Capture has offered hundreds of pages of recommendations

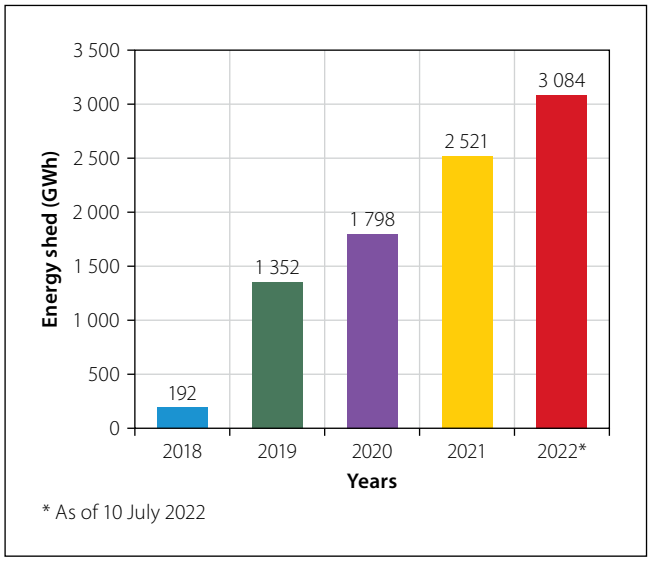


Figure 4 Loadshedding 2018 to 2022 (mybroadband ref CSIR)

to clean up procurement. National Treasury has admitted that some procurement regulations have led to outcomes that were counterproductive. In some instances, transformation initiatives, such as the requirement for local content, have been misinterpreted by government buyers (e.g. requiring local content for imported goods) or distorted by tenderers and community activists as mentioned earlier. It is therefore encouraging that infrastructure is receiving special attention in the revised procurement regulations.

The negative effects of electricity loadshedding cannot be overstated. The impact cuts across all infrastructure sectors, decreasing the performance of everything from the treatment of drinking water and the treatment of raw sewage to the operation of transport networks and health facilities. It also creates conditions conducive to criminal activity with direct impacts on infrastructure. And 2022 is set to be the worst year on record. The inability of Eskom to achieve a reliable recovery of its core function – to power the economy – is a classic case of multi-faceted failure: both political and managerial. It also illustrates the difficulty of implementing a quick turnaround when critical infrastructure is overwhelmed.

More broadly, the depletion of seasoned professionals means that public institutions have a much-reduced ability to be the "knowledgeable client" in procurement processes, negotiations and contract management – this is especially worrying in light of Government's renewed interest in public-private partnerships. The very regulations that govern supply chain management are structured to cater for a routine, administrative process to purchase commodities. Infrastructure acquisition by contrast is complex and requires a strategic approach, especially if the intention is to create alliances of shared risk between the public and private sectors. At present, neither the regulatory framework nor the required institutional skills are in place to achieve this outcome.

The backlog in infrastructure presents an unintended silver lining: the opportunity to take advantage of the most modern, cost-effective designs including those, for example, which increase resilience by reducing the need for maintenance. Recent advances in water and waste treatment, for example, offer savings and improved performance over some outdated systems currently in use. There is need for caution, however. In some instances these new systems are incompatible with existing installations or use bespoke spares that might be hard to source (or even have a single source to which government becomes beholden) and require specific technical skills for efficient operation.

The fate of infrastructure projects is often determined in the strategic planning phase. Strategic Environmental Assessments are useful to identify and prioritise projects that advance national development goals by highlighting the value of preserving and improving existing assets and identifying what should be abandoned. The benefits include achieving environmentally and socially sound and sustainable development while saving time and money by avoiding costly mistakes. Although endorsed by Government, it is still not part and parcel of the infrastructure planning landscape of South Africa. New-build projects with high visibility are often preferred, rather than spending money on maintaining and upgrading existing assets.

Moreover, before an institution (e.g. a municipality or a provincial government department) procures new or refurbishes existing infrastructure, it should consider if it will have the resources

to operate and maintain that infrastructure for its design life – bearing in mind other liabilities it might have. And if it cannot, it should consider other options, for example acquiring infrastructure that would be more robust should it not be operated optimally, or which does more or less the same job but at a lower price or requiring lesser skills. Such solutions are frequently available but ignored for a variety of reasons.

Until more institutions that undertake procurement, asset management and service delivery have the correct balance of skilled personnel, implement proper governance procedures, and make decisions that are based on relevant data, there is little chance that the current dismal situation will improve.

Data management and infrastructure monitoring

Data analytics is a relatively young field that offers the opportunity to make significant gains for a moderate investment. Internationally, the digital twin concept is being adopted to manage infrastructure system data. But when it comes to infrastructure in South Africa, data acquisition seems to be thought of as a secondary concern. This is a fundamental and crucial error. The collection and analysis of data is a business matter of the highest importance. It requires the close attention of the top executives of any organisation. Without it the organisation cannot perform competently.

Whether it be the visual inspection of a road or laser surveillance of the profile of a rail line, the chemistry of treated water or a record of the number of functional school toilets, consistent and accurate data collection is essential to understanding the current stock, performance and reliability of infrastructure assets. Moreover, such information is vital to scheduling maintenance and renewal of existing facilities, and to predicting future needs.

Without the relevant information, evidence-based, accountable decision making gives way instead to satisfying the shrillest demands of the public. The South African Constitution explicitly states that a basic principle of public administration and co-operative government is that "transparency must be fostered by providing the public with timely, accessible and accurate information." But in preparing this report it became clear that this situation does not pertain to infrastructure. Most municipalities as well as many provincial and national departments and SOCs do not collect or analyse data that is crucial to their core functions. Some do not have the ability to integrate and interpret the data that is collected. At best, it might be said that bureaucratic inertia is rife. At worst, it could be attributed to reluctance, obfuscation and even concealment of data by prominent infrastructure agencies to avoid embarrassment. To be clear, many owners or operators of assets simply do not collect condition and performance data. Some frankly admit to this failing. It is hard to decide which is worse: to be ignorant of the condition of assets under your control or to blindly allocate resources based on the loudest cries for attention.

Frequently, the data sets that are updated are not consistent across institutions, making comparison or aggregation difficult. Data should also facilitate comparison with best-practice peers and enable policymakers to build a comprehensive understanding of economic, social and environmental impacts.

In this context, it is positive that the Department of Water and Sanitation has released the Green Drop Report and Blue Drop Progress Report after a hiatus of eight years, even though the results paint a bleak picture of water and sanitation services. It is only through candid appraisal of the facts that effective turnaround measures can be instituted.

As is mentioned in the various sector reports later in this IRC, Covid-19 has interrupted the data collection of even competent agencies and it will take some time for systems to normalise. In other instances, the retention of familiar legacy systems is a hindrance to the highly productive and inexpensive systems now available. In general, though, not enough attention is paid to the collection and analysis of relevant data to inform decisions that will have an impact for generations to come.

Reasons for optimism

There is no doubting the generally poor state of the nation's infrastructure, nor that in many areas the condition is in decline. But it would be unfair to ignore the performance of the many leaders, managers, professionals and both skilled and unskilled workers who persevere in their tasks to make things better.

It is also undoubted that addressing the enormous legacy backlogs inherited after apartheid has had consequences. Such gains as the increased access to improved sanitation, drinking water, electricity and transport have placed these systems under unbearable pressure. However, even in many of the poorest performing entities there is real cause for hope of a turnaround.

A significant number of institutions continue to perform well and are improving in each of the sectors examined. Examples of these include:

- The South African National Roads Agency Ltd (SANRAL) continues to excel in roadbuilding and management, to

the extent that the network under its care has improved its condition in recent years. It has achieved this while steadily absorbing more of the provincial and regional road network, which was generally in a poorer condition than SANRAL roads.

- It is understandable that Eskom's generation challenges receive so much censure. But its transmission network, although aged, is excellent. This is crucial since so much electricity is generated at great distances from where it is used.
- Within Transnet the good performance of the heavy haul lines (especially iron ore) stand in stark contrast to both metro and long-distance passenger services.
- The major oil and gas pipelines and the ICT network are in excellent condition.
- The country's commercial and fishing harbours are in fine condition and there are signs of improving performance in that sector.
- Airports Company South Africa (ACSA) has weathered the most challenging years of its existence while maintaining its airports in fair condition.
- Even in local government there is a scattering of municipalities that lead the way in administration and service delivery, e.g. the Drakenstein, Mossel Bay and Witzenberg Local Municipalities and the Ekurhuleni Metropolitan Municipality. All of these received clean audits by the Auditor General. Interestingly, they were also awarded Green Drop Certification for sanitation.

There are also promising signs in the approach taken by regulators, such as:

- The policy underpinnings for life cycle costing, maintenance budgeting and asset management are excellent. Clear and detailed procedures have been shared by Government with all asset owners.
- The proposal to professionalise the public service, placing emphasis on competence and ethics and isolating government departments from politics is positive. In recent years this has found tacit expression in some senior appointments at infrastructure entities.
- The recent implementation of a District Development Model, if implemented well, has the potential benefit of aggregating limited resources and leveraging support programmes.

We found that a variety of factors play a role in the standout entities, such as:

- Stable leadership, e.g. SANRAL and Gautrain have had only two CEOs for the past two decades
- Strategic importance, e.g. pressure is placed on Transnet by major business groupings to operate the heavy haul iron ore line and the oil and gas pipelines efficiently
- Imposed minimum standards, e.g. ACSA must conform to international standards or it cannot operate
- Financial solvency, continuity of competent senior staff and effective management systems are common to many of these successful units.

These stand as examples of excellence or at least competence for struggling entities.

Section D: Condition assessments by sector

Introduction

This section presents summaries drawn from the detailed reports that SAICE prepared on each of the infrastructure sectors. A wide net was cast for information. Where they existed, infrastructure condition reports and management information systems were most valuable. Departmental annual reports, Stats SA reports and Auditor General reports were useful, as were NGO and media reports. Finally, the expert knowledge of professionals in each of the sectors was canvassed.

The process is as rigorous as SAICE is able to ensure, given that some infrastructure owners do not undertake condition assessments with the necessary frequency, and/or are not willing to divulge their findings.

While there are exceptions (e.g. national roads, airports, heavy haul freight lines, Gautrain, harbours, major oil and gas pipelines, and Eskom's transmission network), it is of great concern that so much of the country's fixed infrastructure appears to be stuck in a condition that is not satisfactory at best. Many reasons can be found for this, as have been alluded to earlier. In this section we provide a more detailed picture and the specific challenges that beset each sector. What is clear is the graphic trend in deterioration. When we published the last IRC in 2017, eight municipalities were under administration by the national or relevant provincial government. This number has since increased to 33 municipalities.

The stark reality is that commissioning new infrastructure, or rehabilitating or repairing existing infrastructure that is no longer functional, is simply not sustainable in the medium to long term without addressing the factors that impact negatively on operations and maintenance. Without skilled operators, appropriate operating procedures and basic maintenance, much of the more sophisticated or less robust infrastructure cannot be expected to deliver service consistently.

The scope of infrastructure for this report has been extended to include ICT and oil and gas pipelines. Reports on the state of fire infrastructure and coastal management are new, but at this stage these aspects have not been graded. Fishing harbours make a return after being absent in the 2017 IRC for lack of credible data.

National water resources infrastructure

South Africa has an arid to semi-arid climate with an annual rainfall of 465 mm (half the world average) unevenly spread across the country – over 60% of the country's river flow comes from only 20% of the land area. Much of this precious surface water is transported large distances through inter-basin transfer schemes to the major centres of demand. Agriculture, as well as many small towns, may rely on ground-water and/or abstraction directly from nearby rivers.

Water quantity and quality are intrinsically linked with groundwater recharged from surface water runoff. The deteriorating quality of this runoff is proving to be a major constraint to economic and social development.

Current water usage in many areas already exceeds the reliable yield of existing water infrastructure, and the cost of future expansions is rising rapidly. Although South Africa uses about 40% of the country's total water runoff, much of the water is not available at the required assurance level, and thus water scarcity is an increasing threat. Climate change will intensify the pressure on water systems. Recent occurrences of drought and flood events have emphasised the need for proactive planning, improved water conservation measures and changes in consumption behaviour (demand management).

The major water resources infrastructure owned and operated by the Department of Water and Sanitation (DWS) consists of large dams, abstraction works and bulk transfer schemes (pipelines and canals). DWS currently controls 257 water schemes, of which 25% (65) are schemes where raw water is collected and transferred from one catchment to another. While the total number of registered dams (wall height over 5 m and storage capacity over 12 000 m^3) is more than 5 000, only 257 store about 93% of the total volume of water in the country. The remainder of the dams support local water supply (e.g. agriculture and small towns) and deliver water within particular catchments.

The following paragraphs briefly describe key challenges, and provide context for the IRC grading.

Major work is still needed to complete some key water resource infrastructure projects and the delays are of great concern, particularly projects such as the Lesotho Highlands Water Project which is crucial to water security in the Integrated Vaal River System that supplies Gauteng and surrounding areas as far away as the power stations on the Mpumalanga Highveld. Delays in the Polihali Dam and Transfer Tunnel have heightened water security risks for the region.

DWS's own capacity to implement and manage projects has reduced over the years and is now under extreme pressure. Although the Department is making good use of the Trans-Caledon Tunnel Authority and water boards for project implementation, there is pressure on the delivery mechanisms because of major resource constraints in personnel and funding. Funding is an ongoing challenge and greater budgets (or private funding) are required if all the needed actions, as stated in the National Water and Sanitation Master Plan, are to be successfully addressed and demand for water is to be met.

The regular occurrence of major power outages and loadshedding from Eskom is a further key threat to major water supply systems and heightens risks of possible system failures. The water-energy nexus is a crucial dimension and needs careful management as water transfer requires energy for pumping, and water supplies are needed for electricity generation. Failure of one has disastrous implications for the other.

Many government water schemes (mainly for irrigation with large canal systems) are very old (approaching 100 years) and have exceeded their useful life; some require urgent rehabilitation. Failure would have a significant negative impact on food security and on local communities and economies.

The rehabilitation of dams gathered some momentum in 2021 after roughly four years of low investment. Information in the public domain on the condition of dams is very limited. The Annual Dam Safety Reports, which carry crucial information on the status of dam safety and highlight priorities for mitigating risks and plans for ongoing maintenance requirements, have not been published since 2016/17. This is a critical issue. DWS is both player and referee in the arena of dam safety as it owns, maintains and operates key dams but also regulates the safety of those dams. This goes against best international practice where regulatory and operational functions should be separated. Once the National Water Resources Infrastructure Agency (NWRIA) is established there should be separation between the functions of regulation and operation of the national water infrastructure.

Effective water resource infrastructure planning is dependent on good hydrological and rainfall information. However, DWS has lost numerous hydrological gauging/monitoring and rainfall stations, and the resultant decline in reliable data is a threat to the country's water security. DWS must ensure adequate funding for the expansion of the hydrological monitoring network (particularly rainfall, evaporation and streamflow stations) and for the continued collection and maintenance of hydrological and climate data records.

Internationally, metropolitan areas reuse water. In London, for example, every drop of water is used seven times. South Africa should investigate the potential for water reuse systems.

Over the last decade there has been a major loss of senior engineering personnel from DWS, mainly due to the retirement of staff – currently more than 100 senior level engineering posts are vacant. This loss of institutional knowledge and the strong technical skills base are not easily replaced. A concerted effort to attract experienced professionals is required.

The long-promised NWRIA, once established, will merge the Trans-Caledon Tunnel Authority with the DWS Infrastructure Branch. It will take over the operation of DWS's major water

resources infrastructure consisting of large dams, abstraction works and bulk transfer schemes. The two major advantages of this move will be:

- The new entity will have the ability to secure private funding for projects where cost recovery is ensured through effective and efficient operational and financial arrangements with larger water user institutions, such as metropolitan municipalities, water boards, water user associations and large industrial users.

- Formation of the NWRIA will separate the policy development and regulatory responsibilities of DWS from its responsibility for development of infrastructure projects and their subsequent management. In line with best international practice, the dam owner and operator will be separated from the safety regulator.

Water supply services infrastructure

Water supply infrastructure in the form of water treatment works, pump stations, reservoirs and reticulation is the responsibility of the local government sphere, within the definition of which it is convenient to include water boards. They are supported and regulated by national government departments, in particular the DWS. A wide range of legislation and frameworks govern water supply (and sanitation), including the free basic water and sanitation policy.

According to Stats SA, 15 525 million households (or 88.7% of all South Africans) are dependent on municipalities and water boards for daily safe and reliable water supply. The balance (11.3%) are either not served yet (new informal settlements or remote rural areas) or are privately supplied (e.g. farms, game lodges and mining towns). As a reliable and safe municipal supply is critical for national health and economic wellbeing, it is essential that the infrastructure supplying this water is functional and well-maintained.

This SAICE IRC water services report uses information from a number of reports as indicators for the grading of existing infrastructure because no direct data on its condition is readily available. The first is the Blue Drop Progress Report 2022. This report provides a risk rating for each Water Services Authority (WSA) (either a municipality or a combination of municipalities as authorised in terms of the Water Services Act (No. 108 of 1997)) based on drinking water treatment capacity, treated water quality, skills availability and progress with water safety plans.

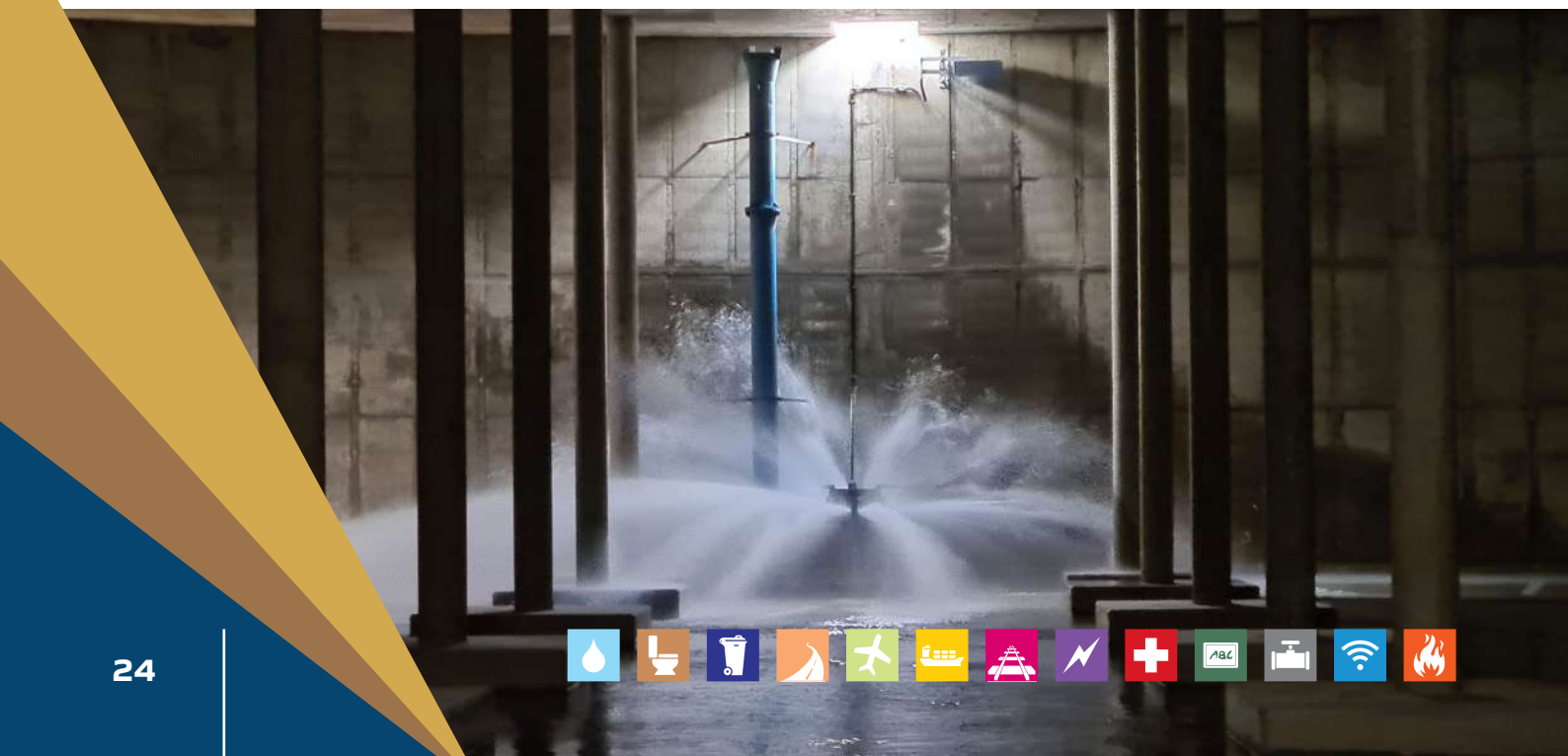
During 2021, all 144 WSAs, responsible for 1 186 water supply systems, were assessed. The resulting National Blue Drop Risk Rating found that:

- Less than half (48%) of water supply systems are in the low risk category
- 18% are in the medium risk category
- 11% are in the high risk category
- 23% are in the critical risk category.

The fact that 34% of systems are in the high and critical risk categories is of great concern. These WSAs have been placed under regulatory focus, requiring each of them to submit a detailed corrective action plan to DWS.

Moreover:

- Only 40% of water supply systems achieved microbiological water quality compliance and a mere 23% have achieved chemical water quality compliance.



- Regarding monitoring of water quality, it was found that 66% of water supply systems have adequate microbiological monitoring compliance and a mere 17% have adequate chemical monitoring compliance. This in effect means that one third of all water supply systems have no mechanism to sound the alarm when there is life-threatening microbiological contamination in the drinking water. It was also found that 83% of all systems cannot effectively detect harmful chemical pollutants.

This is disturbing because water quality compliance is critical to ensuring delivery of safe drinking water that does not present a health risk to consumers.

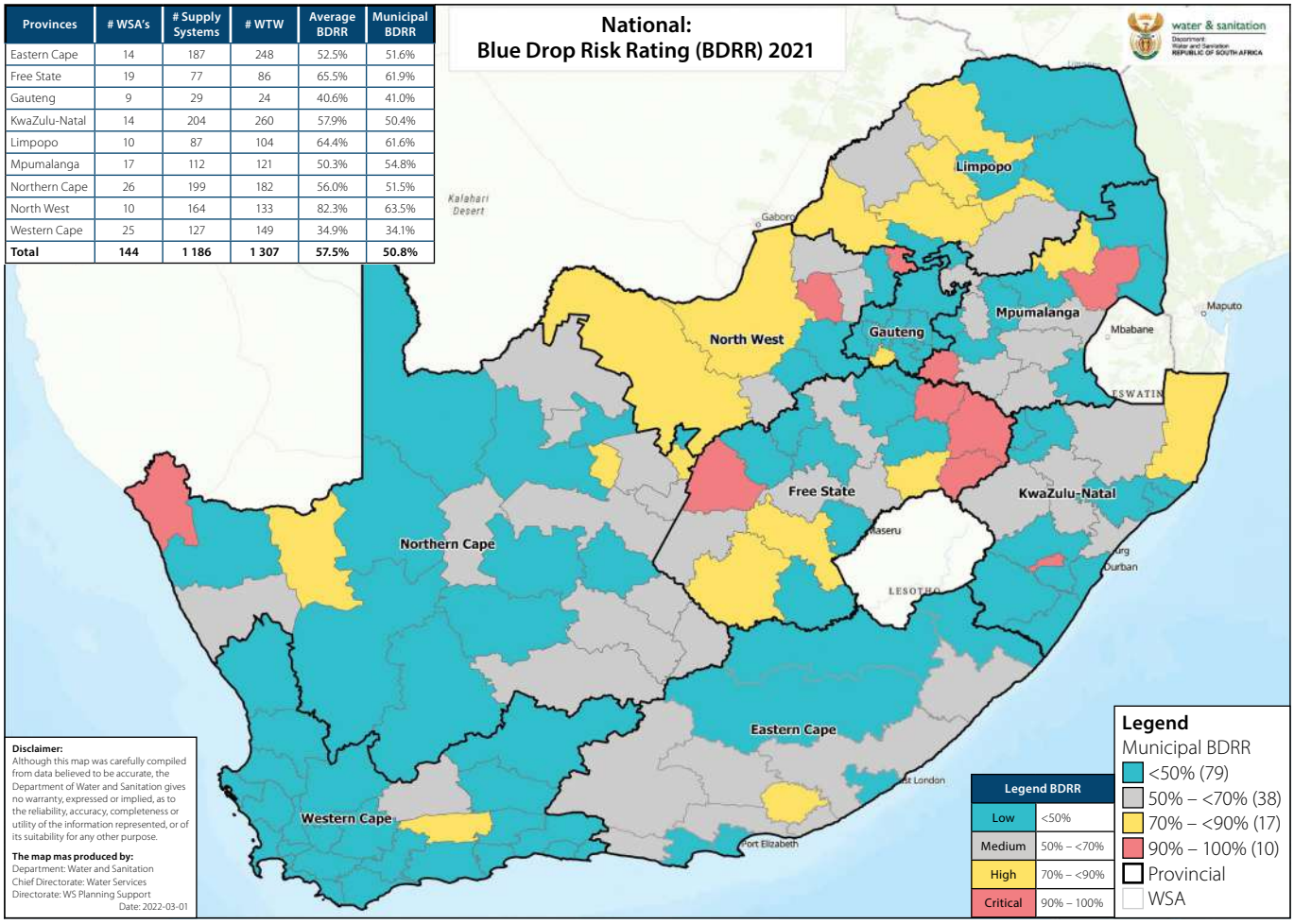
The Blue Drop performance rating has clearly indicated where the challenges are greatest – particularly for smaller towns and rural areas. It has also indicated the main factors contributing to these challenges. Prominent among these are skills and budget issues as well as a lack of maintenance plans. Nonetheless, in all the metros, and in many other towns as well, the water supplied to households is very seldom not safe to drink – not many countries are able to boast that water can be drunk from the tap without additional treatment in the house.

Figure 5 illustrates that the scores are, without exception, higher around the major urban areas, and/or where water boards treat water in bulk and supply it to municipalities (to a great extent, the same urban areas).

Table 2 The Blue Drop Risk Rating categorisation

Low	Medium	High	Critical
<50%	50% to <70%	70% to <90%	90% to 100%

While the quality of drinking water is vital, the reliability of water supply is of even greater importance. Stats SA's General Household Survey (GHS) reports on the functionality of municipal water supply services by measuring the extent to which households that received water from a municipality had reported, over the 12 months before the survey, interruptions that lasted more than two days at a time, or more than 15 days in total during the whole period. The 2020 report revealed that households in the mostly rural provinces of Limpopo (58.5%), Mpumalanga (56.4%) and North West (55.3%) reported the most interruptions, while households in the more urbanised Western Cape (5.2%) and Gauteng (9.9%) experienced the fewest



Provinces	# WSA's	# Supply Systems	# WTW	Average BDRR	Municipal BDRR
Eastern Cape	14	187	248	52.5%	51.6%
Free State	19	77	86	65.5%	61.9%
Gauteng	9	29	24	40.6%	41.0%
KwaZulu-Natal	14	204	260	57.9%	50.4%
Limpopo	10	87	104	64.4%	61.6%
Mpumalanga	17	112	121	50.3%	54.8%
Northern Cape	26	199	182	56.0%	51.5%
North West	10	164	133	82.3%	63.5%
Western Cape	25	127	149	34.9%	34.1%
Total	**144**	**1 186**	**1 307**	**57.5%**	**50.8%**

Figure 5 National Blue Drop Risk Rating 2021

interruptions. This is not a coincidence, if only because locations of urban interruptions can be more easily reached for repairs. Approximately a quarter (28.6%) of South African households reported some dysfunctional water supply. Given that reported interruptions were 25.7% in 2015, the latest GHS report indicates a worrying downward trend in functionality.

Several other sources such as the Municipal Strategic Self-Assessment reports for each WSA, provided by the DWS, generally corroborate the findings of the Blue Drop progress assessments and are in turn substantiated by the practical experience and knowledge of the SAICE Water Engineering Division members.

South Africa loses nearly 41% of its treated water through leaks and illegal connections. The latest estimates from DWS put the cost of these losses at about R8 billion a year. The majority of WSAs therefore cannot account for at least one third of the water they produce or buy. Most of this is the result of poorly maintained infrastructure. Despite this, projects are launched to augment current water supply in the same areas without serious efforts to curb losses. As a result, the opportunity to eliminate or postpone the implementation of costly additional infrastructure is lost. Moreover, instead of the new infrastructure being viewed by WSAs as a precious gift to be cared for, it is often neglected and allowed to fall into dysfunctionality and/or disrepair.

Sanitation services infrastructure

Sanitation services comprise the provision of on-site or reticulated sanitation, and the conveyance and treatment of wastewater. Responsibility for providing sustainable sanitation and the safe treatment and disposal and/or reuse of wastewater lies within the mandate of WSAs with the DWS as the regulator.

The percentage of households nationally with access to improved sanitation increased from 61.7% in 2002 to 84.1% in 2021. That 84.1% was made up as follows:

- 64.8% used flush toilets that were either connected to a public sewerage system or septic or conservancy tanks
- 19.3% used engineered on-site sanitation systems such as the ventilated improved pit latrine (VIP).

Some 15.9% of households did not have access to improved sanitation, but used simple pits, convenient open spaces, or other makeshift arrangements.

Bearing in mind that the performance of a sanitation service is a function of the combination of infrastructure and its condition on the one hand, and on the other hand the skill with which this infrastructure is operated, the performance of wastewater treatment systems varies widely across the country. Some sanitation systems give excellent results, but others fail in many critical respects.

It must also be borne in mind that a treatment works is only part of a system. A reticulation system collects from the sewered area. While almost always flowing under gravity, in some specific instances pumping of low points is also required. Some of the most publicised incidences of sewage impacting on the environment have been because of pump failure, e.g. from Emfuleni into the Vaal River, and eThekwini

where, because of pump station failure, faecal material periodically contaminates popular swimming areas leading to closure of beaches. Even more widespread are sewage spills because of blockages in the reticulation.

This SAICE IRC sanitation services report uses information from various publications as indicators for the grading of existing infrastructure because no direct data on its condition is readily available. By far the most comprehensive and up to date of these publications is the Green Drop Report 2022, released by DWS in April 2022. It describes the results of the 2021 assessment of every wastewater system (including wastewater treatment) of any consequence and provides a cumulative risk rating for each wastewater treatment works.

The Green Drop Report 2022 provides feedback on the assessment of all Water Services Institutions (private companies, municipalities and other government institutions) with 995 wastewater networks and treatment works, comprising 850 municipal wastewater treatment systems, 115 systems owned by the national and provincial Departments of Public Works, and 30 privately-owned systems. It does not however report on on-site sanitation systems.

Table 3 Legend for Green Drop scores

Colour code	Score	Description	No. of WSAs
	90% to 100%	Excellent: Need to maintain via continued improvement	2
	80% to 90%	Good: Improve where gaps identified to shift to 'Excellent'	13
	50% to 80%	Average: Ample room for improvement	25
	31% to 50%	Very Poor: Need targeted intervention towards gradual sustainable improvement	39
	0% to 31%	Critical: Need urgent intervention for all aspects of wastewater services	65

Figure 6 illustrates that the Green Drop scores are, on average, higher around major urban areas.

Only 23 wastewater systems achieved Green Drop Status. A further 30 received high scores except in that microbiological

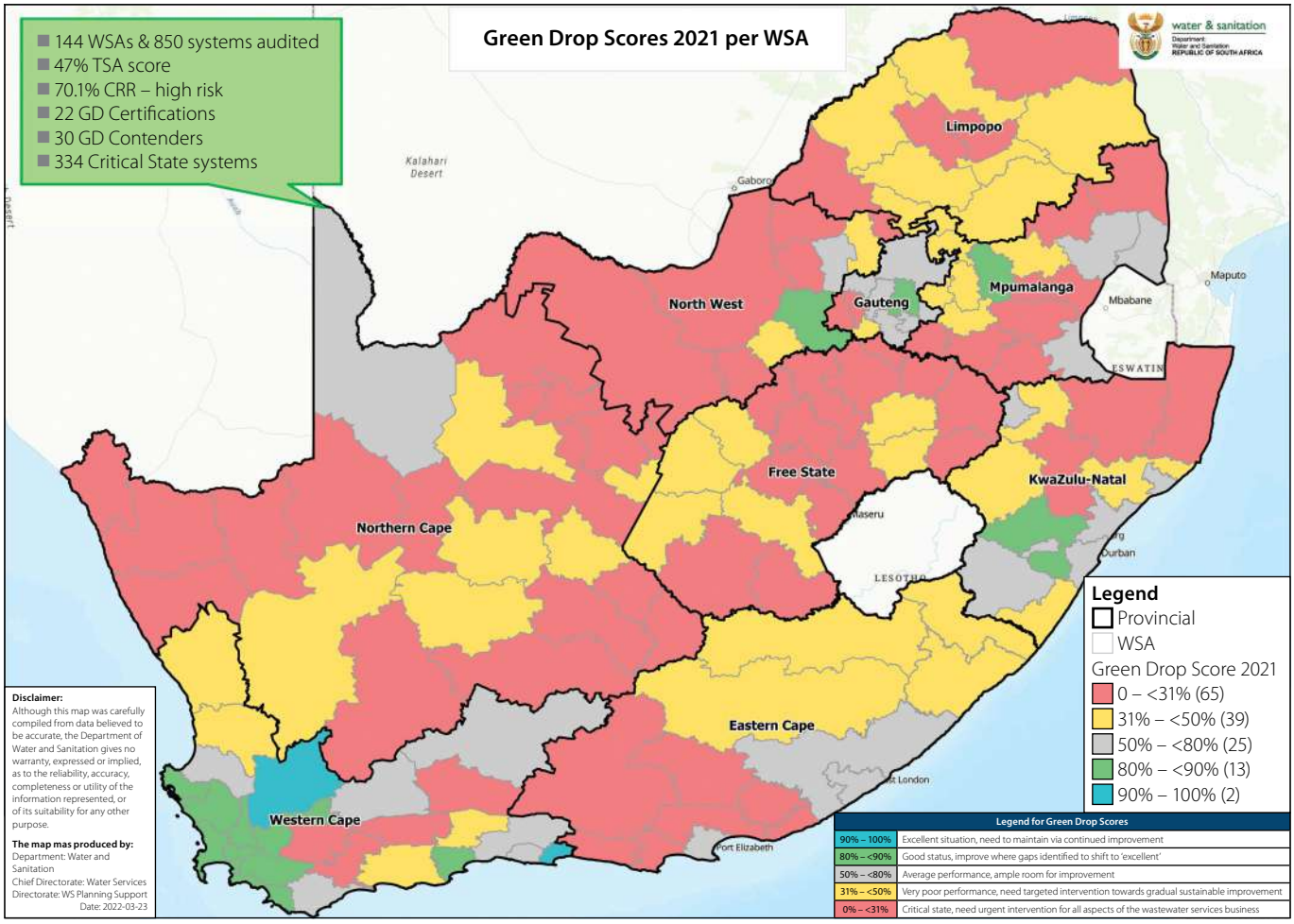


Figure 6 Green Drop scores 2021

and chemical effluent quality did not meet the Green Drop standard.

When comparing the latest Green Drop report with previous ones, it is clear that performance gradually improved in the period 2009 to 2013 but now, according to the 2022 report, has declined back to 2009 levels. In 2009, 33 Green Drops were awarded, 40 in 2011, and 60 in 2013, but only 22 in 2022. Even more worrying is the fact that a total of 334 (39%) municipal wastewater systems were identified to be in a critical state in the 2022 report, compared to 248 (29%) in 2013. The downward trend exposed in the latest report is a clear indication that standards dropped in the nine years during which regulatory supervision slackened.

Wastewater systems which failed to achieve the minimum Green Drop target of 31% have now been placed under regulatory focus. DWS will attempt to turn these around or will arrange for suitable interventions by a capacitated water board or any other suitable mode of sanitation services support.

In respect of on-site sanitation systems, there is no up-to-date central database of the condition of the engineered systems, much less of any informal systems. However, the information that is available suggests that many of the engineered systems have filled up and are therefore no longer usable. In response to this, few municipalities have policies on pit emptying, let alone pit-emptying programmes or control over householders disposing of the faecal sludge themselves.

The following observations from the Green Drop audits are of interest:

- Several institutions have invested in infrastructure upgrades, extensions, and refurbishments. However, usually because maintenance and/or operation has been sub-optimum, within a few years these systems fail to meet the regulatory standards (e.g. effluent from treatment works not meeting quality limits). Other reasons for failure include that, even when new, they do not meet accepted engineering and workmanship standards – in some cases the work is left incomplete.

- Sometimes a treatment works is taken out of commission while infrastructure is being upgraded, allowing untreated wastewater to bypass directly to the receiving water body.

- Non-payment or very late payment of contractors, laboratories and other professional service providers is widely found, leading to services not being rendered, or being delayed or discontinued.

- Vandalism and theft have been playing an increasing role. Few WSAs have effective counterstrategies or contingency plans in place.

- Of the greatest concern is the overall sub-standard quality of final effluent and biosolids being discharged to their receiving environments. This increases the risk of diseases being transmitted, especially to communities downstream.

- Institutions have varying capacity and competency in terms of plant managers/superintendents, process controllers, engineers, technicians, technologists, and scientists, while having reasonable access to contracted maintenance and laboratory services. Institutions with lower technical skills ratios are generally associated with lower Green Drop scores. Related to this is that many WSAs are unable to undertake the required monitoring of operational and compliance parameters.

- Many wastewater systems are operating close to or beyond their hydraulic capacity, while a high number of WSAs do not know the design capacity or actual inflow to their treatment works. WSAs are thereby limited in their ability to plan to meet medium-term demand projections, or to confirm if spare capacity is available.

- In general, there is a low level of awareness of energy efficiency and conservation at most WSAs. The majority of WSAs do not monitor their energy consumption, but statistics of most of those that do show they exceed the industry and technology benchmarks. This means that many opportunities are forfeited to improve energy efficiency, reduce cost, and mitigate CO_2 footprint.

Solid waste management

Solid waste management needs to be evaluated in terms of both collection and disposal.

Solid waste collection should be evaluated in terms of the service provided rather than the infrastructure used. But precisely what that service should be varies, particularly in reflecting the different requirements for urban and rural areas. Moreover, it depends upon the service the municipality is contractually committed to provide. For example, if it is supposed to be a twice-weekly kerbside collection service, but most weeks the municipality only collects once, the service would not be

rated as poor, given that in other municipalities a once-weekly service would be regarded as acceptable.

The state of the solid waste management service as a whole is evaluated in terms of how close a municipality is to providing a service in terms of the draft National Waste Collection Standards – as noted above, varying standards apply. A further complication in some circumstances is that on-site disposal, rather than municipal collection, can be considered an appropriate level of service in terms of the National Policy on Free Basic Refuse Removal.

The 2020 National Waste Management Strategy outlines critical matters such as waste minimisation, effective and sustainable waste services, compliance, enforcement and awareness (education). It also addresses (a) the role of waste pickers and others in the circular economy, (b) regulation/economic interventions to increase separation at source programmes, (c) skills gaps in the sector and (d) Treasury interventions regarding operational expenditure.

Solid waste disposal can be assessed as good if there are well-managed licensed disposal sites and as poor if they are not well managed. There are, however, areas where there are no disposal sites with the result that dumping of waste takes place anywhere. Compared to this situation, an unlicensed site that is well managed could be considered a "good" level of service.

There is a dearth of up-to-date information on the state of solid waste management services – the last national State of Waste Report was published in 2018. Other sources consulted by SAICE were of more recent vintage but were generally of samples of municipalities. Moreover, most available data relates to backlogs, i.e. areas unserved, rather than to the status of current services.

Waste collection services

In 2016 – the latest year with available data – refuse was removed at least once a week for 68.6% of households living in formal dwellings, while 78.7% of households living in traditional or rural dwellings dumped on site or utilised their own refuse dumps. Some 45.8% of informal dwellings had some form of municipal service, whereas communal containers and refuse dumps were used by 15.6% of households. The national averages for households with no collection service were 11.7% of informal dwellings and 9.5% of traditional dwellings. This is despite the targets set in the National Policy on Free Basic Refuse Removal.

In 2021 an NGO researched removal of solid waste in the Mpumalanga and Western Cape provinces. In the Western Cape more than 80% of households have weekly removal services. In most cases this has increased by about 10% since 2011. In the Mpumalanga province, by contrast, figures as low as 4.5% and as high as 70% are reported, with a general decline of 3% to 5% in service levels since 2011.

Waste disposal services

Assessing the status of waste disposal services in South Africa requires consideration of whether:

- Disposal sites are licensed
- Licensed disposal sites are compliant with the licensing conditions
- The disposal sites are adequate for future demand.

As a national average, 64% of solid waste disposal sites are licensed. Provinces have between 35% and 96% licensed.

The same NGO, also in 2021, undertook an audit of the compliance of 153 municipal landfill sites around the country, assessing access and controls, resources, operations, drainage and monitoring, and recordkeeping. 126 did not comply with the minimum requirements of the licensing conditions. Gauteng (9 of 17 sites) and Western Cape (12 of 27 sites) were the only two provinces that showed some form of compliance.

Almost all urban areas are running out of approved or licensed space at landfill sites.

Recycling is helping to reduce the amount of waste to be collected and disposed of, but not by much. Whereas 54% of mainstream recyclables are currently recycled, with scrap metal doing the best at 80% and e-waste doing the worst at 14%, the percentage (by tonnage) of all mainstream recyclables diverted from landfill sites is less than 4%. Targets for waste reduction and recycling set by various industry bodies are some way off realisation (e.g. targets for paper and packaging, pesticides, lighting and tyres).

Attention is also drawn to the constraints in terms of airspace and the costs of commissioning and operating new landfills. Mention is made of the relatively high percentage of recycling in some sectors but much lower percentages in others. Most municipalities are simply not meeting requirements in terms of service levels. This confirms the overall impression gained from the various other references and sources.

The conclusion is that there has been some regression over the past five years, hence the lower grades given.

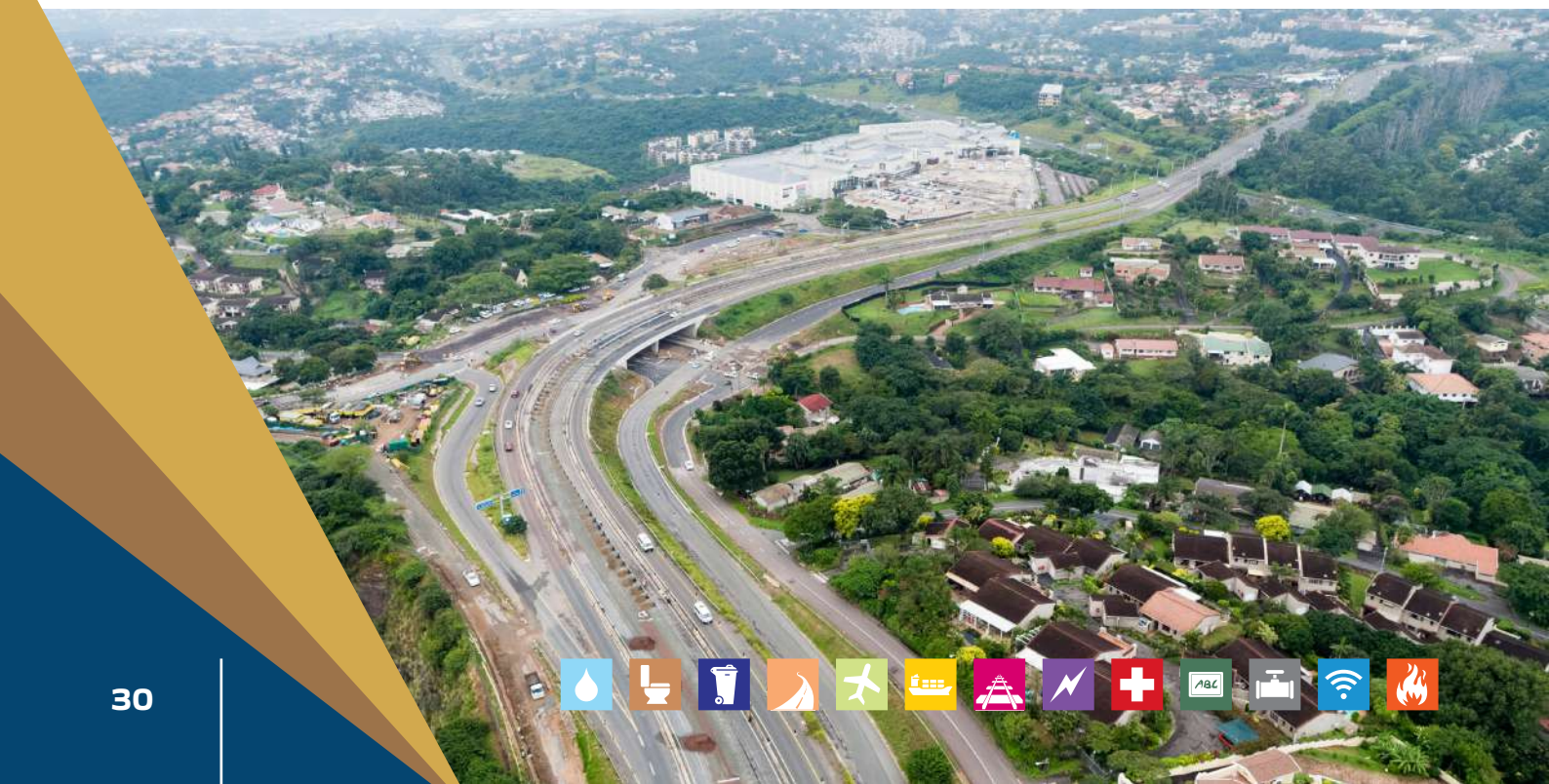
Road infrastructure

South Africa's road network is approximately 750 000 km in length and said to be the tenth longest road network of any nation. Responsibility for it is split as follows: (a) primary intercity, with economic roads mainly managed by SANRAL on behalf of the Department of Transport (DoT); (b) the secondary and tertiary intercity network, primary access and mobility roads, largely managed by the nine provincial departments; and (c) the urban and rural municipal roads managed by local authorities. Table 4 refers.

Table 4 Records of road lengths in South Africa (Department of Transport)

An overview of the South African road network			
Authority	**Paved**	**Gravel**	**Total**
SANRAL	21 403	0	21 403
Provinces – 9	47 348	226 273	273 621
Metros – 8	51 682	14 461	66 143
Municipalities	37 691	219 223	256 914
Total	158 124	459 957	618 081
Un-proclaimed (estimate)		131 919	131 919
Estimated total	**158 124**	**591 876**	**750 000**
*rounded estimate			

The general state or condition of a surfaced or gravel road network is customarily described in terms of a visual condition index (VCI) using a five-point scale, i.e. very good, good, fair, poor and bad (very poor). Ideally, the VCI is assessed annually (or at least biennially) and, if reported over time, shows the trend in road condition. Knowledge of this condition, and of



Type	Year	Very good	Good	Fair	Poor	Very poor
Length (km)	2021	3 164	9 153	8 398	1 478	60
%	2021	14.22	41.13	37.74	6.64	0.27

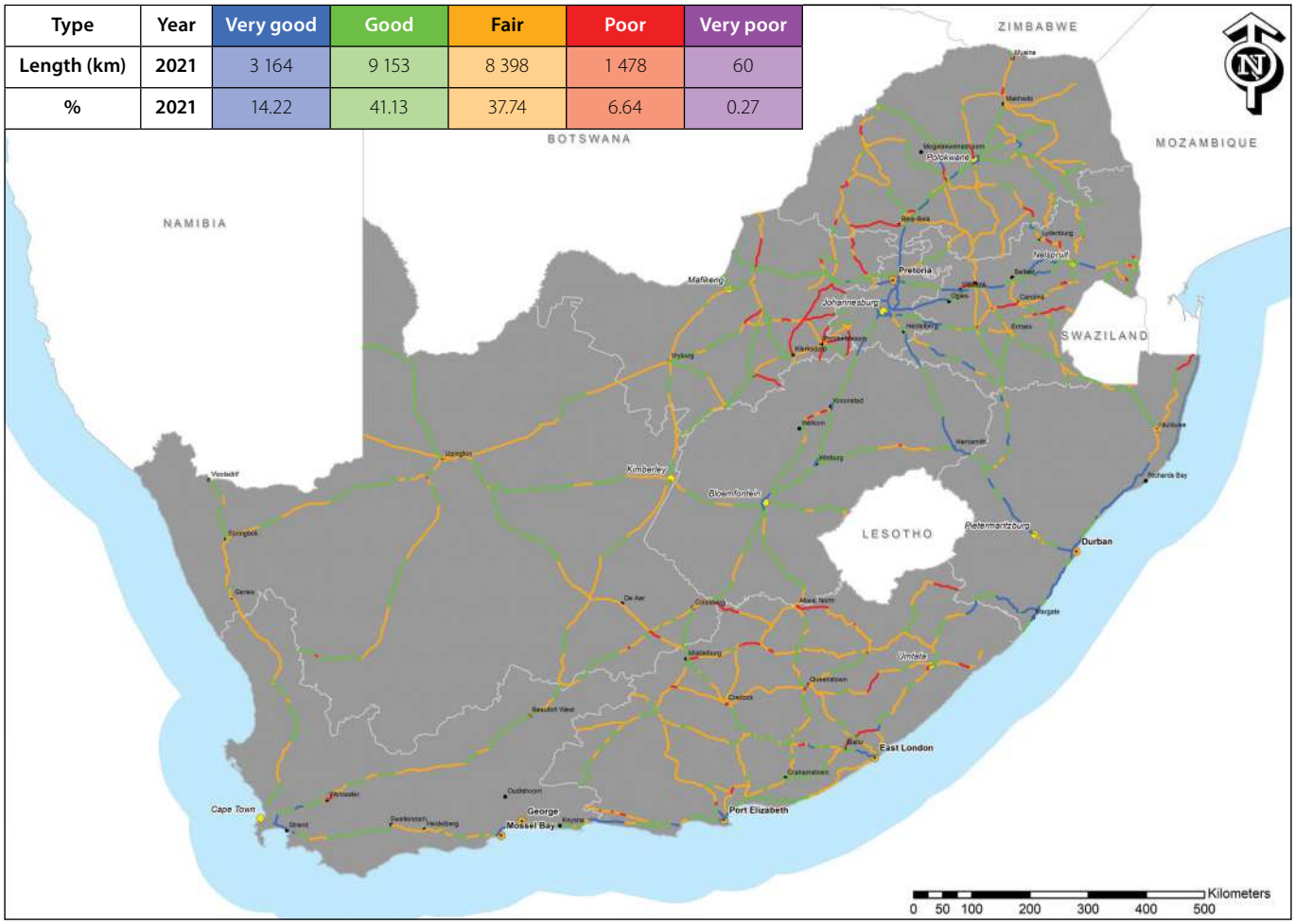


Figure 7 The SANRAL 2020/21 pavement condition (SANRAL, 2021)

these trends, should inform the road construction, rehabilitation and/or maintenance priorities of the owner of the road.

In practice, few South African road authorities undertake regular condition assessments of their road systems. However, good information, for example with respect to reasonably up-to-date VCI data and knowledge of infrastructure plans and budgets, was obtained from:

- SANRAL
- Two provincial roads authorities (Western Cape and Mpumalanga)
- The majority of the metropolitan municipalities.

The SANRAL 2020/2021 pavement condition is shown in Figure 7.

Information from other roads authorities, in particular district and local municipalities, was comparatively scarce and too incomplete to enable general conclusions to be drawn, other than to infer that authorities which are not sufficiently informed of the condition of their roads would very likely also not be able to manage these assets in a satisfactory manner.

Thus, because it has not been possible to obtain sufficient reliable road condition data for non-metro municipalities other than in the Western Cape, the report card is able to offer a 2022 equivalent to the 2017 grading for "other municipalities' paved roads" only on the basis that, from what is known, their roads generally suffer from significant and increasing maintenance neglect.

The majority of roads authorities, provincial and municipal, do not have up-to-date knowledge of the condition of their road systems – it may be that the last condition assessment was done years ago, and/or that a condition assessment was done on only a portion of the network. Only a minority of authorities maintain a pavement management system. However, knowledge of the condition of their road systems, together with knowledge of the usage of the system, is essential for prioritisation of expenditure. For example, it is standard practice to ensure that roads that are more important to the economy receive preferential attention. The Mpumalanga and Western Cape provincial roads departments, which follow this practice, are thus able to ensure that roads carrying higher volumes of traffic are kept in better condition. As Figure 8 illustrates, the expenditure per kilometre on the more densely trafficked roads is higher.

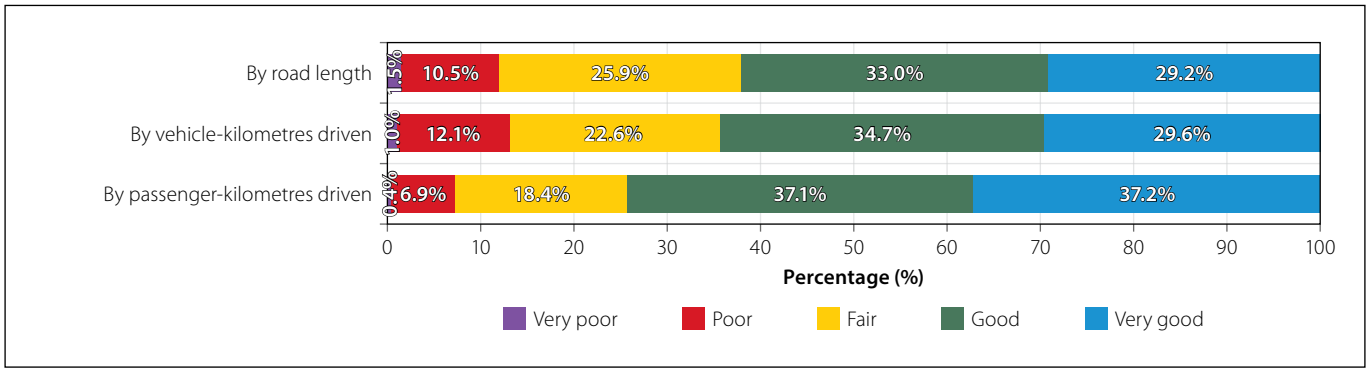


Figure 8 Western Cape paved road condition by road length, vehicle-km and passenger-km (2019)

However, higher traffic is not – or should not be – the only determinant of road maintenance prioritisation. For one thing, it leads to funding year after year being allocated to roads in good condition, whereas low-volume routes are correspondingly neglected. Consider though that a particular road might carry a very low volume of traffic, but is the only link for some otherwise isolated communities. Surely this road should receive better attention than its count of low vehicle-kilometres driven would suggest.

The consequences of the widespread underfunding of road condition maintenance and improvement, year after year, are seldom assessed by roads authorities. Of the provinces, only Mpumalanga and Western Cape were able to report on this. Figure 9, which illustrates a prediction of far less "very good" and far more "very poor" lengths, should give cause for concern.

The Mpumalanga coal haul roads, vital to the South African economy, may serve as another example of the consequences of underfunding. The current Medium Term Expenditure Framework funding level for coal haul roads, for fog sprays, reseals, rehabilitation, re-graveling and upgrading to paved standards of unpaved roads, at an average of R328 million per annum for the period 2020 to 2029, is insufficient to prevent further deterioration of the coal paved road network. An annual funding level in excess of R1 190 million is necessary to maintain paved coal haul roads with preventative maintenance and rehabilitation treatments to ensure that the proportion of roads in "poor" and "very poor" condition stays below an acceptable 10% of the network length.

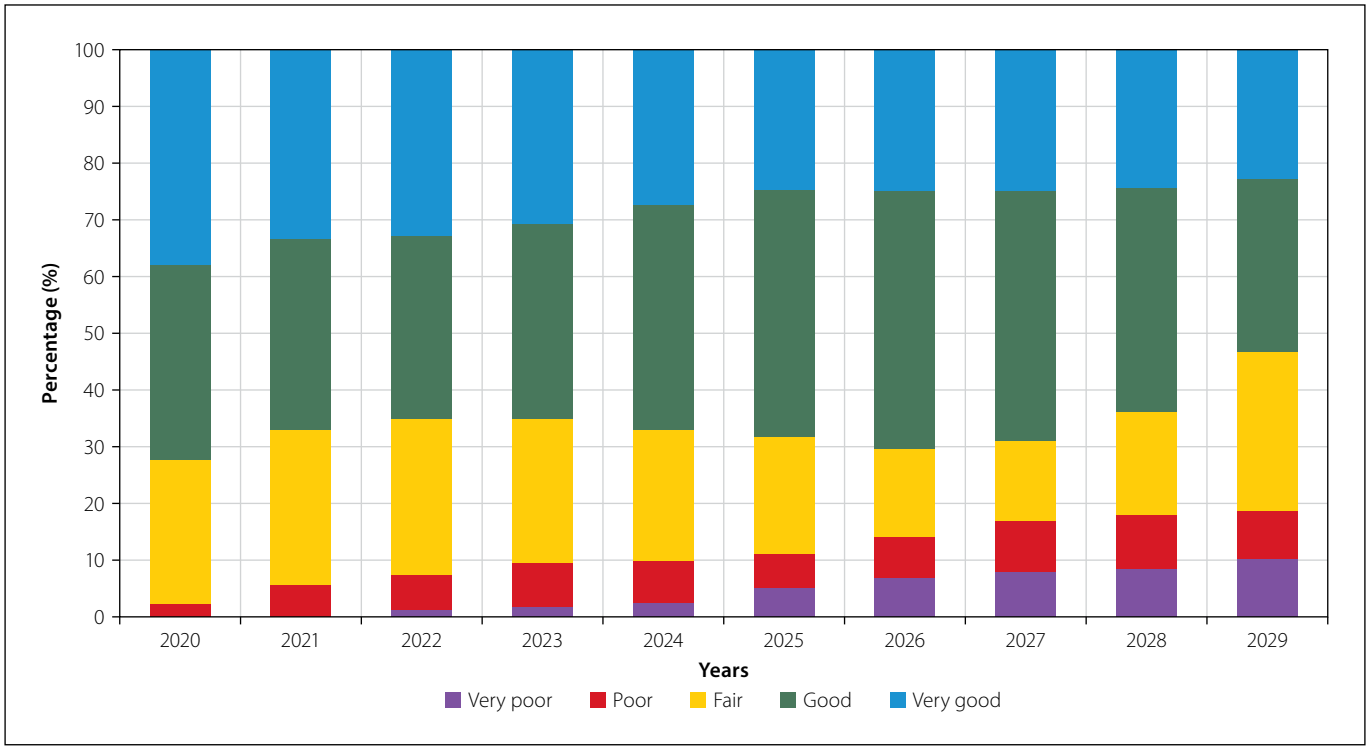


Figure 9 City of Cape Town predicted condition deterioration with no change in maintenance budget allocation

To conclude, the following general observations should be of value:

- There is no reliable database (Table 4 notwithstanding) of the lengths and ownerships of roads. Comparison between information sources reveals apparent duplication of ownership, sections of road with no owner, and other discrepancies.

- The limited capacity of the majority of road authorities is of great concern. The importance of skills and experience in each phase of project processes cannot be overemphasised, nor can the need for systems for assessing and recording road condition and road construction and maintenance work needed and completed.

- There are variations in the ways that authorities report expenditure. A uniform reporting system needs to be developed.

- Prioritisation of road expenditure is happening within all the provinces and authorities but, although guidance is given in the Technical Methods for Highways 22 Road Asset Management Manual, there is currently no uniformity in how these maintenance schedules are set, leading to significant differences in approach.

- Areas where greater policy clarity is desirable include (a) a consistent methodology for prioritising road expenditure and (b) a consistent methodology to estimate the economic significance of roads within the provincial networks.

- The secondary and tertiary intercity road network is undergoing accelerated deterioration, so much so that both the efficiency and cost of moving freight on the network face severe challenges. In addition, road safety is compromised by the condition of the network.

- Widespread overloading of roads and poor stormwater management are further major contributory factors to the deterioration of the road network. Sometimes this damage can be limited by (in the case of overloading) more effective policing or (in the case of poor drainage) a high standard of stormwater system maintenance. But increases in surface runoff because of more extensive urban development and thus more impermeable surfaces can cause stormwater infrastructure, even if in good condition, to no longer be able to cope.

- The gravel road network is too extensive and the budgets too constrained for the entire network to be kept in a satisfactory condition.

- A positive move has been that in 2018 the DoT initiated a programme to force provincial road authorities to develop, maintain and operate proper pavement management systems. DoT would then be able to measure annual performance plans for municipalities and provincial road authorities. This process was interrupted by the Covid-19 travel bans and progress is therefore not where it was planned to have been.

While it is the road infrastructure that is discussed here, it must not be forgotten that most South Africans depend heavily on public transport, which is the main mode of transport for 73% of all South African households. Moreover, not only do many users of public transport walk considerable distances as part of their daily commute, but some 20% of workers walk all the way to their place of employment. These statistics point to the need for improved public transport as well as non-motorised transport infrastructure, which in practice is often lacking and, even when available, not captured in asset registers. The lack of non-motorised transport infrastructure is one of the main contributors to the extremely high number of road fatalities in South Africa. The country recorded a total of 12 577 road fatalities in 2021, of which over 40% were pedestrians.

Airports infrastructure

In 2020 the Covid-19 pandemic led to a *de facto* shutdown of the aviation industry. In April 2020, passenger traffic globally fell by a staggering 94% year-on-year – an unprecedented contraction – which brought with it a corresponding devastating loss for both aeronautical and non-aeronautical revenue. Although air cargo movement increased dramatically during the pandemic, 2021 revenue was still less than half of peak pre-pandemic levels.

Worse still, because of the sustained impact of the pandemic, the recovery has been prolonged when compared with historical major aviation shocks (e.g. September 2011 attacks in the USA, SARS virus and the 2008 global financial crisis). Key skills were lost during this period and many airlines and airports have consequently been unable to cope with the demand since global economic activity has resumed (Figure 10).

ACSA owns the major airports that enable more than 80% of South Africa's international and domestic commercial air travel (the IRC does not consider the secondary commercial airports or the many minor airports and landing strips around the country).

The nine airports that ACSA owns and operates are:

- Three major international airports: Oliver Tambo International in Johannesburg, Cape Town International, and King Shaka International in Durban
- Six smaller commercial airports: George Airport, Bram Fischer International Airport in Bloemfontein, Upington Airport, Kimberley Airport, Chief Dawid Stuurman International Airport in Gqeberha and East London Airport.

These airports together have a throughput capacity of 27.25 million passengers. Actual passenger numbers peaked at approximately 21 million in 2019.

ACSA is responsible for the property as a whole at all nine airports. The runways, taxiways, terminals and some of the hangars and technical areas are its particular concern. ACSA also owns the instrument landing system equipment, which is maintained by Air Traffic and Navigation Services.

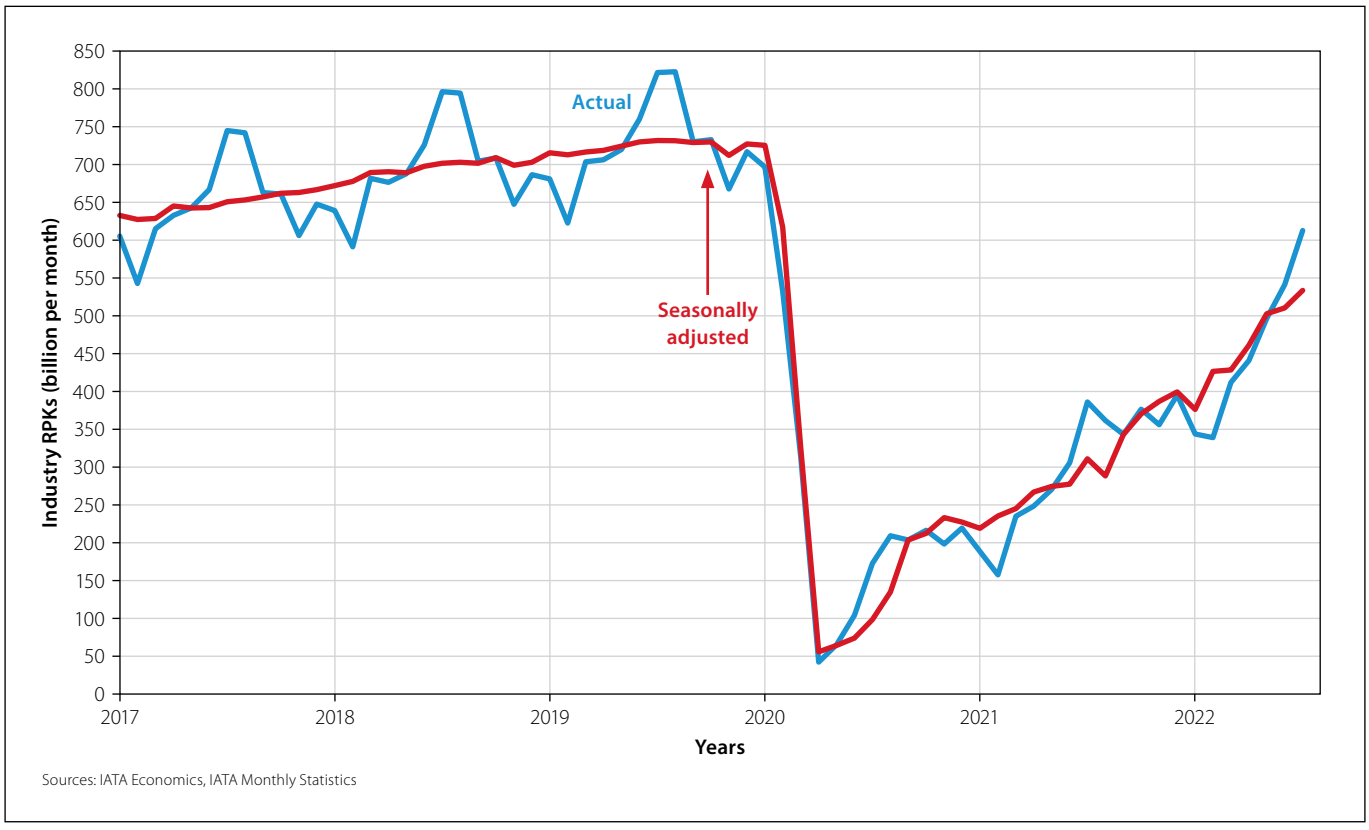


Figure 10 Global air passenger volumes (in revenue passenger kilometres – RPKs) to July 2022 (IATA Economics, July 2022)

ACSA is required to pay close attention to the condition of its infrastructure to comply with regulatory authorities, especially the International Civil Aviation Organisation and the Civil Aviation Authority of South Africa.

Instrument landing systems, runway approach lights and airfield ground lights have the highest priority as they are crucial to safety. The next priority grouping covers runways, baggage handling systems, fuel hydrant lines, security, emergency power generation and lighting within terminals, and all "people movers" such as lifts, escalators, travelators, loading bridges, shuttles, etc. All ACSA airports have standby generators with enough capacity to meet the power needs of the high priority elements.

During 2018/19 ACSA began to implement a new airport management system, populating it with a visual assessment survey (expressed as a pavement condition index (PCI)) at all the airports, and incorporating detailed modelling of deterioration in condition. However, because of Covid-19-associated delays, the first full condition assessment has not yet been completed.

Although major rehabilitation works were also halted by Covid-19, this did not result in a major downgrade in the current PCI ratings because of the reduction in traffic-induced wear and tear on infrastructure. However, surface deterioration, which is mostly due to exposure to environmental effects (e.g. asphalt hardening and brittleness due to ultra-violet exposure), continued. The PCI index of critical infrastructure may therefore have deteriorated since the 2019 rating, but probably not significantly.

ACSA has shown resilience to both natural and man-made setbacks, particularly by establishing parallel supply channels (alternative rail routes for aviation fuel, filtered borehole water and sufficient standby electricity generation capacity) until normal supplies stabilised.

ACSA's success in operating and maintaining its airports has in the past been attributed to its strong financial state, competent technical and managerial staff, and mandatory regulatory compliance. However, revenue for the 2020/21 financial year was less than a third of the R7.1 billion generated in the previous financial year, and the company declared a loss of R2.6 billion – only the second loss-making year in the company's 28-year history.

The 60% decline in air traffic movements in 2020/21 led to the loss of significant human resources and the rescheduling of capital projects at all airports. The 2021/22 financial year showed an improvement in passenger numbers and revenue, although income was still 45% lower than pre-pandemic levels and ACSA again declared a loss.

As a consequence, maintenance and refurbishment over these two financial years became limited to keeping airports operating safely and efficiently. The current general appearance and condition of the airports reflects this prioritisation.

Covid-19 also impacted operational and safety considerations. For example, in August 2020 the regular re-certification of instrument landing systems was delayed due to the nationwide (and global) lockdown – not a desirable situation. Moreover, because of a current impasse between ACSA and the service provider, there is reason to believe that the age and capability of security equipment has also been compromised.

By mid-2022 international and domestic travel demand in South Africa had recovered to approximately 30% and 80% respectively of pre-Covid-19 levels. It remains to be seen how the recovery in aviation is handled with the significantly diminished technical skills base at ACSA's disposal, combined with the reduction in revenue.

Commercial harbours

South Africa has nine commercial ports, namely Saldanha Bay, Cape Town, Mossel Bay, Port Elizabeth, Ngqura, East London, Durban and Richards Bay, with the ninth being the much smaller Port Nolloth. All these ports are owned by Transnet, a state-owned enterprise, and wholly owned by the South African government. Its business unit, Transnet National Ports Authority (TNPA), is responsible for the ports and associated infrastructure.

The TNPA owns and is responsible for the ports and their infrastructure and is the "landlord" of the terminal operators.

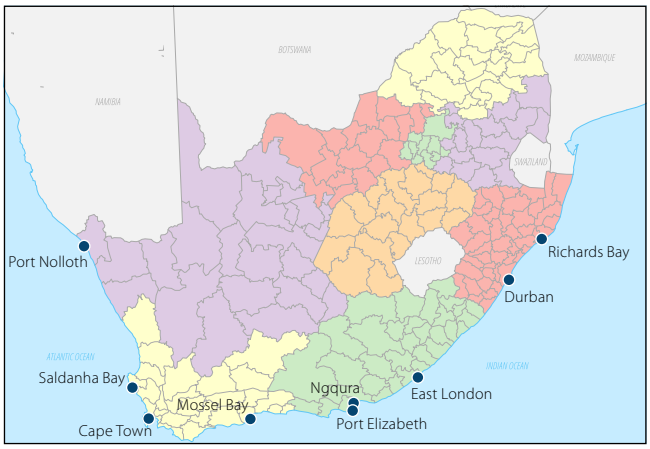


Figure 11 Location of commercial ports

Another Transnet business unit, Transnet Port Terminals, is one of several terminal operators (others include Bidvest and major oil companies). Each of these is responsible for its own equipment, such as straddle carriers, cranes and conveyor belts, and terminal facilities such as grain elevators.

This report deals only with the infrastructure for which TNPA is responsible, being primarily:

- Breakwaters and seawalls
- Navigable areas (including services such as dredging)
- Quays and other berthing structures
- Roads and paving
- Railway infrastructure
- Buildings (including office buildings, workshops and sheds, electrical sub-stations, etc.)
- Other structures and utilities, including bridges and culverts, tunnels, retaining walls, drydocks, slipways, Syncrolifts, fencing, and underground services (including water and sanitation and fire protection systems)
- Electrical and mechanical aspects of the above, including lighting and pumping
- Navigational aids (not only within ports, but along the coast e.g. beacons, lighthouses and telecommunications).

While all the ports handle general cargo and provide bunkering (refuelling) services, some focus on bulk commodities, such as exporting iron ore and importing petroleum at Saldanha. Others predominantly serve only one major industry, like the offshore oil industry in the case of Mossel Bay. While others may specialise in one cargo type, they also have facilities for the handling of different types of commodities. Between them they have 127 vessel berths handling more than 160 million tonnes of cargo annually. Of these, break-bulk operations utilise 42 berths, dry-bulk 30 berths, container operations 18 berths and liquid bulk operations 16 berths.

The throughput of most of the ports decreased between 2019 and 2021, most likely because of the state of the economy and the effects of the Covid-19 pandemic on international trade. This resulted in a nett financial loss for TNPA for the first time in recent years. TNPA's total revenue decreased from R12.17 billion in 2020 to R11.56 billion in 2021.

The implication of this financial position is that the organisation cannot, from the strength of the balance sheet alone, make the necessary infrastructure investments to grow the business. Given that some of the ports already operate close to capacity, major capital investment will need to be made to increase cargo handling capacity. Transnet and its subsidiaries have therefore been seeking to capture growth opportunities through partnerships and collaborations, making use of private sector participation. Private sector investors have already indicated their interest in initiatives such as the Durban hub strategy which seeks to double auto capacity and create an import fuel terminal, and the Ngqura plan to expand into a regional transhipment hub

while also being the primary manganese export channel for the country.

TNPA is responsible for sustained functionality of its assets, safe conditions for port users, and the facilitation of safe navigation along the coast of South Africa. These assets must be maintained to a high standard, which requires in the first instance knowledge of the condition of the assets. Accordingly, asset condition assessments are undertaken in line with the TNPA Asset Maintenance Principles and Procedures (AMPP) guidelines. These guidelines provide the framework in terms of which engineering assets are inspected and assessed, and maintenance then planned.

The AMPP process typically includes the execution of the following:

- Regular and annual visual inspections
- Determination of workload and tasks required based on inspection findings
- Planning of the required maintenance works
- Budgeting and costing of the required works
- Execution of the required maintenance
- Continuous audit of work done and asset condition.

The eight port engineers (Port Nolloth's inspections are done by Port of Cape Town engineers) are required to ensure that all infrastructure is inspected annually, in accordance with the AMPP. These inspections are reported to the chief engineer at Transnet's head office and are then audited by a team appointed by the chief engineer to ensure standardisation and compliance. Maintenance programmes for the following years are developed based on the findings, and the various initiatives and projects are tracked closely by the TNPA chief engineer's department.

The wet assets, such as the underwater portions of quay walls, are also audited by a consultant every few years. Inspections by divers are performed as required.

The 2017 IRC made specific mention of the need for refurbishment of most of the breakwaters. The most recent assessment of the condition of all breakwaters, conducted by the CSIR in 2018/2019, identified that they were then all in good condition, albeit with some damage. TNPA has since made good progress with a large-scale repair project to deal with the areas of concern. The main outlier is Cape Town, where sections of the breakwater now need urgent repair.

The ports, particularly Cape Town, Port Elizabeth and Durban, have facilities for drydocking of large ships. With this capacity, ship repair, properly supported and husbanded, could be a major industry and economic sector. However, on the TNPA books the drydocks run at a loss. This has led to the facilities being neglected in both maintenance and staffing. TNPA has attempted to remedy this through the government-driven Operation Phakisa initiative. Despite the planned 2019 completion date, many of the Phakisa projects remain ongoing, but TNPA remains committed to completing them.

Apart from its duties with respect to shipping, e.g. inspecting ships for seaworthiness, the South African Maritime Safety Authority exercises regulatory functions over certain infrastructure at the harbours and along the coastline, such as navigation aids like beacons and telecommunications (which are governed by international agreements) and lighthouses.

Previous IRCs have shown that money and effort have been invested in planning and initiating upgrades of both the fixed and moveable assets of each port. Efforts such as keeping entrance channels to the required depth, construction and maintenance of sand bypass systems, and dredging have been executed in an effort to maintain the ports at an acceptable standard.

Fishing harbours and coastal management

Fishing harbours

The national Department of Public Works and Infrastructure's (DPWI) Small Harbours and State Coastal Properties Development Unit, established in 2015, is currently responsible for the 12 proclaimed fishing harbours, all of which are in the Western Cape (Figure 12),

Figure 12 Location of the 12 proclaimed fishing harbours

and approximately 1 500 state coastal properties. The unit oversees the infrastructure asset management of these harbours and coastal properties and by the end of the 2021/22 financial year was close to completing a multi-year comprehensive refurbishment of all fishing harbours. This intervention included the removal of sunken vessels, dredging of basins, repairs to slipways, shore crane replacements, building renovations, security installations, and civil and electrical infrastructure repairs.

Given that the refurbishment programme is not yet completed, it is probably premature to expect the DPWI to make any firm commitments in terms of budgets, or whatever necessary, to maintaining the harbour infrastructure at the level to which it has just been restored. SAICE is, however, mindful of prior experience – a similar major refurbishment of all 12 harbours ended in 2007, but thereafter far too little was done in terms of maintenance and repair. The result was that by the time the 2011 IRC appeared, deterioration was so apparent that SAICE could grade the harbours no higher than C and reported that, despite the 12 harbours having been restored to "an excellent condition" just a few years before:

> "A regular, planned maintenance programme implemented immediately would have consolidated this upgrade. Unfortunately, this did not occur, thus harbour conditions have deteriorated significantly since 2007. Failure to implement follow-on maintenance contracts will adversely affect facilities and, by implication, the livelihoods of fishing communities that use the harbours, as well as facilities associated with tourism. This is a clear example of the results of a non-life cycle cost approach to infrastructure in general."

It is hoped that a planned maintenance programme will be instituted shortly to ensure that the now (2022) improved condition of the infrastructure is kept up. However, the prospects of this are not currently promising as the harbour operator (the Department of Forestry, Fisheries and the Environment) has neither sufficient budget nor suitable personnel.

Coastal management

The coast is subject to severe and increasing population pressure and development, both formal and informal. While there remains the legacy of past bad practice, the Integrated Coastal Zone Management Act (No. 24 of 2008) has had beneficial effects. Nonetheless, bad practices continue, for example the removal or vegetation of dune fields which, away from the seashore, are often regarded by developers as a nuisance, despite their fulfilling an essential marine purpose, i.e. preventing down-drift shoreline erosion.

Estuary management is also generally badly undertaken. In the case of the smaller estuaries that close in the dry season, "management" usually involves the artificial opening of the estuary to control the flood lines in the wet season. Management of the coastlines and estuaries, as well as the construction of seawalls, car parks, boat ramps, and tidal pools

are generally (although exceptions exist) done without due consideration of the impact on the surrounding environment which results in short lifespans.

A corps of coastal engineers is needed in the public service to provide overall coherence. In this regard, eThekwini Metropolitan Municipality has been the only municipality with the necessary competence, having some years ago established a Coastal Engineering and Management group as a part of the Drainage Department. More recently, Cape Town has established a Coastal Engineering Group as part of its Coastal Environment Department. For the rest of the coastline, competent coastal engineering services within municipalities seem to be lacking or limited to the ad hoc appointment of consulting engineers, but without the client municipality having the capacity to frame appropriate terms of reference for these consultants. Thus, coastal management, such as there is, has been mostly concerned with environmental issues and compliance with the terms of the Integrated Coastal Zone Management Act, together with ad hoc, often inappropriate, engineering when needed.

Because of the paucity of information available, it has not been possible to give an overall grading for coastal management.

Rail infrastructure

Rail usage trends

Rail passenger patronage and rail freight growth have followed very different trajectories over the last seven decades. Freight rail traffic grew by a factor of five (albeit driven by the export of coal and iron ore) while passenger transport disappeared for all practical purposes.

Despite a return to density on corridors having been an important objective over the last couple of decades, the declining trends in rail, as opposed to road market share, is a major policy failure. Gaps such as these in macroeconomic and macrologistic developments are usually caused by deficiencies in three pillars of development management, namely infrastructure, policy, and spatial planning. Safety and security have deteriorated quickly, and fewer and fewer trains

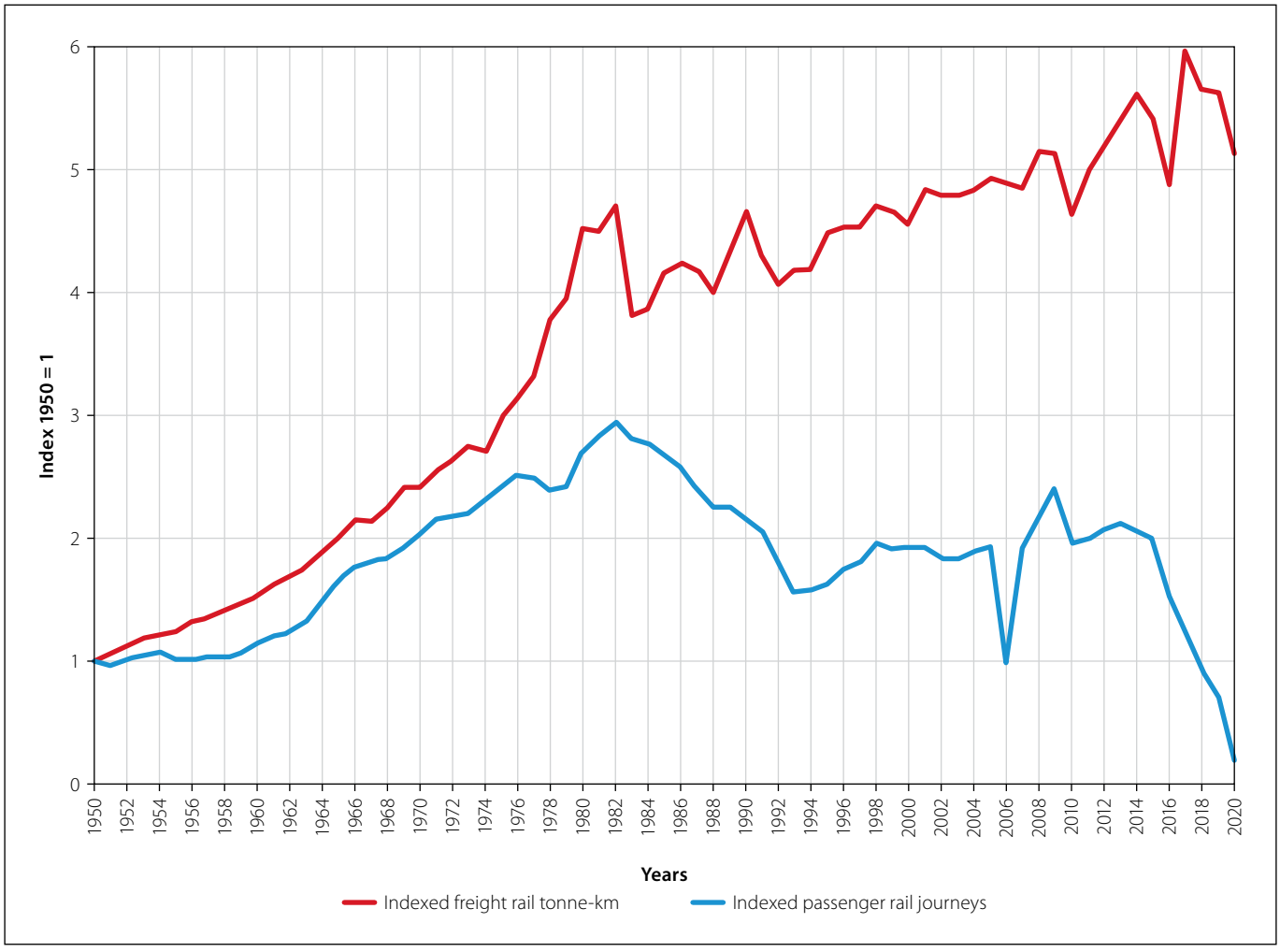
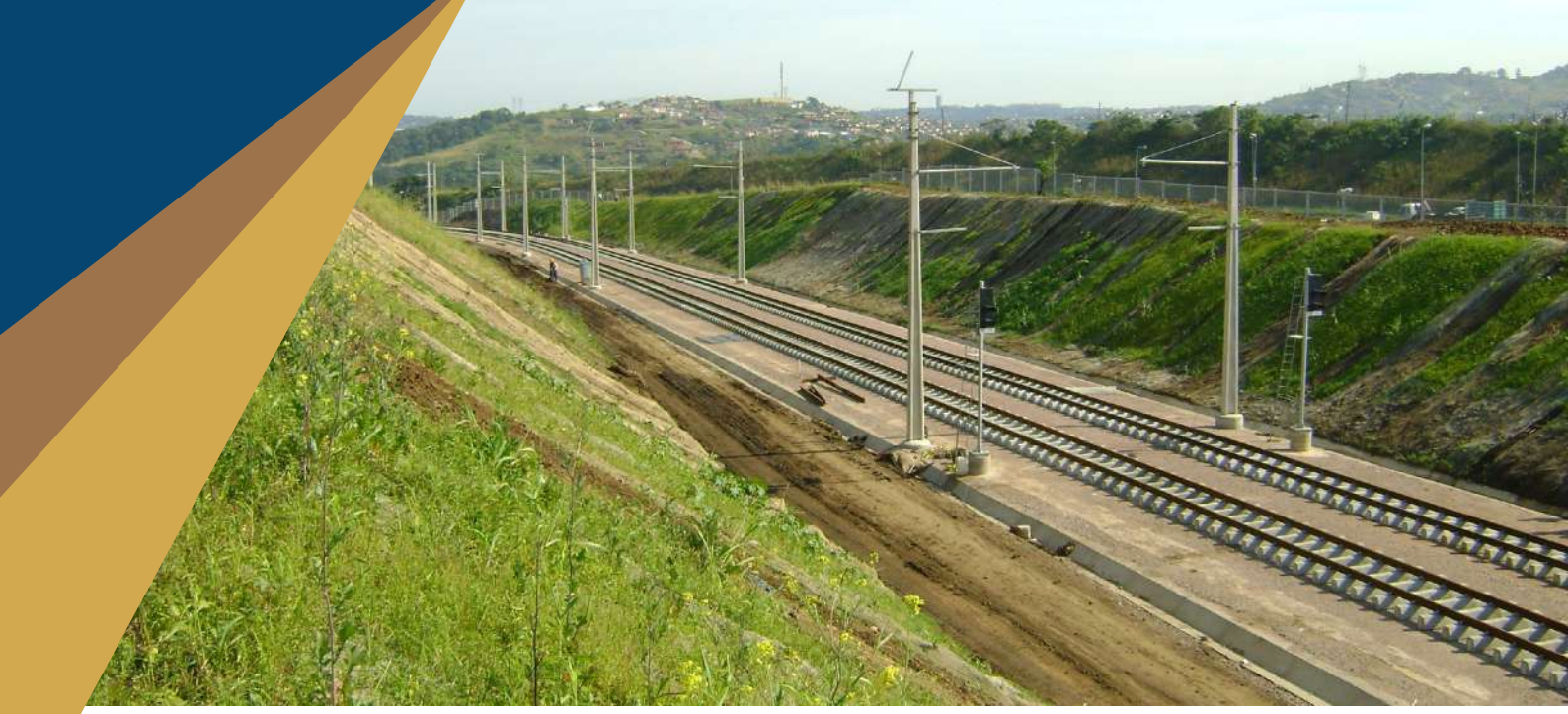


Figure 13 **Historical trends in passenger rail journeys and freight rail tonne-km (data from Transnet Freight Rail and PRASA)**



are dispatched each year due to infrastructure, process, and systems issues.

Increased vulnerability to theft, sabotage, vandalism, and therefore increased costs of security and repair or replacement, applies across the railway system with the Passenger Rail Agency of South Africa (PRASA) and Transnet Freight Rail (TFR) networks most severely impacted. New efforts are now underway to protect railway infrastructure, for example Transnet is shifting to outcomes-based security contracts, has developed comprehensive plans in this regard, and is working with the South African Police Service and security agencies to proactively address criminality.

The five distinct rail networks differ markedly in challenges, condition and performance:

- TFR network:
  - the heavy haul network
  - the general freight network (parts of which provide access for limited PRASA mainline passenger services)
  - the branch line network
- PRASA network (in metropolitan areas it shares with TFR)
- Gautrain network.

Usership

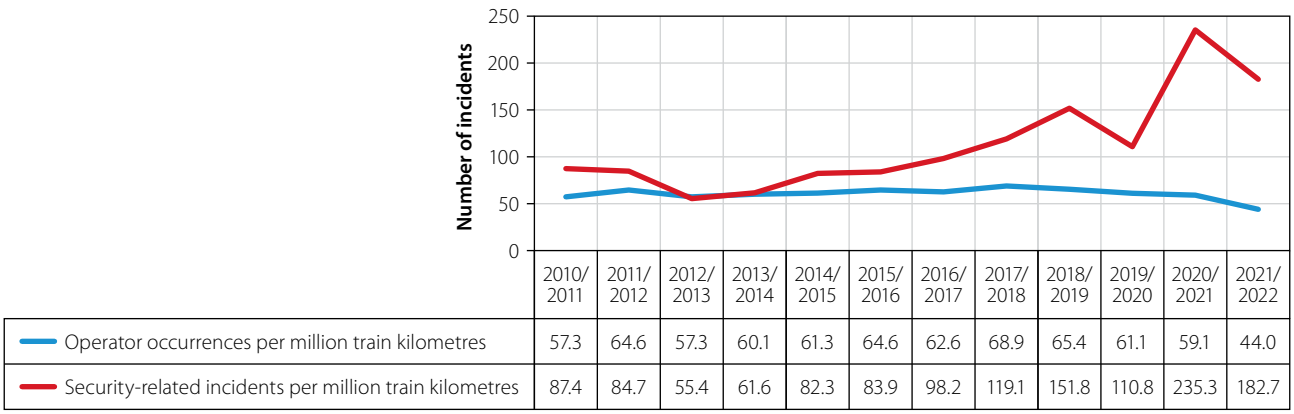
The decline in freight tonne performance across all freight segments since the last IRC publication is evident (Table 5). A slow decline has rapidly accelerated over the past two years.

The historical evolution of the freight rail network involved a focus on developing heavy haul lines without developing other corridors, a lack of general freight densification and competitive service delivery, and a failure to implement a separate management structure for low-density branch lines. This resulted in imbalances which have in turn impacted the maintenance regime. Technology has been invested into heavy haul lines to bring them to world-class standards, and maintenance spend on general freight networks has been sustained, while – with few exceptions – almost no investment has been made into branch lines.

The rising trend of sabotage, theft and vandalism has resulted in high costs of corrective maintenance as opposed to preventative or asset life cycle maintenance regimes and have impacted safety performance. Figure 14 shows that operators have been exposed to a growing trend of security-related incidents since 2013/14 with a sharp rise

Table 5 Transnet Freight Rail tonne performance (Transnet and TFR Annual Reports 2017–2022)

	2017	2018	2019	2020	2021	2022
Export coal million tonnes	73.8	77.0	72.01	72.52	66.9	58.3
Export iron ore million tonnes	57.2	58.52	58.43	58.85	53.0	54.6
General freight million tonnes*	88.1	90.76	84.69	80.99	63.4	60.2
Total TFR freight million tonnes	**219.1**	**226.3**	**215.1**	**212.3**	**183.3**	**173.1**
*Separate statistics for branch lines not available						



	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	2020/2021	2021/2022
Operator occurrences per million train kilometres	57.3	64.6	57.3	60.1	61.3	64.6	62.6	68.9	65.4	61.1	59.1	44.0
Security-related incidents per million train kilometres	87.4	84.7	55.4	61.6	82.3	83.9	98.2	119.1	151.8	110.8	235.3	182.7

Figure 14 Operator occurrences and security-related incidents trend (RSR, 2022)

in 2021/22 following a correction in 2019/20. Since 2013/14 theft and malicious damage to property (vandalism) have accounted for 87% of all reported security-related incidents. This long-term destruction places all operations at significant risk and must be arrested if South Africa is to utilise the rail mode to its fullest potential.

The PRASA passenger intercity and commuter rail network comprises 2 228 km of track. The dramatic decline in PRASA rail performance over the past five years, accelerated by Covid-19 restrictions, is reflected in passenger number trends on both metro services and mainline passenger services (MLPS), as seen in Table 6.

The PRASA Corporate Plan indicates that "MLPS is near collapse". Its performance has declined for the past decade, with revenue decreasing from R248 million in 2012/13 to R67 million in 2019/20. In 2020/21 MLPS was only allowed to recommence services at alert level 1 of the Covid-19 lockdown restrictions. This, in addition to the unreliability of the service, is set to lead to revenue of only R8.7 million for the 2021/22 financial year. MLPS also does not have reliable locomotives (due to maintenance capacity challenges) and is investigating lease options for refurbished locomotives.

Condition

The TFR and PRASA systems have built up severe maintenance backlogs in both rail infrastructure and rolling stock. This has occurred over at least the past decade due to many issues including mismanagement, loss of market share, failure to reduce costs by increasing density, poor service levels, and the tragedy of state capture.

The different rail infrastructure systems have dissimilar characteristics, given their different rail transport tasks in the country's economy. The high-density, low-cost heavy haul lines include the 26 tonnes per axle coal export line from the coal fields to Richards Bay and the 30 tonnes per axle ore export line that runs from Sishen to Saldanha conveying both iron ore and manganese.

Transnet has indicated capacity constraints for the primary export commodities (e.g. coal and iron ore) driven by locomotive unavailability, vandalism of rail infrastructure and continued cable theft.

An important indicator of these constraints on the coal line is the massive drop in throughput (one third less than the maximum tonnage achieved). This is attributable to an array of systemic issues including:

- Maintenance practice deterioration, e.g. less rail grinding
- Deteriorating track condition and rolling stock
- Mismatch between motive power and infrastructure condition
- Management capacity
- Ageing signalling infrastructure
- Vandalism of rail infrastructure and continued cable theft.

Table 6 Passenger journeys (thousands)

	2017	2018	2019	2020	2021	2022
Metro passenger journeys	286 900	241 680	170 287	32 053	17 337	15 772
MLPS passenger journeys	15 100	12 720	8 962	1 687	912	830

The above problems have necessitated the increasing imposition of speed restrictions on the line.

The iron ore line is prone to similar challenges, but it is in better condition than the coal line system.

The main general freight corridors (18 to 20 tonnes per axle) are the most critical for rail growth and to relieve the country's overburdened road infrastructure. This network is generally in fair condition, although there has been significant deterioration since the last IRC. This has been brought about by maintenance practices constrained by financial issues and further jeopardised by requirements to repair stolen or vandalised equipment, especially electric overhead cables and signalling equipment. This periodically necessitates the imposition of temporary speed restrictions in certain sections, hindering service reliability. Declining performance is reflected in both volume and safety performance.

The most important general freight line, the Natal Corridor, was severely damaged by floods in April 2022. At the time of writing, assessments of the affected lines had been conducted, but no commitments had been made as to when the lines would be returned to operation.

Branch lines (less than 18 tonnes per axle) are critical for the primary economy, food security and rural access to markets. The volumes and density of these lines are extremely low, and their infrastructure is generally very poor due to a lack of maintenance spending over a long period, exacerbated by theft (even of extended sections of track) and vandalism. Only a low percentage are operational – and even parts of this portion are in disuse. The lack of investment in the branch line network has resulted in a significant and increasing maintenance backlog of track infrastructure, stations, and yards.

The general condition of the PRASA passenger commuter rail network is very poor, particularly signalling equipment and station building structures. Operational issues such as outdated equipment (including rolling stock), theft, arson, and vandalism – and passenger safety from criminality – also need to be addressed to improve poor operational performance and unreliable service. Mainline passenger services are now almost non-existent due to the unreliability of locomotives.

During the Covid-19 lockdown, the bulk of PRASA's private security contracts were deemed to have been awarded irregularly and were thus cancelled, apparently without thought of the consequences. The criminal activity that ensued, exacerbated by rising unemployment and accompanied by the encroachment of informal settlements on rail reserves, resulted in an unprecedented destruction of the network. However, some of the corridors have recently been repaired and are in operation again.

The Gautrain system is in good condition. Sound maintenance practices are in place and asset assessments attest to the good quality of the system. However, since the line was built the track geometry has deteriorated marginally and, consequently, localised speed restrictions have been introduced.

Electricity infrastructure

South Africa's electricity infrastructure consists of bulk electricity generation, national transmission, regional

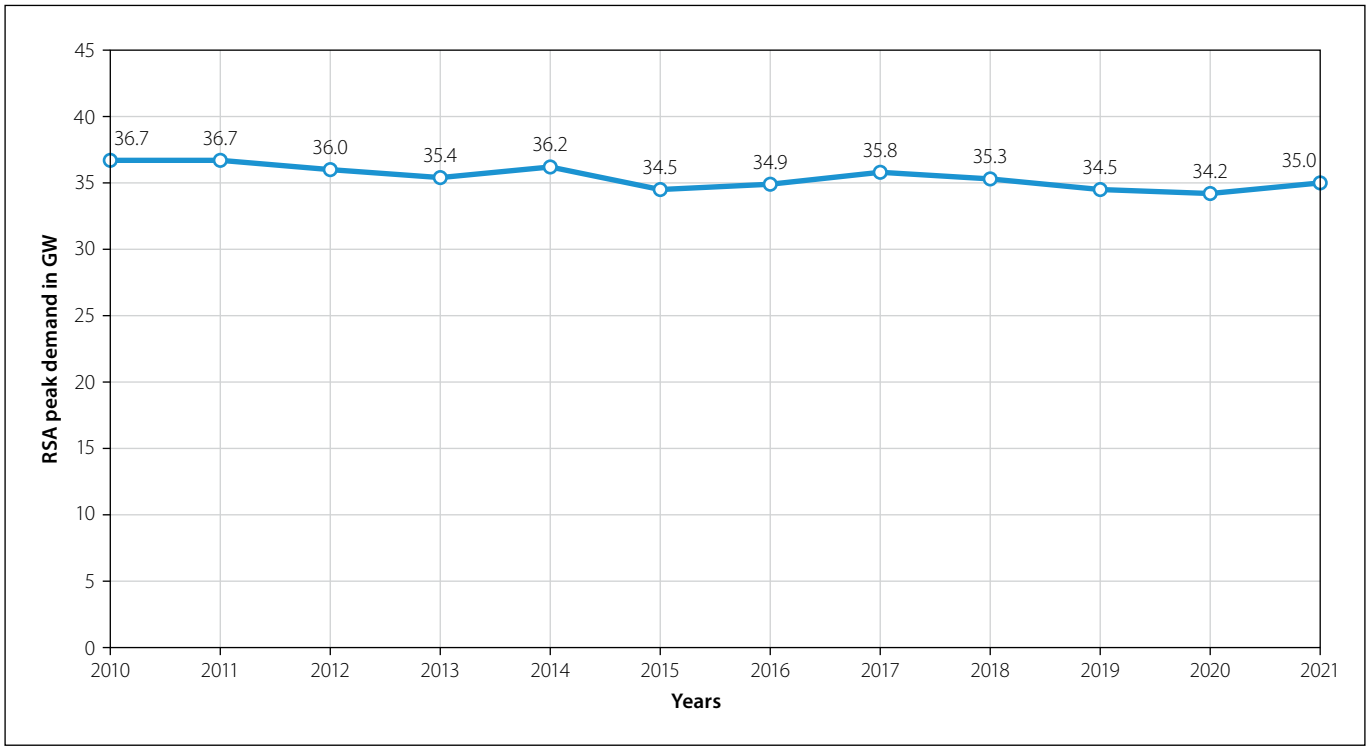


Figure 15 Declining peak demand for Eskom electricity since 2010 (CSIR, 2022)

interconnection, provincial distribution, urban metro and municipal distribution and reticulation to rural towns, farms, and communities, with a secondary contribution from localised generation capacity, such as from solar and wind.

The Department of Mineral Resources and Energy (DMRE) has the legislative mandate to regulate, transform and promote the minerals and energy sectors, providing sustainable and affordable energy for growth and development. The Department of Public Enterprises is the shareholder representative mandated to oversee state-owned enterprises, including Eskom which provides the bulk electricity generation, national transmission, regional interconnection, provincial distribution, and much of the local reticulation (mostly the rural areas, but also to mines and many industries). The mandate for the remaining distribution, mostly to urban areas, vests with municipal electricity undertakings. The National Energy Regulator of South Africa (NERSA) has the mandate to regulate the electricity supply and distribution industry. The regulations define product pricing, product quality and services as delivered to customers.

Eskom generates approximately 95% of the electricity used in South Africa. Regionally, Eskom trades electrical energy both bilaterally and competitively as a member of the Southern African Power Pool. Nationally, Eskom facilitates the DMRE power purchases from Independent Power Producers.

The South African electricity sector is characterised by:

- Demand slowly falling since the 2008 global economic crisis
- Rising prices
- Increasing unavailability – national grid loadshedding that commenced in 2007 continues unabated
- Increasing vandalism, theft and damage of infrastructure.

Demand

Annual peak demand for Eskom electricity, while fluctuating, has been on a slow decline over the last 10 years (Figure 15).

Undoubted contributors to this falling demand have been the discouraging rise in electricity prices and increasing unreliability of supply. These have constrained economic growth, despite the trend to alternate sources of power. The downgrading of South Africa by global rating agencies bears witness.

National generation

Eskom's strategy some decades ago, driven primarily by a central generation pool of large thermal coal-fired power stations, was to develop an extra-high-voltage national grid that traversed the country, penetrated deeply into the rural and agricultural community, and connected with Southern Africa.

Since Eskom's establishment coal has overwhelmingly dominated the energy mix of national electricity generation. Currently, Eskom owns 15 thermal coal power stations. The

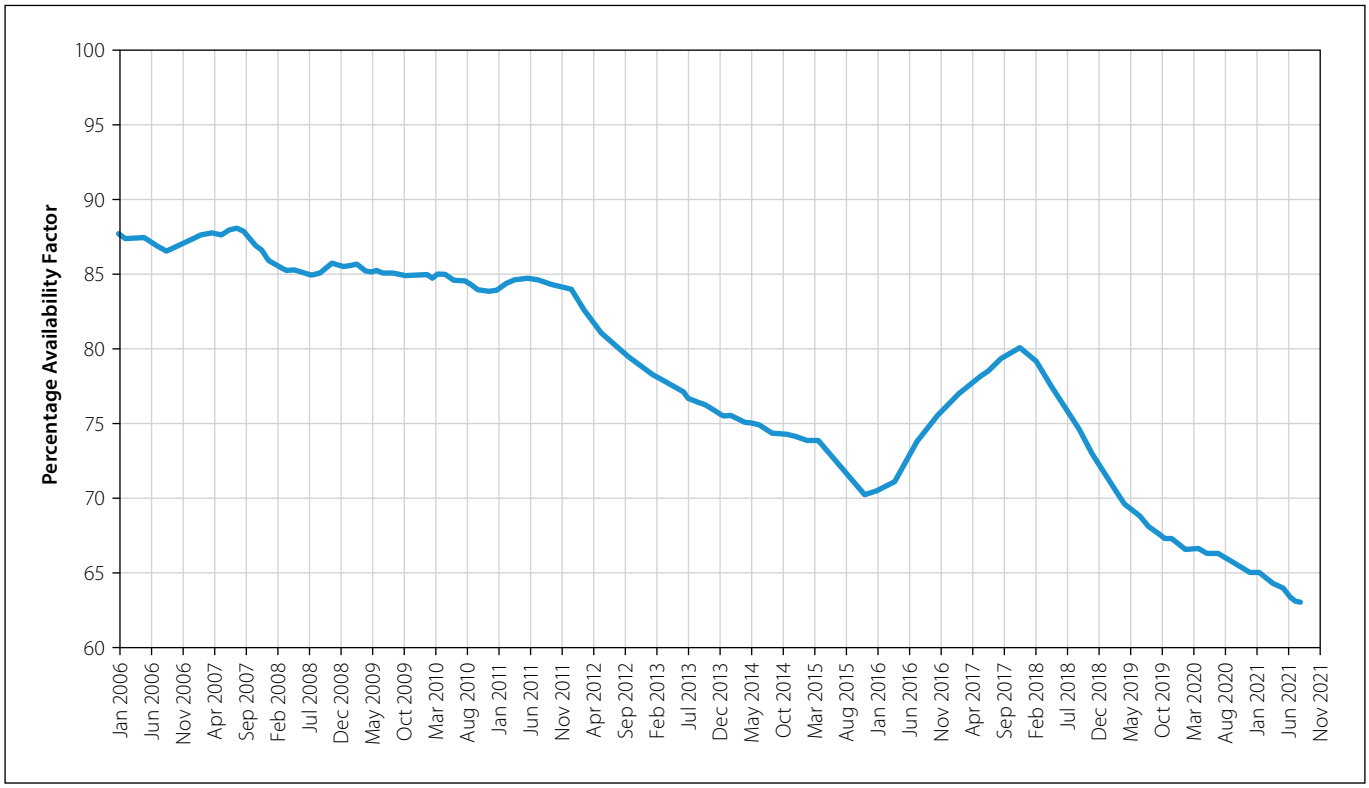


Figure 16 Declining national grid generation availability factor for the period 2006 to date (Eskom)

newest of these are Medupi and Kusile, each with six 800 MW nominal capacity synchronous generators. Each of the next eight has six 600 MW nominal capacity synchronous generators. The oldest five power stations are smaller and of varying sizes, ranging from 300 MW to 100 MW nominal capacity synchronous generators.

Coal is projected to remain the dominant energy source for the planning period up to 2030. Thereafter, and up to 2050, all the existing coal-fired power stations will be decommissioned. However, for a transition to cleaner energy sources to proceed smoothly, and at the same time to allow adequate downtime for maintenance and selective refurbishment of existing plants (some of them already more than 50 years old), additional generation capacity was required sooner. In particular:

- Medupi and Kusile which should have come into full operation between 2015 and 2017 with 6 GW of capacity, at which time Eskom could decommission older plants that are reaching the end of their planned lifespan. However, both were commissioned years late, and have since been plagued by breakdowns.

- Procurement of non-thermal generation capacity has been very slow.

The result of this too-slow acquisition of new generation capacity, together with further extended spells over the last decade of under-maintenance in support of "our philosophy of keeping the lights on at all costs," first reported in the 2017 IRC, has been a growing maintenance backlog. The situation has worsened since publication of the 2017 IRC, when it was reported that the backlog was:

> "increasingly leading to unplanned outages (load losses) – some of our running plants have partial load losses, because parts are worn out, and we do not have a time window to replace/fix."

Exacerbating the problem, Eskom plants were designed to use low-grade coal, which is cheaper but has abrasive qualities that cause greater wear and tear. Together with significant losses of key staff in the last two years, the outcome has been that the energy availability factor (EAF) of the national grid has declined steeply (Figure 16). The consequences of poor EAF are increased use of emergency high-cost diesel generation and increased frequency and severity of forced national loadshedding. This contributes to Eskom's rapidly increasing electricity operating costs (651.98 R/MWh in 2017 to 893.99 R/MWh in 2021), placing upward pressure on electricity tariffs.

National transmission

The national transmission system consists of 33 027 km of overhead lines operating at voltages of 765 kV, 400 kV,

Table 7 National network performance (Eskom, 2021)

Category	2021	2020	2018	2016	2014	2012
Total system minutes lost	3.48	4.36	2.09	2.41	3.05	4.73
Number of major incidents	2	3	0	1	0	1

275 kV, 220 kV and 533 kV DC together with 153 135 MVA of transformer capacity resident in 446 power transformers.

The average age of the transmission network is 39 years, with the oldest substations and lines being 60 years old. Given this age, the network could be vulnerable, but diligent refurbishment of switch gear, instrument transformers and power transformers over the years has contained deterioration in performance. The network performance has been consistent, neither improving nor deteriorating significantly (Table 7).

Distribution

Eskom and municipalities distribute electricity to approximately 9 million customers. Eskom retails approximately 60% of the grid electricity in South Africa to 40% of the customers, being mining, energy-intensive industries, traction, and direct reticulation to rural towns, farms, and communities. The remaining distribution is undertaken by 187 municipalities which purchase bulk supplies from Eskom and then resell the power to residential, business, and industrial customers where the municipality has a local distribution network.

The Eskom distribution grid consists of 351 023 km of overhead lines and 7 734 km of cables, operating at voltages of 132 kV, 88 kV, 33 kV, 22 kV and 11 kV together with 153 814 MVA of transformer capacity resident in 390 785 power transformers. These figures exclude the distribution and reticulation circuits of the municipalities, the extent of which is enormous – greater even than the Eskom distribution network. Detailed information on that network is difficult to come by.

Eskom's distribution network performance is measured in system events and in system hours. For the last five years, lost performance was in the range 13.2 to 18.9 events, with an annual average of 15.78 events. Corresponding time lost was in the range 34.4 to 38.9 hours, with an annual average of 36.82 hours. Over the last decade, neither of the indicators has improved or deteriorated.

For years NERSA has reported the failure by municipal electricity distributors to comply with licensing conditions, largely because of insufficient refurbishment and maintenance. Networks in many municipalities are in a poor state of maintenance, with substantial investment required to maintain and rehabilitate assets. Chronic underinvestment in the upgrading and maintenance of the local distribution networks, increasing vandalism and theft of distribution plant and equipment, as well as the impact of illegal connections (these latter two factors also affecting the Eskom local distribution network) have been significant additional causes of outages.

Because so very little information on the condition of the municipal-owned infrastructure is available, it has not been possible, for the purposes of the 2022 IRC, to allocate a grading to it.

Oil and gas pipelines

About 50 large-diameter oil and gas pipelines link strategic centres in the country and/or short-distance offshore facilities, such as between the Durban single buoy mooring (SBM) and the shore. Discounting pipelines no longer in commission, the onshore network measures approximately 4 600 km. The private sector owns approximately one-third of this network. Very little of the 500 km network of offshore pipelines is still operating because the gas and condensate reserves off the coast of Mossel Bay, for which most of this network was built, has been depleted.

This report covers the major oil and gas pipelines within port limits, offshore and cross-country, excluding private distribution networks within urban areas, such as that owned by Egoli Gas.

The largest of the pipelines are:

- **Crude oil and refined fuels:** The 24-inch "multipurpose" pipeline, which carries refined fuel from Durban to Gauteng. Commissioned in 2015, and owned and operated by Transnet Pipelines, this 825 km-long pipeline can transport up to 148 Mℓ per week. The oil and refined fuel pipeline with the largest diameter is the 42-inch line from the Durban SBM, but this runs for only 2.5 km.
- **Gas:** The 26-inch pipeline carrying natural gas 865 km (in total length) from the Pande and Temane fields in Mozambique to Secunda. Commissioned in 2004, it is owned 20% by Sasol, 40% by the South African Government and 40% by the Mozambique Government.

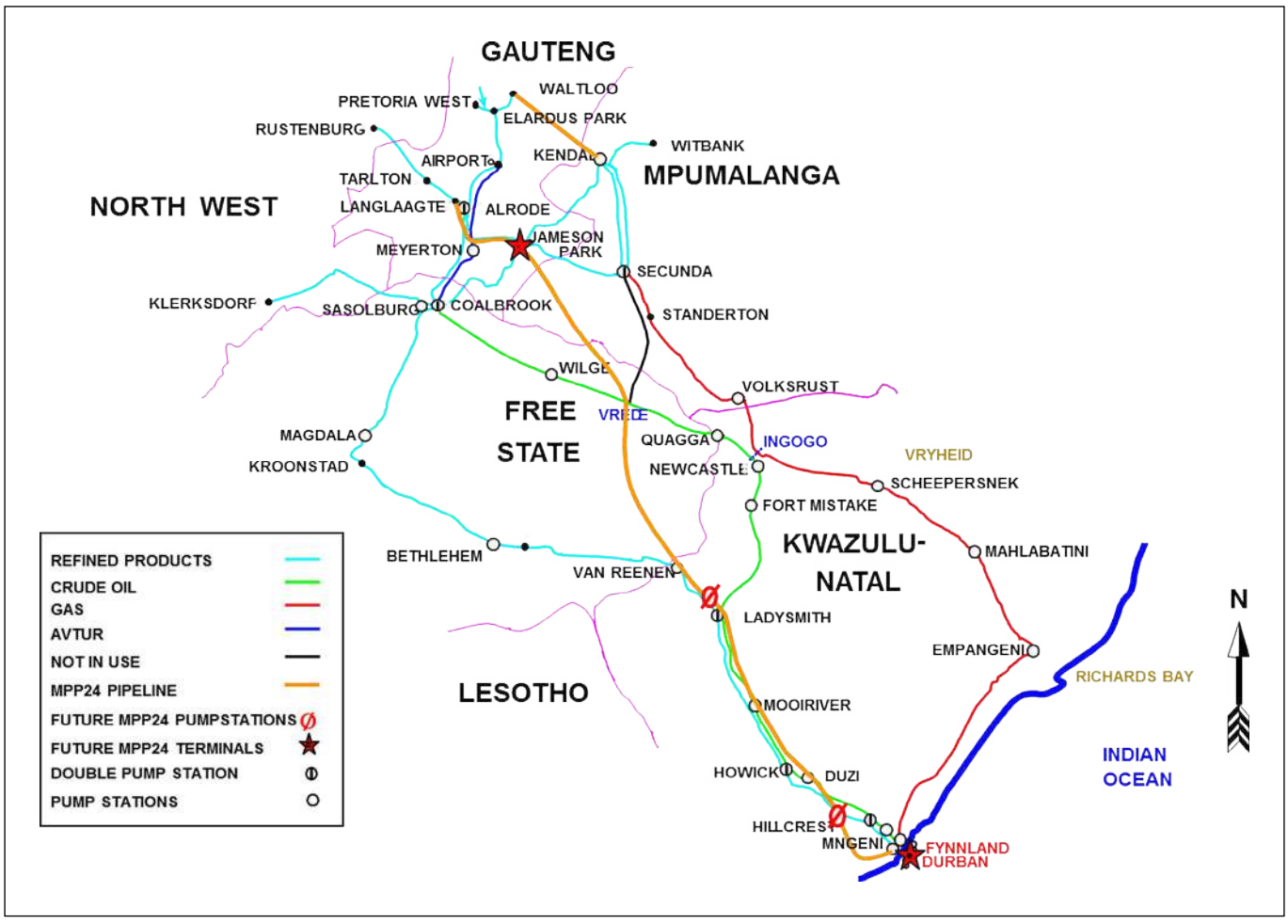


Figure 17 Transnet pipelines

Established in 1965, Transnet Pipelines is the pipeline owner and operator with the largest network and largest volume of product. Its network traverses the eastern part of South Africa from Durban (where crude and refined petroleum products are imported) to the industrial hubs in the Free State, North West, Gauteng and Mpumalanga provinces (Figure 17).

NERSA regulates the piped gas and petroleum pipeline industries in terms of the Gas Act (No. 48 of 2001) and Petroleum Pipelines Act (No. 60 of 2003). Its Licensing and Infrastructure Planning division is responsible inter alia for:

- The issuing of licences for the construction and operation of petroleum pipeline facilities.
- Gathering information on all petroleum pipelines activities throughout the country to assist with planning and to ensure orderly infrastructure distribution as well as development and security of supply.

In 2021 TNPA announced that all the facilities at its main coastal hub, Island View in the port of Durban, will be moved to Richards Bay in the long term. The reason given for this is that the proposed Durban Digout Port – i.e. extending the harbour into the now vacated old Durban airport area – is deemed too expensive. Closure of the Island View site would enable the required significant expansion of the Durban container terminal facilities. However, timing of the relocation of the current Island View facilities to Richards Bay, including the construction of new fuel storage, quays and pipelines, has not been announced.

The theft of infrastructure such as rail lines and cables is on the rise and, routed as they are through long stretches of open country, they cannot be closely guarded. Being similarly located, pipelines are also periodically breached and fuel stolen, sometimes with hazardous results and always with damage to the environment (e.g. fuel spills into streams and groundwater).

The pipelines still in use represent major capital investment by their owners in order to provide a service for which the owners are remunerated. For this reason, they are inspected as rigorously as their largely underground location permits. Once detected, leaks or ingress into the pipeline are quickly repaired.

Healthcare infrastructure

The provincial Departments of Health and Public Works are custodians and implementing agents for almost all public healthcare facilities in each province (excepting some municipal facilities in a small number of municipalities). The national Department of Health acts as an advisor and policy setting body.

Private hospitals and clinics are not considered or graded in this report.

There are nearly 4 200 public healthcare facilities in the country. This number comprises 394 hospitals of varying size and areas of medical expertise, 3 777 clinics and community health centres, and a small number of forensic laboratories, mortuaries and offices. Table 8 gives an idea of their provincial distribution and corresponding provincial populations.

While the number of facilities in a province has some correlation to the population, it is also related to the size (area) of the province and the proportion of the population that is urbanised.

Table 8 Geographic distribution of health facilities

	Gauteng	KwaZulu-Natal	Western Cape	Eastern Cape	Northern Cape	Limpopo	Free State	Mpuma-langa	North West	Totals
Population (millions)	15.81	11.56	7.11	6.73	1.21	5.85	2.93	4.74	4.12	60.06
Clinics and other non-hospital facilities	473	781	179	929	0	537	182	382	314	3 777
Hospitals	37	67	51	92	32	41	32	33	9	394
Total number of facilities by province	510	848	230	1 021	32	578	214	415	323	4 171

All provinces have their challenges in providing a quality health service, with some of them being common to all provinces (such as staff shortages and budget constraints) and others (such as malaria) only in some provinces. With particular regard to infrastructure condition and use, some of the challenges are theft of equipment and supplies, poor access roads, unreliable water and electricity supply, and lack of maintenance. Information on the infrastructure condition of health facilities is extremely limited.

It is reported that during the past two years a significant amount has been spent on Covid-19-related infrastructure at health facilities. This has meant that, particularly at main hospitals, certain items such as generators, boilers, air-conditioning systems and some wards, as well as certain medical equipment such as ventilators, vital signs monitoring and gas systems have been upgraded.

Since 2014 each department has been required to produce a User Asset Management Plan. An aspect of this is a self-evaluation tool using guidelines to evaluate facilities into five categories of condition: C5 (excellent), C4 (good), C3 (fair), C2 (poor), C1 (very poor). Facilities graded at C2 and C1 are considered to pose high risks to healthcare and/or are unfit for occupancy respectively. Not all provinces appear to comply.

Figure 18 shows how the infrastructure condition was assessed by province.

From the limited information, it is noted that Mpumalanga and Free State have a significant number of facilities in the high risk (red) zone. The major fire at Charlotte Maxeke Hospital in Gauteng is a warning of what can happen if assessments are deferred or findings not urgently addressed. There is also an Ideal Clinic Programme that grades clinics in terms of good infrastructure, adequate staff, adequate medical supplies, and good administration procedures. An ideal clinic is one that gets a high enough score to earn silver, gold or platinum status. Table 9 shows the outcome of the 2020/21 assessments.

Audits by the Auditor General can give insight into why a department is not meeting all its financial obligations, such as paying contractors on time, not wasting money and

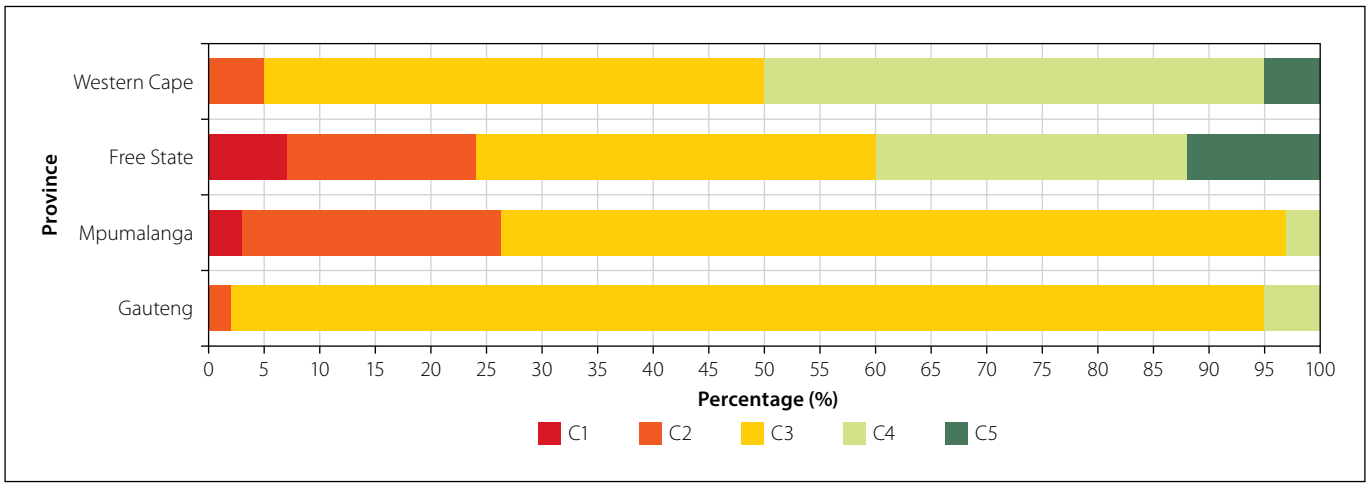


Figure 18 Health infrastructure condition by province

Table 9 Ideal clinic status by province (2020/21)

Province	Ideal clinic status (%)
Gauteng	89
Mpumalanga	33
Limpopo	18
North West	16
Northern Cape	44
Free State	43
KwaZulu-Natal	78
Western Cape	67
Eastern Cape	11

employing correctly qualified staff. In 2020/21, the Western Cape received a clean audit (the best outcome). North West, which is under administration, and Gauteng earned unqualified audits. The remainder received qualified audits.

At the height of the Covid-19 pandemic the Public Protector reported on investigations into a limited number of facilities in four provinces, namely Eastern Cape, KwaZulu-Natal, Mpumalanga and North West. In all four provinces it was found that poor physical infrastructure, staff shortages, lack of laundry services and poor IT communication were problematic.

Public ordinary schools

Basic education, including primary and secondary schooling, is a concurrent national and provincial responsibility. Public ordinary schools operate under the authority of their respective provincial Departments of Basic Education, all under the umbrella of the national Department of Basic Education (DBE). The responsibility for early childhood development is currently being transferred from the Department of Social Development to the DBE, which will add additional challenges in the provision and maintenance of suitable infrastructure.

There is a great deal of variation across and within provinces in terms of access to education and the condition of school infrastructure.

The schools infrastructure programme has given most attention to addressing backlogs, particularly those preventing learners from accessing schools and endangering their health and safety, e.g. replacing schools built from inappropriate materials such as mud or asbestos.

In 2021 there were 22 740 public ordinary schools, compared to 23 600 and 24 460 schools reported in the 2017 and 2011 IRCs respectively. Learner enrolment at these 22 740 schools totalled 12.7 million, with 405 000 educators. The decrease in the number of schools, in the face of real increase in the number of learners, is due to the closing of very small schools. Gauteng and the Western Cape, both under pressure thanks to migration from other provinces, were the only provinces to have increased their number of public schools.

Public school infrastructure varies from very good for schools in affluent locations that are attended by learners from the middle class to barely fit-for-purpose schools in underdeveloped and impoverished communities.

The National Education Information Management System, which was set up in 2007, has not been kept up to date by all provinces, hampering attempts to identify schools that deserve priority attention.

In 2013 the DBE published norms and standards with respect to school infrastructure, with self-imposed deadlines setting out by when these norms and standards would be achieved. However, these deadlines were not met and the Minister expunged the deadlines in August 2022. By this action she eliminated the embarrassment of continually being held accountable for failures to get schools in line with these minimum norms and standards.

Lack of budget is the main culprit in all provinces. In 2022, the DBE estimated the cost of repair, maintenance and refurbishment required for all schools to meet the 2013 norms and standards. This estimated cost exceeds (by a big margin) any funding that is likely to be found. It is clear therefore that, without significant additional funding, the condition of school infrastructure will not improve by much. This is despite recognition that further improvement to school infrastructure is one of the measures needed to help address South Africa's long-running crisis in basic education outcomes.

Paradoxically, inability to fully spend allocated budgets is a significant problem in some provinces. For example, Limpopo's latest annual report (2018/19) states that many school infrastructure project targets were missed. The target for water supply was 33 projects – 12 were completed; the target for provision of electricity was one project – two were in fact completed; the target for provision of sanitation was 59 – 33 were completed; the target for scheduled maintenance was 43 – only 34 were completed.

It is of great concern that the focus on the construction of new schools has de-prioritised the maintenance of existing schools. As a result, and also because basic cleaning is often not undertaken, or not undertaken satisfactorily or systematically, the condition of schools' water and sanitation facilities, in particular, leaves much to be desired.

The DBE reports claim that less than 1% of schools are without water and toilets. However, much existing infrastructure is not in a working condition. In some provinces these facilities at the majority of rural schools are out of order much of the time. Many schools have unreliable electricity infrastructure and water supply, and toilets are not fit for use.

Yet, even well-intentioned efforts may have adverse infrastructure consequences if paired with misinformation. An example of this is civil activism that demands flush toilets rather than VIPs, despite the latter being generally easier to provide and maintain, and adequately safe for learner health. Moreover, VIPs can be used in areas where water supply is limited or erratic.

Poor or inadequate sanitation facilities especially impact female learners, particularly at the time of menstruation when privacy, frustrated by inadequate toilets, is denied. In some cases this may cause female learners to miss school during menstruation. The closely related issue of the unavailability and unaffordability of sanitary pads has received considerable media and public attention.

While maintenance budgets are invariably too low, the funds available are often not optimally used and much more could be done with the infrastructure and funding that is available. Schools should adopt basic proactive infrastructure maintenance practices and implement them consistently. Budgets should be ring-fenced to ensure that funding is spent for the intended purpose and not on other items, essential as they might be. There is some evidence that maintenance budgets are sometimes dipped into to hire additional teachers, host a sports day, or purchase computers. There is some evidence, too, that many schools appear inclined to give attention to infrastructure only when it breaks, rather than undertaking a proactive maintenance programme. An additional problem is that evaluation of school infrastructure does not follow consistent practice across provinces. This complicates estimation of maintenance budgets.

The condition of school infrastructure has much to do with the abilities of management, that is the principal and the elected school governing body. There are some remarkable schools in remote, poor rural locations that confirm this premise, i.e. that the quality of management makes a very significant difference.

The two years of focus on the Covid-19 pandemic and the consequential high expenditure on sanitation has also set the general maintenance trajectory back.

Damage, theft and vandalism to public schooling infrastructure have evolved as key themes, and protection against these is becoming more and more essential. Criminality, such as destruction during service delivery protests or theft of electricity equipment (which all education departments cite as a contributor to slow electrification of schools), threatens schooling infrastructure. Funds to combat vandalism could, though, arguably be better spent on improving basic school infrastructure.

School infrastructure also includes the provision of secure fencing, libraries, classrooms, laboratories, sports facilities, computer facilities and internet access. While the 2017 IRC indicated that there had been little progress in addressing these lower priority backlogs, it is highly unlikely that significant progress in addressing these shortcomings has been made in the last five years. However, improvement of technology might in due course make redundant the need for dedicated libraries and computer labs.

Public higher education and training infrastructure

Public higher education is managed by the Department of Higher Education and Training (DHET).

There are 26 public universities (13 traditional universities, six comprehensive universities and seven universities of technology), mostly in the largest urban areas. Two of the 26 are new (post-2013), namely the University of Mpumalanga in Mbombela and Sol Plaatje University in Kimberley. Some institutions have more than one campus spread over different towns.

The 50 Technical and Vocational Education and Training (TVET) Colleges have 364 campuses spread across the country's rural and urban areas and each province has a Continuing Education and Training (CET) college with numerous satellite centres.

About 1.1 million students are currently enrolled at the universities. This population has grown by an average of 2% per annum over the past 10 years, doubling since 1994. A further approximately 0.7 million students are enrolled at TVET colleges and 0.1 million at CET colleges. Private higher education colleges register with the DHET but are not supported in any way.

To facilitate the improvement of infrastructure at higher education institutions, the DHET has introduced several support programmes and provided norms and standards. Student accommodation has received particular attention in recent years. There has also been significant training of personnel to capacitate the institutions (mainly TVETs) to plan and prioritise infrastructure provision and maintenance.

The Macro Infrastructure Framework was introduced in 2017 with the specific aim of strengthening monitoring of spending. It comprises self-assessments and monitoring site visits conducted on an annual or biannual basis. In 2018 only 11 universities did not receive poor to fair ratings. However, by 2021 this had improved to 19 out of the 24 institutions getting good ratings (the two new universities are measured on a different basis). This indicates that most of the universities are now able to manage infrastructure projects successfully.

The Covid-19 pandemic had a major influence on higher education institutions. Firstly, many new and refurbishment infrastructure projects were delayed or postponed for several

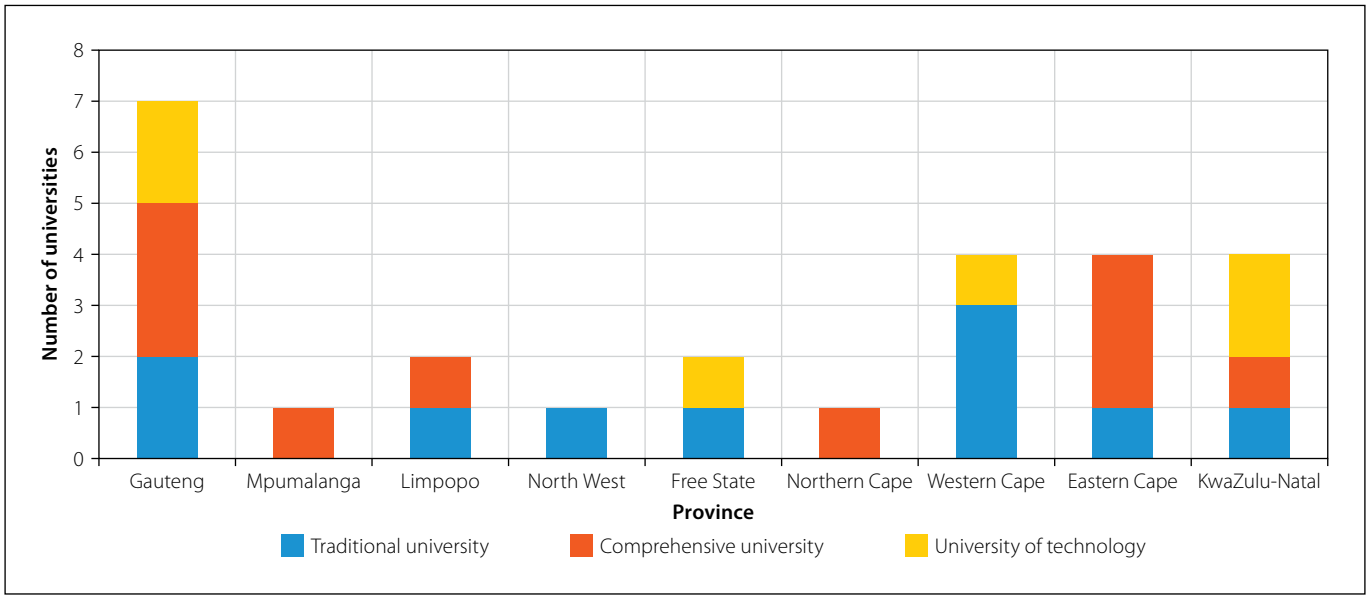


Figure 19 Provincial distribution of South African universities

months. Secondly, the institutions had to urgently upgrade ICT infrastructure to enable them to conduct virtual teaching and learning. As a result, funds earmarked for other purposes, including maintenance and repair, were redirected to ICT projects.

Although vandalism of higher education infrastructure and damage associated with student protests peaked during the Fees Must Fall campaign of 2016, it has continued since then. This has disrupted learning while placing great strain on infrastructure budgets. Addressing the damage has required further diversion of funds from the construction of additional facilities and the maintenance, repair and refurbishment of existing facilities.

Universities

The universities are autonomous but receive significant funding from the DHET for both capital and operational purposes. In the period from 2018 to 2020, DHET spent R1 billion on further developing the infrastructure of the two new universities. In the same period, the Department spent about R8.5 billion at the 24 established universities for new/refurbishment/maintenance infrastructure projects, with about 40% of the funding spent on student accommodation. There is also a Historically Disadvantaged Institution (HDI) Development Framework through which the eight HDIs are provided additional assistance.

In terms of their statutes, the universities are able to raise funds via donations, bequests, etc. and apply that to both their capital and operational needs. Approved projects are co-funded by DHET with contributions ranging from 0% to 50% from the Infrastructure Efficiency Grant fund.

The vast majority of the respondents to a survey conducted by SAICE in 2022 indicated that the 860 institution-owned buildings/facilities do not have enough capacity for the number of students enrolled. This may either indicate that facility capacity has not kept up with student growth numbers or could be due to a failure to conduct space audits and a faculty "ownership" culture which inhibits shared use of spaces.

The respondents also offered the following comments on infrastructure:

- Older buildings generally require refurbishment
- Some buildings do not meet current occupational health and building regulation requirements
- At some institutions, only ad hoc reactive maintenance is conducted
- Annual maintenance and repair budgets are generally not sufficient for the work that is required.

TVET colleges

Over the past 30 years, the TVET institutions have grown student numbers from around 100 000 to 700 000 enrolments per year. The DHET recognised that there had been insufficient funding for infrastructure development, and an amount of R2 billion has been budgeted for the 2018 to 2024 period to address priority needs in bulk services, statutory compliance, sanitation, and building and student accommodation repairs and maintenance. However, a donor-funded project to audit TVET infrastructure was not

completed due to the service provider going into liquidation during the Covid-19 pandemic.

The various initiatives noted above have gone some way towards addressing the concerns raised in the 2017 IRC, such as the disparity between urban and rural facilities and addressing the institutional capacity for asset management.

Information and communication technology infrastructure

This report relies on published information readily available in the public domain – particularly the Independent Communications Authority of South Africa (ICASA) 7th annual State of Information Communication Technology sector report, released in March 2022 – together with information from informed sources. It deals only with the telecommunications sector and not with broadcasting or postal services.

Unlike the other infrastructure sectors considered in the IRC, where the infrastructure that is graded is almost exclusively owned by the public sector, telecommunications infrastructure, although dependent on some public infrastructure sector services (particularly electricity supply), is almost exclusively owned by the private sector.

Availability and quality of telecommunications is increasingly vital as the world moves towards digitalisation with more reliance on sharing of information in the cloud and cloud services. Customers pay for, and demand, reliable services and increasing variety, capacity and speed of services. Providing these services places heavy pressure on telecommunications suppliers, driving the high standards of maintenance and continual cycle of investment.

While no direct measures of the condition of telecommunications infrastructure could be found, the condition can be inferred indirectly from statistics of the availability, quality and reliability of the telecommunications service. But first we provide some brief statistics of access and investment that illustrate the movement to mobile and internet services.

From data published in Stats SA's GHS report, the proportion of households who use only cellular phones as a means of communication increased from 87.8% in 2019 to 89.4% in 2020. Households using both cellular phones and fixed lines (or landlines) increased from 7.1% in 2018 to 8.3% in 2019. The proportion of households without either a cellular or a landline phone decreased from 3.8% in 2019 to 1.8% in 2020.

The national proportion of households with access to internet was at 74.1% in 2020. This reported high percentage is mainly because at least one member of the household had access to internet through mobile devices and laptops.

Comparing 2021 to 2022 for telecommunications investment, the following is noted:

- Annual investment in mobile communication services increased by 10.5%
- Infrastructure spend increased by 118%
- Annual investment in fixed (wired) broadband service decreased by 19.6%
- Annual investment in fixed telephone services decreased by 97.3%.

Key features of South African telecommunications include:

- Fibre infrastructure in South Africa is generally in good condition
- The hosting market is in very good condition
- Databases are in good condition and there are a lot of them
- Copper cabling is vulnerable to theft
- The market is competitive
- Additional spectrum was auctioned earlier in 2022
- Newer technologies such as 5G are coming to the forefront
- Regulation and legislation, particularly regarding way-leaves for buried cables, is a bottleneck when installing fibre infrastructure over long distances
- Loadshedding creates strain on existing transformers, possibly even damaging them, which could take between three and ten days to repair or replace
- The theft of backup batteries and generators is a very large and growing problem.

To describe the effect of loadshedding in more detail, the cell towers and other infrastructure that require electricity typically take a minimum of 12 hours to recharge their backup batteries (and sometimes up to 24 hours), while the batteries have only a few hours of capacity. One two-hour power interruption each day can thus be coped with, but if there is a second outage, or a longer outage, there will not be enough time to recharge. This means that there is not enough energy left to keep the cell towers operational. Fibre does not take a lot of power, but it takes some, and if batteries are flat or stolen fibre communication will fail.

South Africa has more international than local capacity. The limitation on local connectivity is the cost of termination equipment and switching and routing equipment. Hardware needs to be replaced on a regular basis and most companies work on a three-year cycle, resulting in a continual cycle of investment.

There has been a shortage of spectrum in some of the bands. With the auction for the high demand spectrum now completed by ICASA, companies need to install the equipment to make use of the additional spectrum. It is expected that before the end of 2022 there will be a significant increase in wireless connectivity.

Another consideration is digital security. With increasing reliance on the internet and smartphones comes vulnerability. The opportunity for cyberattacks grows and the increasing number of cyberattacks give cause for concern.

Although the general condition of physical ICT infrastructure in South Africa is good, theft and/or vandalism of equipment means that funds that could have been spent on new equipment or planned maintenance now have to be spent on replacements.

Fire infrastructure

Fire safety considerations should be part of every building, transportation facility, educational institution, municipal infrastructure plan, home next to a forest, and informal settlement.

Data on the number of fires and number of fatalities reported by fire departments from 2003 to 2020 shows a continual increase in the number of fire incidents per year. In 2020 there were 63 316 incidents and 586 deaths reported. However, care should be taken when interpreting the data as both sets of information are incomplete, underrepresenting fire incidents by an estimated three to six times their actual value.

As estimated by fire departments, the loss value has increased drastically from R2.7 billion in 2017 to R23 billion in 2020 – these estimates, too, certainly underrepresent the actual value. Moreover, it is likely that the extensive damage that occurred from the mid-year protests will ensure that the 2021 loss data will be the worst to date.

There are four main reasons for these disturbing trends:

- Non-adherence to building regulations
- Lack of technical competence in design
- Fire safety infrastructure is sometimes considered a "grudge purchase"
- Inadequate municipal fire protection services.

South Africa severely lacks the technical competency needed to provide fire-safe infrastructure. For example, the majority of building designs do not strictly conform to the part of the National Building Regulations (NBR) Code of Practice that deals with fire protection. The local authority is relied upon to evaluate the validity of the designs (that is when the plans are submitted – not always the case), but many municipal officials assigned to this are not appropriately competent.

The fire safety infrastructure utilised in the private sector ranges in quality and suitability. While much might even exceed the requirements of the NBR – this is especially true when building insurers insist on protecting high-value assets – the fire safety infrastructure for most commercial, residential and retail buildings will typically be heavily influenced by the

competency of the fire engineers, architects and approval authorities involved in the project, as well as the attitudes of the building owner/developer. In many cases fire safety infrastructure is considered a grudge purchase, meaning that the lowest cost system which authorities will approve is often selected.

The quality and level of resources of fire departments across the country varies significantly. The 2016 White Paper on the Fire Services noted that "too many fire services especially from resource-poor municipalities are struggling to provide sustainable and cost-effective fire services. The number of lives lost and injuries sustained as a result of fires is alarming." The White Paper further noted that South Africa has one of the highest rates of death and disability related to fire in the world.

Incident statistics reported represent the number of *incidents* reported, not the number of *dwellings* affected. In a single incident several thousand informal dwellers could be left homeless. Hence, informal dwellers are an order of magnitude more likely to lose their homes to fire than formal dwellers.

Although industrial fires represent only a small portion of the total number of fires in South Africa, they constitute a disproportionately large proportion of the value of total losses.

As an example, in December 2019 an attempted theft from one of Transnet's high-pressure petroleum and gas pipelines resulted in petrol spillage and a fire incident. This event not only had an operational impact but also created high-risk conditions for the environment and the community (people within a 500 m radius were evacuated while the fire was being fought).

Municipalities often struggle to get governmental agencies to comply with fire safety regulations, and many governmental buildings appear not to be compliant. A recent high-profile fire is the Parliament Building in Cape Town. Preliminary reports of the January 2022 fire identified contributory factors such as fire doors being propped open, sprinkler systems not functioning, and the detection system not activating.

The 2017 Knysna fire is South Africa's largest wildland disaster, lasting for four days and affecting more than 1 000 homes. Wildland urban interface fires and their impact are likely to increase because climate change is exacerbating conditions conducive to large wildland fires that can spread into towns, while towns are expanding into rural areas.

References

A list of references is available on the SAICE website.

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Acronyms

ACSA	Airports Company South Africa
AMPP	Asset Maintenance Principles and Procedures
CEO	Chief Executive Officer
CET	Continuing Education and Training
CSIR	Council for Scientific and Industrial Research
DBE	Department of Basic Education
DC	Direct current
DHET	Department of Higher Education and Training
DMRE	Department of Mineral Resources and Energy
DoT	Department of Transport
DPWI	Department of Public Works and Infrastructure
DWS	Department of Water and Sanitation
EAF	Energy availability factor
GDP	Gross domestic product
GHS	General Household Survey
GW	Gigawatt
HDI	Historically Disadvantaged Institution
IATA	International Air Transport Association
ICASA	Independent Communications Authority of South Africa
ICT	Information and communication technology
IRC	Infrastructure Report Card
kV	Kilovolt
LGSETA	Local Government Sector Education and Training Authority
Mℓ	Megalitres
MLPS	Mainline Passenger Services
MVA	Megavolt-amperes
MW	Megawatt
MWh	Megawatt hours
NBR	National Building Regulations
NERSA	National Energy Regulator of South Africa
NGO	Non-governmental organisation
NWRIA	National Water Resources Infrastructure Agency
PCI	Pavement condition index
PRASA	Passenger Rail Agency of South Africa
RSR	Railway Safety Regulator
SAAE	South African Academy of Engineering
SAICE	South African Institution of Civil Engineering
SAIEE	South African Institute of Electrical Engineers
SANRAL	South African National Roads Agency Ltd
SBM	Single buoy mooring
SOC	State-owned companies
Stats SA	Statistics South Africa
TFR	Transnet Freight Rail
TNPA	Transnet National Ports Authority
TVET	Technical and Vocational Education and Training
VCI	Visual condition index
VIP	Ventilated improved pit
WSA	Water Services Authority
WSP	Workplace skills plan

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