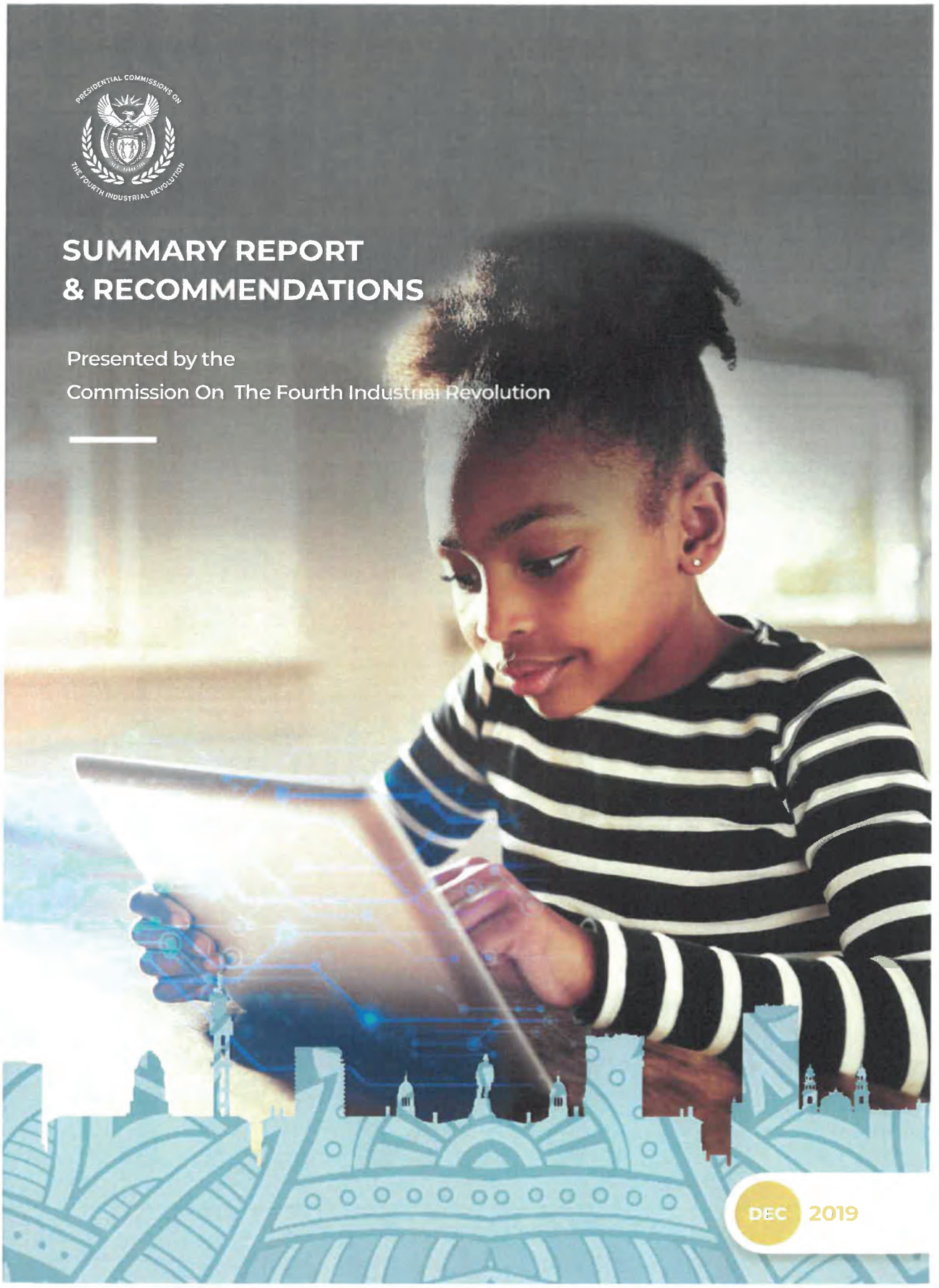
DEPARTMENT OF COMMUNICATIONS AND DIGITAL TECHNOLOGIES

NOTICE 591 OF 2020

I, Stella Ndabeni-Abrahams, Minister of Communications and Digital Technologies, hereby publish, in accordance with paragraph 3.5 of the Terms of Reference of the Presidential Commission on the 4th Industrial Revolution, published in Government Gazette No. 42388 on 9 April 2019, both long and short versions of the Report of the Presidential Commission on the 4th Industrial Revolution (PC4IR) for general information.

Ms Stella Ndabeni-Abrahams, MP
Minister of Communications and Digital Technologies
Date:


PRESIDENTIAL COMMISSION ON THE FOURTH INDUSTRIAL REVOLUTION
SUMMARY REPORT
& RECOMMENDATIONS
Presented by the
Commission On The Fourth Industrial Revolution
DEC 2019

Summary Report & Recommendations

Presented by the
Presidential Commission On The Fourth Industrial Revolution

January 2020

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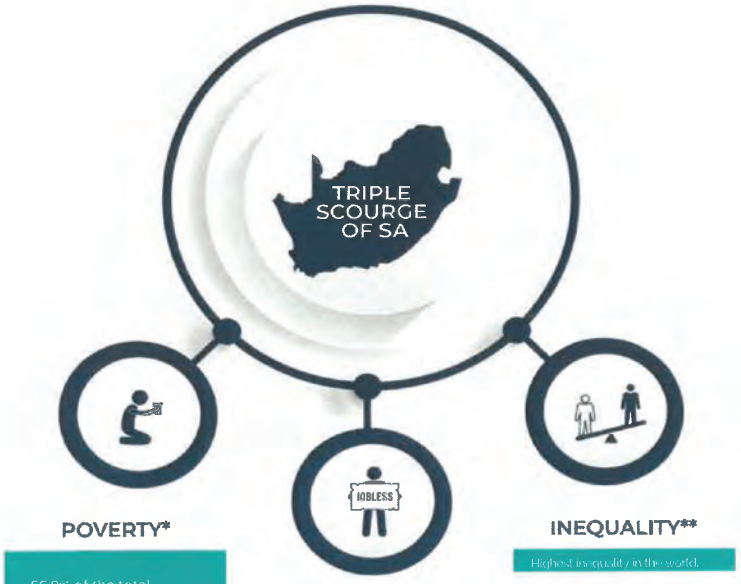
South Africa's vision for development is premised on resolving the nation's historical scars, expressed as the 'triple scourge': Poverty, Unemployment and Inequality. The 4IR Commission is thus a lever, activated by the State, to provide leadership for all of society in understanding and navigating what will be a fundamentally altered future. Indeed, this presently evolving future requires the government to play a central role. The role of the 4IR Commission is thus to clearly articulate the role of the State as well as all institutional actors and citizens in their capacity as equal protagonists in the story of our future.



*Source: www.statssa.gov.za accessed on 15 November 2019

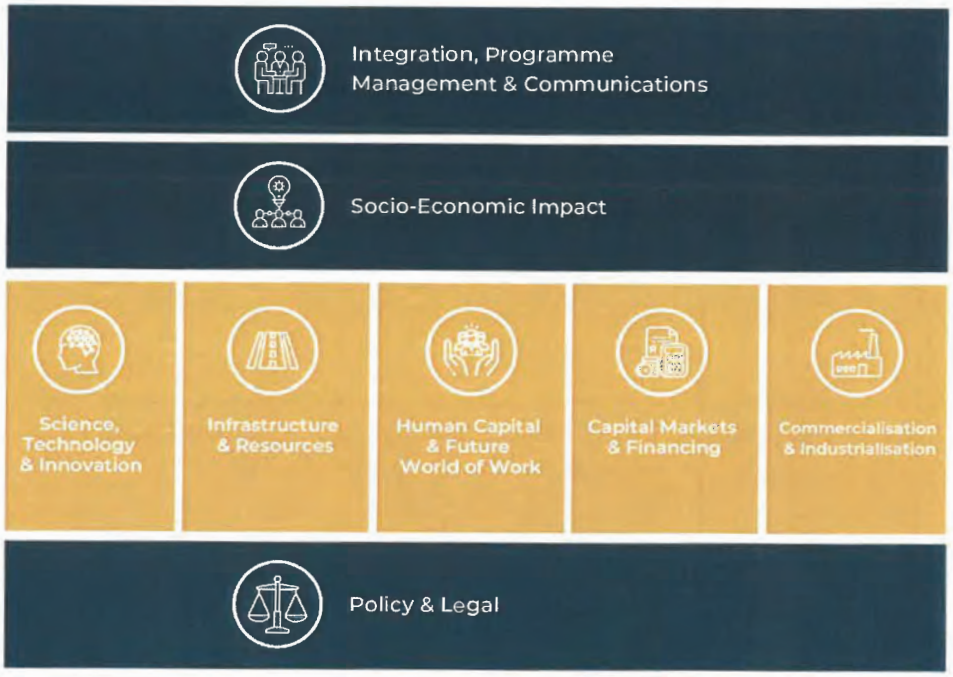
**Source: World Bank Group (2018): Systematic Country Diagnostic: An Incomplete Transition- Overcoming The Legacy Of Exclusion In South Africa

Introduction

The Presidential Commission on the Fourth Industrial Revolution (PC4IR), established and chaired by The President of South Africa, has been tasked with a comprehensive set of responsibilities under its Terms of Reference (TORs). These include proposing the country's overarching strategy for the Fourth Industrial Revolution as well as making recommendations regarding the institutional frameworks and roles of various sectors of society within the broad plan.

This work has been undertaken by the Commissioners, through a workstream approach, focusing their work efforts on critical themes. The Terms of Reference of the PC4IR are included in Annexure A.

PC4IR Workstreams



The possibilities and prioritisation of pathways presented by the 4IR are given material direction and purpose within the South African National Development Plan (NDP) towards 2030. The NDP, South Africa's long-term development strategy, contains critical targets for the eradication of poverty and the reduction of unemployment and extreme inequality. Thus, in evaluating the socio-economic impacts and opportunities of the 4IR, there is an opportunity to address the core concerns of the NDP and in so doing, provide a policy-embedded path towards our constitutional objectives in the context of a significantly improved and altered future.

PART 01 BACKGROUND

To understand the impact of the 4IR requires an appreciation of South Africa's current standing. Indeed, South Africa's grand challenges, poverty, inequality and unemployment, mediate all considerations of the kind of future we ought to plan for. Additionally, the 4IR also poses questions to our current conceptualisations of the path to dignified and meaningful work and life. For example, there are choices to be made about whether or not people ought to work, as the correlation between work and income will become less pronounced over time. This then raises questions about what forms of creative effort or production we may want to preserve for our people in the future. In other words, the 4IR is not only about changes in production methodologies but also a new concept of human life and identity.

THE SOCIO-ECONOMY IN HISTORICAL CONTEXT

Undoubtedly, the 4IR represents an opportunity to place South Africa in a leadership role, casting behind a history of exploitation and exclusion. To achieve this, we must develop a deep understanding of our past, recognising that it is not a failure of human capabilities but rather a clash in economic and social value systems that resulted in grossly unequal outcomes.

Indeed, scholarly accounts of the nature, origins, and impact of industrial change in Africa often begin with the emergence of British industrialisation in the latter part of the 18th century and into the 19th century[2]. In an attempt to explain more recent examples of rapid industrial development and socio-economic change, the focus has shifted from the European (and mainly British) cases to the East Asian examples[3]. Within this context, considerations of the economic profile of various parts of Africa (and other regions that were colonised) are eclipsed save only to highlight the extent of Europe's (or Asian Tigers') relative economic and industrial advancement during the same time period. Not only this, but the story of industrialisation or that of emergent economic organisation beyond sole reliance on agriculture tends also to pivot towards European intervention in African society and economy rather

1 de la Escosura, L.P. (2004). Exceptionalism and Industrialisation: Britain and its European Rivals, 1688 - 1815. Cambridge: Cambridge University Press; Harvie, C., Martin, G., and Scharf, A. Eds. (1970). Industrialisation and Culture, 1830 - 1914. London and Basingstoke: MacMillan and Co. LTD; Hopkins, E. (2009). Industrial Britain: A Social History, 1830 - 1951. London: Routledge.

2, 3 Evans. P. (1998). 'Transferable Lessons: Re-Examining the Institutional Prerequisites of East Asian Economic Policies'. The Journal of Development Studies Vol (34) 6. pp. 66 – 86; Gareth, A. (2010). 'The Developmental State and Labour-Intensive Industrialisation: 'Late Development' Reconsidered'. Economic History of Developing Regions Vol. 25; 1, pp. 51 – 74; Kay, C. 2002. 'Why East Asia overtook Latin America: Agrarian reform, industrialisation and development'. Third World Quarterly Vol(23', 6. pp. 1073 – 1102; Sugihara, K. (2007). 'Labour Intensive Industrialisation in Global History'. Australian Economic History Review Vol. 47(2).

than endogenous developments developments.[4]
In recent years, studies on the Kingdom of Mapungubwe (c.1075–1220) have shifted away from the mainly archaeological, geological, and environmental to the construction of a narrative around the Kingdom's socio-cultural legacy in Southern Africa. Notably in South Africa, the discursive

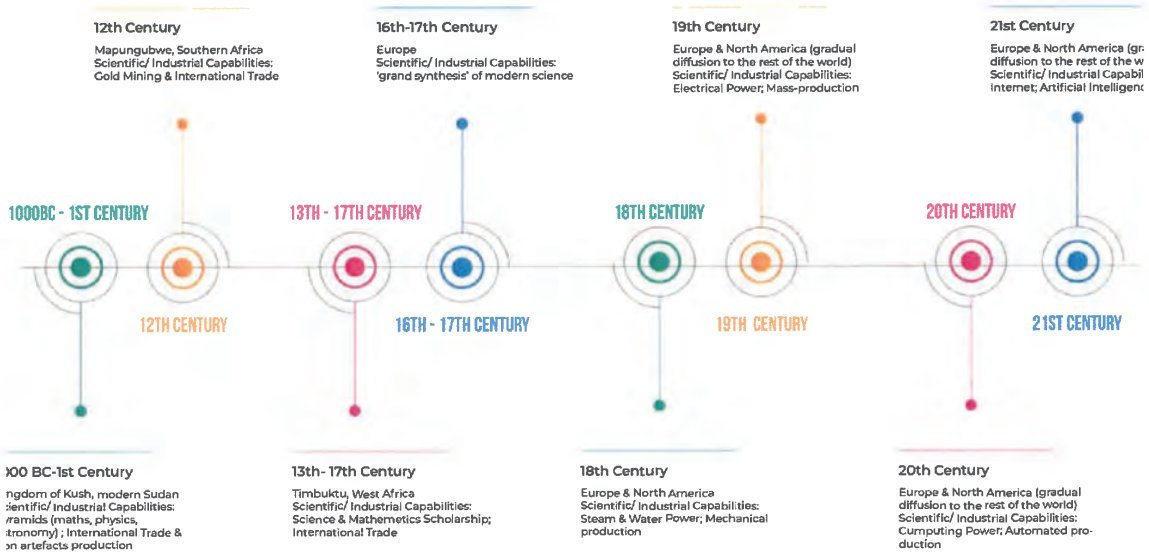
(re)construction of Mapunguwe [5] has come to serve a number of politically and culturally justifiable ends central to which the kingdom's technical capability in mineral extraction have been highlighted as well as Africa's self-directed insertion into global trade networks across the Indian (and Atlantic) Ocean world.[6]

Mapungubwe was a precolonial Southern-African state located at the regional confluence of present-day South Africa, Botswana, Zimbabwe, and Mozambique. At its height, the kingdom had a population of 5000 people and was organised around a class-based social order due, in part, to political-elites' access to and control over gold and ivory trade [7].

Although initially a trade good along the East coast of Africa, over time gold assumed important symbolic value within Mapungubwe society itself, replacing the centrality of cattle as the principal marker of wealth and status.[8]

Therefore, central to the evaluation of history is an appreciation of the distinction between industrialisation and industrial capabilities. What this section surfaces is the fact that science and the attendant industrial capabilities it produces were not limited to 16th century Europe. Indeed, at the intersection of modern-day Zimbabwe, Botswana and South Africa, existed an advanced civilisation, Mapungubwe, which contained within it industrial capabilities and international trade sophistication in as early a time as the 12th century.

The below timeline contextualises Africa's industrial capabilities starting 1000 BC:



4 Fine, B. and Rustomjee, Z. 1996. The Political Economy of South Africa: From Minerals and Energy Complex to Industrialisation. London: C. Hurst and Co.; Marks, S. and Rathbone, R. Eds. (1982). Industrialisation and Social Change in South Africa: African class formation, culture, and consciousness, 1870-1930. London and New York: Longman.

5 Carruthers, J. (2006). 'Mapungubwe: An Historical and Contemporary Analysis of a World Heritage Cultural Landscape'. African Protected Area Conservation and Science Vol 49(1). pp. 1-13; Chirikure, S. (2007). 'Minerals in Society: Iron Production and its Position in Iron-Age Communities of Southern Africa'. Journal of Social Archaeology Vol 7(1). pp. 72–100; Pikirayi, I. (2011) 'The Past Within the Present: The Contemporary Uses of Mapungubwe'. In Sian Tiley-Nel. Ed. Mapungubwe Remembered: Contributions to Mapungubwe by the University of Pretoria. Johannesburg: Chris Van Rensburg Publications.

6 Pwiti, Gilbert. 1991. Trade and Economies in Southern Africa: The Archaeological Evidence. Zambezia 18(2). pp.119-129; Reid, A. and Segobye, A. (2000). 'Politics, Society and Trade on the Eastern Margins of the Kalahari'. Goodwin Series: African Naissance - The Limpopo Valley 1000 Years Ago Vol 8. pp. 58 – 68; Wood, M. (2000). 'Making Connections: Relationships between International Trade and Glass Beads from the Shashe-Limpopo Area'. Goodwin Series: African Naissance - The Limpopo Valley 1000 Years Ago Vol 8, pp. 78-90.

7 Huffman, T. (2008) 'Mapungubwe and Great Zimbabwe: The Origin and Spread of Social Complexity in Southern Africa'. Journal of Anthropological Archaeology Vol(28) 1. pp. 37-54.

8 Woodborne, S., Pienaar, M., and Tiley-Neo, S. (2009). 'Dating the Mapungubwe Hill Gold'. Journal of African Archaeology Vol. (7) 1, pp. 99-105.

In Africa's development outlook in the 4IR, we seek to understand the kind of balance that must be struck between science and capital in order to produce economic competitiveness and societal wellbeing.

KEY FEATURES OF SOUTH AFRICA'S SOCIO-ECONOMY

01 South Africa is a relatively youthful country. Of the approximately 57 million South Africans, the median age is 26 years of age. Historically a relatively low median population age would be characterised as a demographic dividend with potential long-term benefits for the country's productivity and economic growth.

02 In terms of the country's gender profile, women constitute just over half (51%) the total population.

03 The country continues to experience significant internal migration, with nearly two-thirds of all South Africans living in urban areas. This trend is set to continue into the foreseeable future. The failure to plan for and adequately provide social and economic services linked to urbanisation poses a critical challenge for improving human wellbeing.

04 Although the income disparity between ethnicities has narrowed with the emergence of the Black middle class, income disparities among Black South Africans have increased requiring new policy and other structural instruments for addressing the widening gap.

05 Thus, despite improvements in South Africa's overall HDI since 1990, currently pegged at 0.699, disaggregating the overall HDI by its component indices (education, life expectancy, and Gross National Income (GNI) per capita), illustrates a trajectory that has been volatile in terms of life expectancy.

06 The Structure of SA's economy has changed dramatically over the past 2 decades with historical anchor sectors such as mining and energy, reducing in terms of their aggregate contribution to GDP as well as their average growth rate over time.

07 Regression in the Water and Energy sector is the single-biggest threat to South Africa- both in respect of human development and economic growth.

08 Domestic workers are the largest employment group in South Africa. To this end, the largest employment sectors in South Africa are Private Households and Community Services.

09 Whilst the National Development Plan (NDP) envisages aggregate growth of 5.5%, the highest growing sector between 2010 and 2018 has been Finance at 2,6%. This indicates that all sectors are under-performing relative to the growth targets necessary to respond to SA's development challenges.

10 In terms of the World Economic Forum Competitiveness Ranking, South Africa is 67th, out of 140 countries, 5 places down from its 2017 place.

Source: www.statssa.gov.za accessed 20 October 2019

Summary of Key Ideas

The Fourth Industrial Revolution has the potential to catalyse South Africa's path to attaining the goals of the National Development Plan. Therefore, the task of contemplating a 4IR strategy and related institutional arrangements is principally about contemplating solutions to South Africa's development challenges. The quest at the heart of this Commission is thus related to two key questions: South Africa's economic competitiveness and the wellbeing of her people.

Economic Competitiveness + Societal Wellbeing

*World Economic Forum (2019): Insight Report- The Global Competitiveness Report 2019

**Source: Human Development Report Office. 2018. Human Development Indices and Indicators: 2018 Statistical Update. New York: United Nations

In other words, this project roots firmly within the existing vision for South Africa as enshrined in the Constitution, that is, a South Africa that is cognisant of its past, committed to honouring the lives of those who have suffered as a consequence of it and dedicated to engendering social, economic and political belonging to all who live in it.

The central goal of this Summary Report is to generate a common understanding of the key features of the 4IR and their intersections with South Africa's current socio-economic standing and constraints. Given the requirement to achieve economic competitiveness in the 4IR, this report evaluates the 4IR strategies of countries at the forefront of planning, to

provide an understanding of the global context. Each theme, or workstream is then expanded upon to demonstrate the intricacies of the unfolding present and future. Cutting across all workstreams is the question of socio-economic impact, which seeks to focus thinking on the future implications of the choices that must be made in the present.

The key lessons emerging from the 4IR country review are thus:

01 The 4IR is a new epoch in social and economic life. It is driven by technological advancements that will deepen the connections between the biological, physical and digital worlds, therefore blurring or merging capabilities amongst these domains.

02 Success in the 4IR will depend on our ability to unleash the full scientific, industrial and creative capabilities of South African society. In other words, the fundamentals of this revolution are consistent with the aims of our developmental state: economic competitiveness and societal wellbeing.

03 However, failure to respond to the nature of these technological changes as well as their related infrastructural requirements, will pose a threat to South African industries; the relative wellbeing of South African people and their ability to participate in the world as equals.

04 Despite the fact that South Africa is the most industrialised country on the African continent, it has not reaped the full benefits of previous Industrial Revolutions owing to an interrupted history. This has had adverse consequences for our people, banishing most to poverty and socio-economic exclusion.

05 That we are capable is evidence by our history, which includes the ancient Kingdom of Mapungubwe, which was home to advanced scientific, artistic and industrial capabilities.

06 The challenge of our time is therefore not simply about developing human capabilities but the recognition of the competitive landscape and our comparative place amongst nations.

07 To this end, we have evaluated the 4IR strategies of various countries, all of which are pursuing different investments in technological; industrial and human capabilities, in a bid to secure their unique place in the global economy.

08 Cutting across country strategies is the centrality of the state: a focus on leveraging technology to address service delivery challenges; placing research, data management and science at the cross-cutting base of the state and public-private partnerships focused on scientific experimentation.

09 Whilst the South African state is currently fiscally constrained, it has a unique opportunity to use its buying power to ignite the creation of industries of the future. This will simultaneously respond to the delivery of public goods whilst creating a clear, initial market for new industrialists, representative of the broader transformation vision.

10 Government departments will have crucial roles to play in aligning scientific and training efforts to clear industrial development priorities. This will require focus and a possible reduction in programmes.

As a result of extensive research, public and government consultations held by the various Commission workstreams, a view has emerged of our desired 4IR future. Further consultations will be held to gain inputs and build consensus from more sections of society. The Commission is aware that there is a form of acceleration that, done without full consideration of inequality, can further the gap. To veer from our historical development path, the 4IR is an opportunity to more mindfully integrate the majority, who typically live in geographies that lack the appropriate infrastructure for participation.

Done correctly, we also have the opportunity to collaborate more meaningfully across the continent to ensure that we rise together. It is on this basis that the continuous work around the 4IR ought to consider the historical context in order to drive a more holistic development outcome.

The Commission has rallied together in producing a strategic focus for South Africa to effectively participate in the 4IR. The proposed dream for the country in the 4IR is:

South Africa will have a globally competitive, inclusive and shared economy with the technological capability and production capacity that is driven by people harnessing the 4IR to propel the country forward towards its social and economic goals, instead of falling behind.


166
EUROPE

The History of Industrial Revolutions

We are currently in the initial phase of the fourth industrial revolution. The world has witnessed three industrial revolutions over the past 250 years.

Before the three industrial revolutions, Mapungubwe (consisting of modern-day Zimbabwe, Botswana and South Africa) contained within it various industrial capabilities.

Industrial revolutions usher in major socio-economic shifts. The **first industrial revolution** started in the late eighteenth century with the use of steam to power different processes. Prior to this revolution human and animal power was used for production. One of the major inventions, which symbolises this revolution, is the steam engine. Steam power was also used for driving weaving mills etc. This led to increased and localised production in factories. Due to industrialisation, there was an effect on the social structure. People started moving from villages to the cities where industries were located. We were slowly moving away from an agriculture-based society to an industry-based society. The first industrial revolution emerged in England, spreading to different parts of the world over the course of a century.

The **second industrial revolution** took place approximately a century after the first. A key driver of this revolution was the invention of electricity.

During the second industrial revolution, steam power was replaced by electric power. Slowly, electricity began to replace steam in industrial production. Another major invention was that of electric motors, which led to assembly lines and mass production. The invention of electricity changed society in a significant way, most notably increasing economic productivity.

The **third industrial revolution** started in the second half of the twentieth century. Igniting this revolution was the advancement in the semiconductor industry. Transistors were invented in 1947 at the Bell labs in the United States of America (USA). The invention of transistors made it possible to digitise and therefore store information easily. This revolution, also called the digital revolution, also saw the advent of computers leading to the automation of industries, thus increasing production and efficiency. Another important invention of the third industrial revolution was the Internet, which resulted in worldwide virtual connection.

PART 02 DEFINING THE 4 IR

The figure below illustrates the four industrial revolutions.

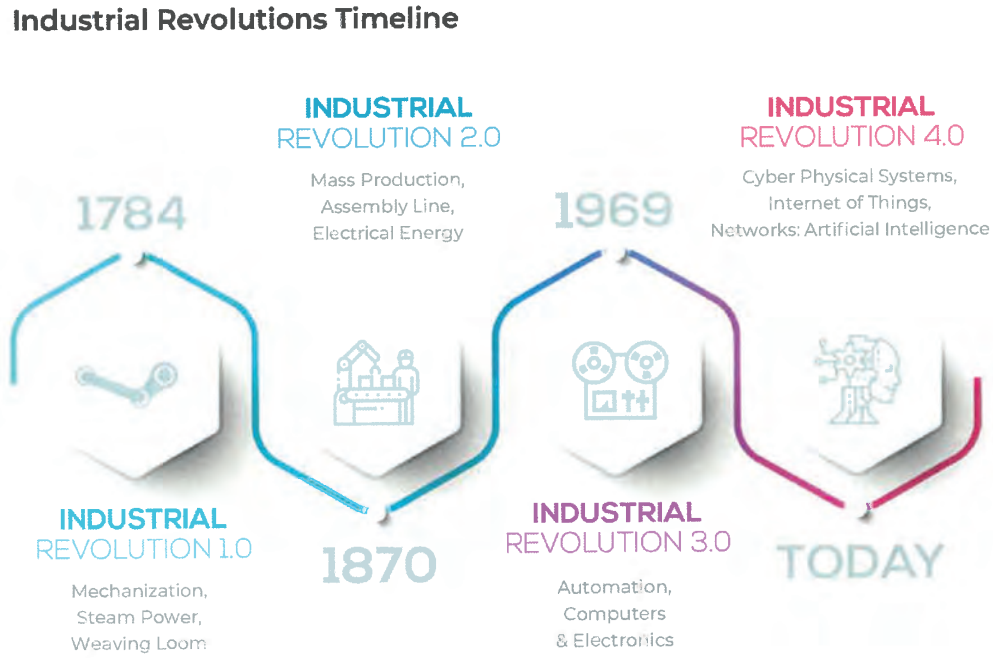


Figure 2: Industrial revolutions timeline[1]

fourth industrial revolution

4

[2]

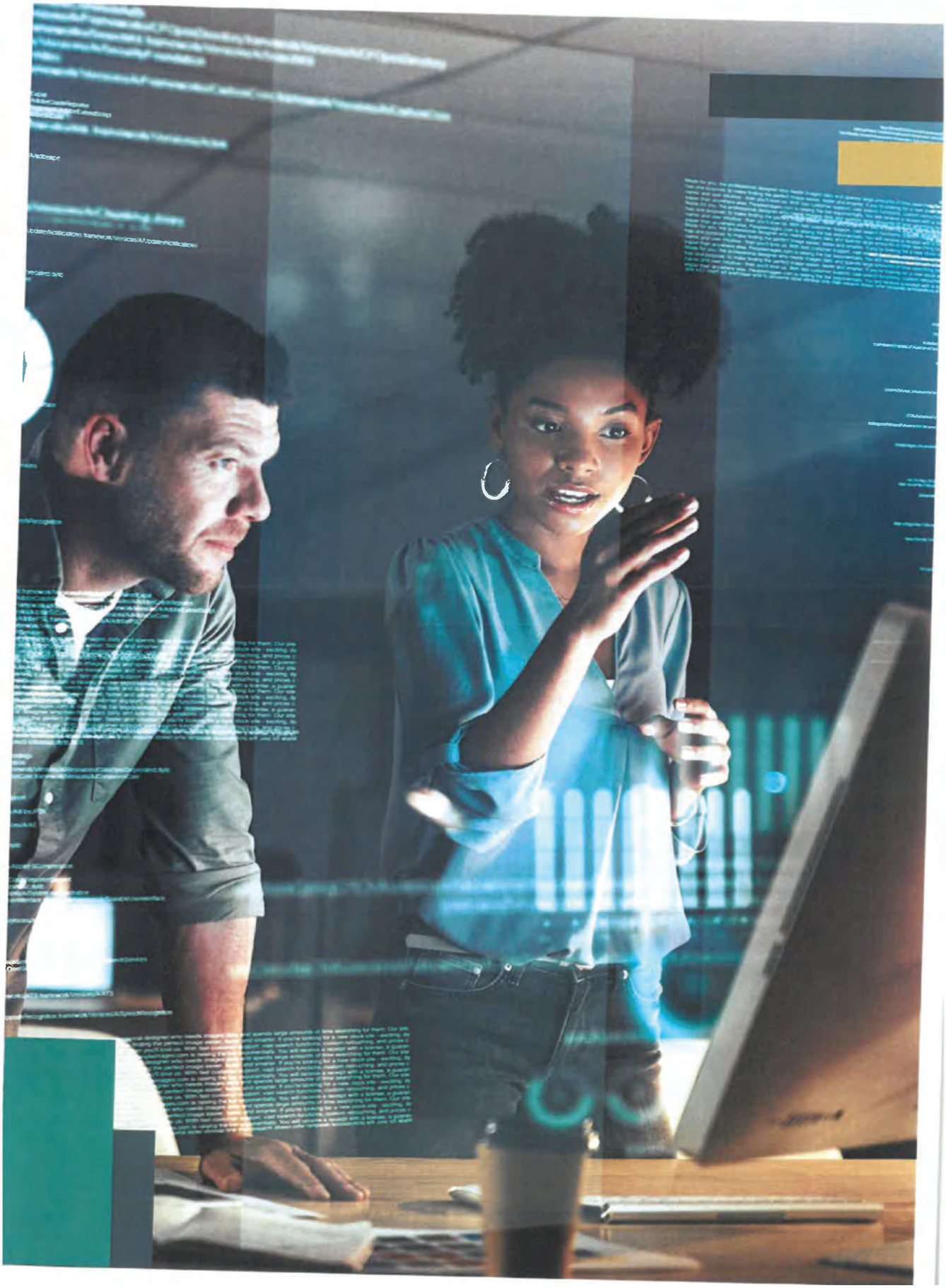
History has shown us that for a country to progress, it should be an active participant in the industrial revolutions

Some caution South Africa's ambitions of being an active participant in this revolution (because we did not fully participate in the last three revolutions;; however, the reduction of global boundaries, as well as the fast pace of this revolution, means that access to the opportunities of this revolution is more readily available and can more quickly be leveraged.

The Commission has adopted an amended definition of the 4IR that ensures a human-centric approach: ***The 4th Industrial Revolution is an era where people are using smart, connected and converged Cyber, Physical and Biological systems and smart business models to define and reshape the social, economic and political spheres.***

1 https://www.seekmomentum.com/blog/manufacturing/the-evolution-of-industry-from-1-to-4

2 https://www.weforum.org/about/the-fourth-industrial-revolution-by-klaus-schwab



PART 03: CROSS COUNTRY 4IR STRATEGY COMPARISON

CASTING OUR EYE BEYOND SOUTH AFRICA

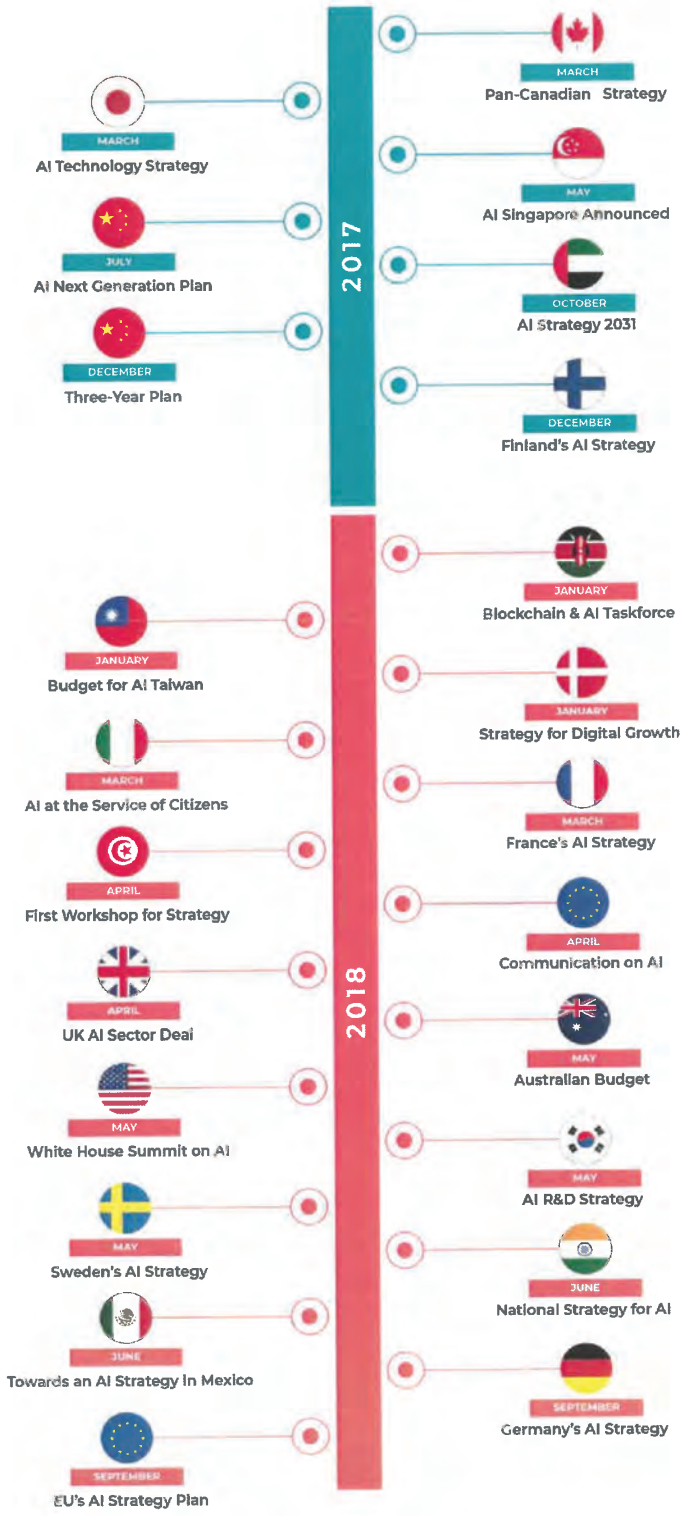
This project concerns itself with the question of development as both an objective and relative outcome. In other words, we understand that in the context of a globalised society, competition and wellbeing are not only about our own standards, but also relative to the quality of economic and social life enjoyed in other nations.

To this end, in determining the socio-economic impact of the 4IR path that South Africa embarks upon, we will also keep a firm eye on the strategies that other countries are undertaking to ascertain gaps and opportunities, both locally and internationally.

The concept of 4IR is new. Therefore, only a handful of countries have developed strategies in response to this unfolding current revolution in anticipation of a different future reality. The below image summarises the focus of the country case studies that have been evaluated by the commission.

This is not to imply that the below countries are the only ones that have begun thinking about the nature and implication of the 4IR for their societies. As the timeline diagram below demonstrates, since 2017, many countries have in fact prepared country concept documents and/or strategies, principally around Artificial Intelligence (AI). Given the focus on AI, this report highlights country cases that are focused on other aspects of the 4IR, mainly manufacturing (Germany and Malaysia) and broad digitisation with a special focus on government service delivery (Singapore). The cases of India and Japan have been included to emphasise 4IR strategies that have a social transformational thrust rather than a purely industrial developmental one.

Timeline of Country 4IR / AI Strategies



The image below highlights the various country strategies and their underlying differences.

Country	Strategy Name	Competitive Thrust	Human Capital	Industrialisation	Enablers
Germany 	Industrie 4.0 (I4.0)	Drive (decentralised) digital manufacturing	Technology (within broader High-Tech Strategy) to drive prosperity and maintain citizen's quality of life	Superior and efficient manufacturing	Private/Public partnerships in experimental research. Regulation, in particular financial services and data management.
India 	#AI4AL	Technology leadership for inclusive growth	Technology-led / -enabled socio-economic transformation	Social priorities drive technological advancement	Research leadership- the world's CERN for AI
Japan 	Society 5.0 (The 5th Science and Technology Basic Plan)	Resolution of social challenges through 4IR technologies	Improve wellbeing of citizens through deep integration of technology into the delivery of public and private goods.	Desired social outcomes determine technology priorities and deployment	Regulation of the trade of data and incorporation of such rules into the World Trade Organisation.
Malaysia 	Industry4WRD	Digital transformation of manufacturing	Manufacturing efficiency, productivity to drive economic growth	Economic and industrial priorities inform strategy	SMME Development
Singapore 	Smart Nation	Digitisation of all areas of life, especially government service delivery	Digitally-enhanced government service delivery	Service-delivery priorities drive technology strategy	Clear & centralised industrial policy planning & infrastructure deployment
United Kingdom 	Industrial Strategy	Asserting global business leadership through AI	Invest in re-training the workforce; establish world-leading technical education centres; attract best minds in AI	Transport; housing & digital infrastructure are the focus areas	Private-public sector deals; investment in venture capital for new enterprises; SMME productivity & growth
United Arab Emirates 	UAE's Fourth Industrial Strategy	Becoming the world's hub and lab for 4IR applications	Enhancing quality of life through e-government and smart consumer experience	E-government; Food & Water Security; Advanced defence manufacturing & smart cities.	Become the world's open lab for autonomous and sustainable mobility to lead the innovations in transportation

SOUTH AFRICA'S INDUSTRIAL DEVELOPMENT STRATEGY

South Africa's Industrial Policy Action Plan[3] views 4IR or digitisation as a component rather than a central feature of the future of economic production and social life. The key issues that the Industrial Plan seeks to address are legacy in nature, rooted in the country's history of unequal development, namely:

1. The concentration of economic ownership and control within the racial minority.
2. The lagging industrial capabilities of the country with respect to the third industrial revolution.
3. The increasingly blurred lines in economic sectors.
4. Poor policy coordination amongst state actors.
5. Aging economic infrastructure (electricity, roads, ports)
6. Corruption within the government sector which reduces the impact of efforts aimed at SMMEs and other types of new entrants through public procurement.

South Africa therefore articulates its strategy in terms of the traditional industrial sectors, namely:

1. Automotives
2. Clothing and Textiles
3. Metal fabrication
4. Agro-processing
5. Forestry and Timber
6. Plastics
7. Chemicals

The current approach to Industrial Planning in South Africa differs from 4IR strategies in 3 key ways:

1. Industry is not understood as a response to socio-economic challenges or the public goods agenda. Therefore, rather than incentivise for products and services it consumes (e.g. the UK is invested in industrial outcomes that advance public transportation through 4IR technology), the South African strategy is biased towards supporting industries that have minimal interface with the state. In this sense, there is no direct lever through which the State can support industrial outcomes in supported sectors.
2. Science and Technology are not expressly articulated as concerns of Industrial Development. In the future, the requirement for aggregated data and advanced technology will force the state to play a more central role in enabling technological capabilities throughout society and the economy.
3. The competitive direction of the South African state is not clear from the Industrial Policy Plan. This leads to investment in multiple arenas without clarity on a finite list of priorities. In contrast, 4IR strategies are built on the principle of comparative advantage- using technology to simultaneously resolve socio-economic challenges and establish the nation as a global leader in at least one key industry.

8 KEY LESSONS FOR SOUTH AFRICA

01 

4IR strategies are typically based on and respond to service delivery challenges as well a social and human development / wellbeing priorities. Particularly with respect to the government, there is a strong emphasis on e-government; using technology to improve mobility around cities and to enhance the quality and deployment of health services.

02 

The State is central to planning and coordination in the 4IR. A high-level inter-departmental multi-stakeholder governance and coordination structure is understood to be the institutional custodian of the 4IR strategy. For many countries, this has meant integrating Higher Education And Training with Science And Technology, making the emergent department a cross-cutting centre of research, data management and technological deployment.

03 

A focus on Regulation, Ethics, and Cultural aspects of the Internet is key, not only to create an enabling policy environment to support private and non-governmental organisations as well as the state but to ensure ethical and transparent use of these new technologies.

04 

Readiness is a recurring theme. To this end, governments are treating the novelty of technologies as opportunities for funded experimentation through private-public collaborations.

05 

4IR strategies place emphasis on leveraging and harnessing capabilities in the private sector to find scalable and profitable solutions that simultaneously uniock social and economic value.

06 

Most strategies, particularly those of emerging economies, make explicit reference to human capital development, both as it pertains to future labour force entrants and the requirement to reskill those transitioning into emerging jobs of the future.

07 

Technological commitment is also important in the context of 4IR strategies. This pertains specifically to the productive capabilities that countries seek to establish expertise and control. Technological choice also informs the human capital development approach.

08 

Strategies also reflect a clear commitment to differentiation and the establishment of a global comparative advantage. To this end, there is an emphasis on particular areas of specialisation through which various countries seek to emerge global as leaders.

3 Industrial Policy Action Plan 2018/19-2020/2021, the Department of Trade and Industry (2018)

The Commission's focus across workstreams responds to the three core concepts that underpin the strategies that are being undertaken by countries at the helm of 4IR planning:

1. **Industrialisation** as it pertains to the core technological choices and related implications for commercialisation and mainstreaming,
2. **Human Capacity Development** as it pertains to current and future participants in the economy as well as human beings in their capacity as citizens.
3. **Enablers,** which constitutes a broader contemplation of the physical infrastructure and institutional and regulatory arrangements that are needed to protect and support new modes of social and economic life.

This section unpacks the work undertaken in diagnosing the general meaning of the above themes in the 4IR and South Africa's current status in relation to what is required going forward.

INDUSTRIALISATION

TECHNOLOGY

The 4IR is about modes of production that entail developing new technologies as well as new business models. Amongst its numerous implications, in the fourth industrial revolution, there will be a greater drive towards using computers for sense-making. This will require the collection of vast amounts of data from multiple sources, powered by constantly evolving computational methods (algorithms) and processing capacity.

Constantly evolving, these technologies have both household and industrial applications and are increasingly interfacing with and, in fact, penetrating the human body, altering the physical and philosophical boundaries between the human and the non-human. The table below provides a concise summary of the technological clusters.

Specifically, in the industrial context, Digital Industrial Technologies can be understood in terms of 9 'clusters', with various applications. The table below outlines the technology clusters that will define industrial production.

Source: https://www.i-scoop.eu/industry-4-0/

Initial analysis of 4IR technologies demonstrates how 4IR technologies can be utilised to alleviate challenges experienced in key sectors for South Africa. These include:

Energy

Through the deployment of digital technologies, energy generation, storage, and transmission can become smarter, more efficient, and more transparent. Digital technologies and other 4IR technologies can enable:

- Smarter energy supply planning and demand management
- Smart energy storage
- The transition to virtually-controlled / managed power plants
- 3D printing of energy infrastructure components

Agriculture and Bio-Diversity Management

The combination of biotechnology with agro-informatics enabled by precision data has the power to improve seed and plant resilience particularly given climate variability. This can enhance food security and, in the case of bio-diversity management and protection, aid in the preservation of existing biodiversity for future generations.

- Experiments with smart and precision farming in South Africa are already underway in the wine industry with the use of drones for mapping and data-gathering
- Automated, energy-efficient water-monitoring sensors that support precise water-use for irrigation

Mining

Historically at the heart of the South Africa's industrial complex, in recent years, the GDP share of the extractive industry has been declining as new areas of the economy, notably in the services sector, advance. In addition, with more than a century of mining, much of the country's mineral wealth has already been expended and what reserves remain lie too deep for safe, human-facilitated extraction.

- Automation and the use of robots can be deployed for deeper-level mineral extraction;
- Digital rock-face mapping (through improved kinematic analysis and advanced 3D virtual isonet analysis) can assist with more precise determination of the mineral-content of rocks and their relative stability- or lack thereof – to justify precision drilling and extraction

Water and Sanitation

- Advancements in the form of smart water meters can provide real-time, detailed water use to drive responsible domestic and industrial water use
- Smart water, sanitation, and hygiene solutions can also become health and disease monitoring tools

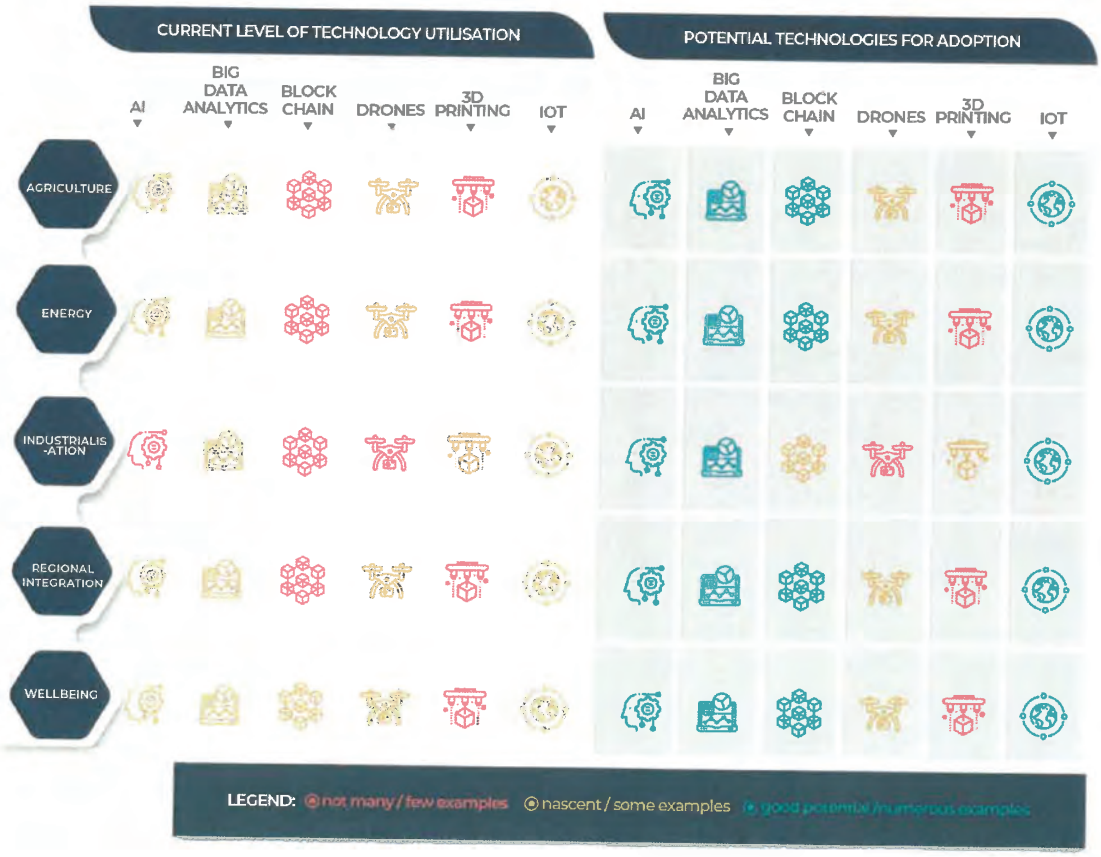
Health

- Telemedicine can bridge the gap in health access by connecting health practitioners with those in need of care
- Predictive health analytics, enabled by Big Data and digitised health information systems, can assist with mapping and predicting health services demand, empowering both private and public healthcare providers to plan accordingly
- Developments in precision medicine will, over time, improve the speed with which tailored treatment reaches the relevant patients at the point most likely to have optimal health impact

PRIORITISING TECHNOLOGICAL INVESTMENTS FOR SOCIO-ECONOMIC SECTORS IDENTIFIED

The *Unlocking the Potential of the Fourth Industrial Revolution in Africa* (2019) report prepared under the auspices of the African Development Bank (AfDB) has argued that there is already significant uptake of the Internet of Things (IoT) on the African continent. At the launch of the report in November 2019, the need for regionally-oriented governmental and industry policies and investment was highlighted. Thus, the report emphasizes, competitive markets that are scalable, particularly in telecommunications and digitisation.

The report is a comparative study that benchmarks the economic, industrial, and technological profile of South Africa, Nigeria, Cameroon, Morocco, and Uganda against South Korea and India. It is arguably the only source of information on 4IR technologies that have been adopted in select sectors of the country economies under review. In the case of the South African socio-economy, the evaluation of the state of 4IR technologies and their use has been undertaken with specific reference to agriculture, energy, manufacturing, and healthcare. It further identifies 4IR technologies with the potential for adoption/deployment, as well as those with a low possibility of uptake or application. The table below is an adaptation of the AfDB report findings on 4IR technological diffusion (and potential) in select sectors of the South African economy that correspond with the AfDB's five priority development and investment areas:



In essence, each of the colour codes above can be used to inform discussion on which technologies to prioritise: that is, which technologies should lie at the heart of the 4IR strategy and how the mix of 4IR technologies can be altered/enhanced over the medium- to long-term. It also gives a snapshot, granted only for these economic sectors rather than for the economy at large, of the technologies that are neither being adopted nor have a high probability of adoption in the foreseeable future. But there are further considerations to be explored and around which choices will have to be made regarding the pace and scope of 4IR technology adoption as well as the human capital requirements accelerating the diffusion of new and emerging technologies. Furthermore, the **regulatory** and **infrastructural requirements** to enable the adoption of new technologies, particularly for SMMEs, will also need to be deliberated.

An aspect of 4IR technologies that tends to be ignored relates to the manufacture and/or assembling of new technologies. For example, while 3D printing facilitates the on-site creation of components of (or whole) commodities, 3d printers themselves need to be manufactured or at least some of their parts manufactured and assembled. As such, determining which 4IR technologies to prioritise is as much about the application as it is about the physical artefacts that facilitates the technology.

DRIVING 4IR COMMERCIALISATION AND INDUSTRIALISATION

The task of this Commission, which is to propose a 4IR strategy for the country, is essentially about outlining and building the industrial capacity to effectively incorporate emerging technologies into existing (and unlocking new) production processes and value chains. South Africa therefore stands at the cusp of a historical opportunity to leverage and direct technology and unprecedented production capabilities for economic competitiveness. Not only this but these technologies can assist in addressing perennial human and social developmental challenges in the areas of health, education, human settlement, food security and nutrition. For South Africa, then, the opportunity is one in which to create economic value through a targeted industrial development strategy and to harness technology and scientific innovation towards the goal of societal wellbeing.

Currently, the government and broader society are grappling with South Africa's readiness for the 4IR and indeed, what 'readiness' looks like at the macro-industrial scale. It can reasonably be asserted that South Africa's position in terms of 4IR readiness is at a nascent phase – albeit at the most advanced position within the continent and arguably with the greatest possibility to transition to a high-potential position.

Technologies of the 4IR have been in existence for some time, thus opportunities are on enabling commercialisation, upgrading existing industries and creation of new industries are apparent.

Some of the work that needs to be done to take advantage of these opportunities include:

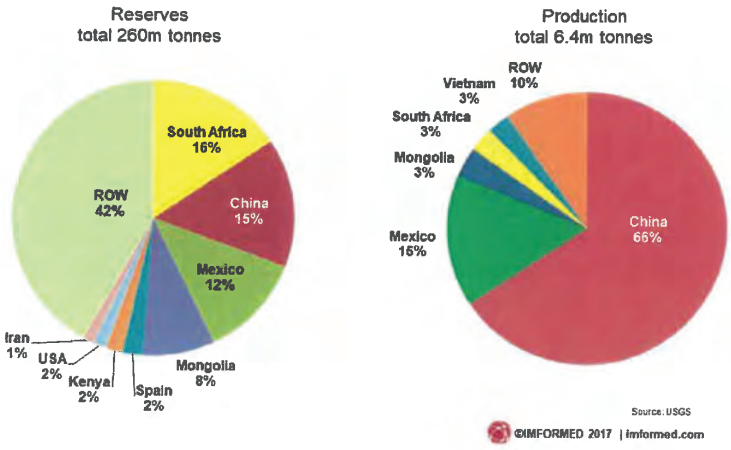
- Closing the innovation chasm, where homegrown innovation is lost (not commercialised or lost to other markets),
- Combine and leverage 4IR technologies to solve societal, economic and development issues,
- Upgrade existing sectors and industries while creating new ones,
- Drive economic growth and trade for GDP growth and South Africa's prosperity.

Looking at the initial stages of the 4IR value chain, there is one component that plays a critical role: Calcium Fluorite (CaF_2) also known as Fluorspar. It is key component in Lithium-ion (Li-ion) batteries. Li-ion batteries are found in electronics, mobile phones, laptops, tablets, Electric Cars, Robots and other machinery. South Africa has the largest reserves of this mineral.

South Africa has a critical role to play in the Fourth Industrial Revolution that is beyond just technology and that role is within primary basic needs of the 4IR which is raw materials in battery manufacturing.

SMMEs also have to be positioned for commercialisation of 4IR homegrown innovations and building these to global scale and relevance.

World fluorspar reserves & production



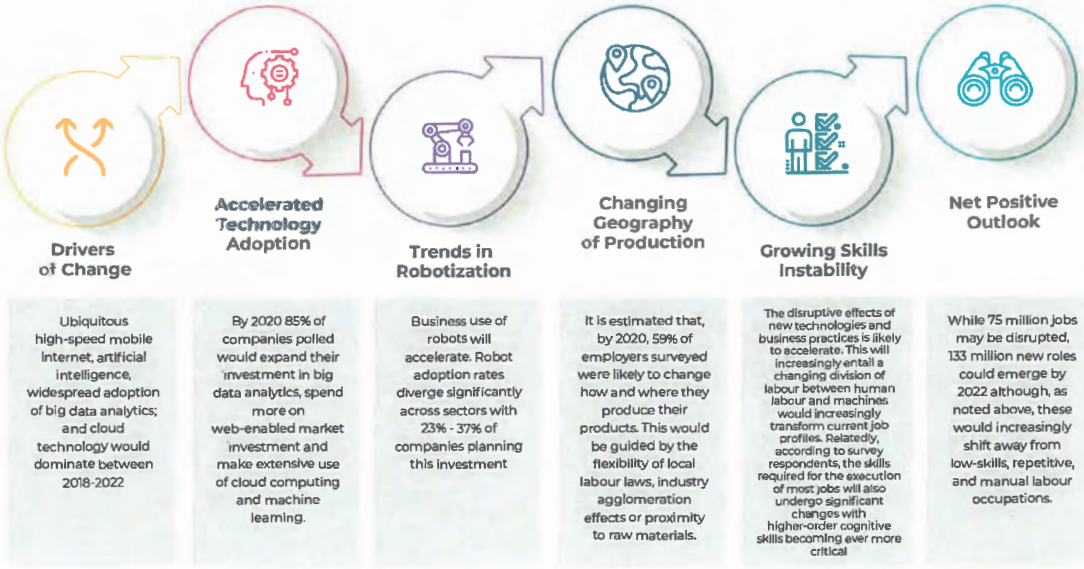
HUMAN CAPACITY AND THE FUTURE OF WORK

The changes that new technologies are beginning and will likely continue to introduce in business and industrial production practices will have a notable impact on the South African labour market. Currently, a key challenge in South Africa relates to two key labour market characteristics: unemployment and underemployment, both of which have been attributed, in part, to a seeming skills mismatch.

Especially evident among recent graduates, one of the factors associated with the country's youth unemployment crisis is the lack of skills and qualifications that are relevant to the sectors of the economy in which there are employment opportunities.[4] This is compounded by the numbers of young people who are classified as neither in employment nor in education (NEETS) [5] These features of a critical segment of the South African labour market not only represents a failure to leverage the potential economic benefits of a youthful population. Principally, it constrains the possibilities for and pace of migrating to a high-skills economy such as a digital or AI-powered one. As noted by Business Unity South Africa (BUSA) in its presentation to the International Labour Organisation (ILO)[6], business sustainability, economic competitiveness, and profitability depend on the availability of a skilled and capable workforce.

Human capacity is therefore an important feature of the economy; a key consideration in establishing an environment for private sector growth and investment.

In considering the future of work and, specifically, the types of jobs that will be available, the World Economic Forum (WEF)[7] has identified the following as some of the central considerations in this changing landscape:



Source: World Economic Forum (2018): The Future Of Jobs Report

4 Altman, Miriam . 2006. "Low Wage Work in South Africa." IZA/World Bank Conference on Employment & Development . Berlin.
Beukes, Rochelle, Tina Fransman, Simba Murozvi , and Derek Yu. 2016. "Underemployment in South Africa." ERSA Research Brief. Economic Research Southern Africa, February.

5 Rogan, Michael. 2019. "Introduction: The Post-School Education and Training Landscape in South Africa: 'Massification' Amidst Inequality." In Post-School Education and the Labour Market in South Africa, edited by Michael Rogan. Pretoria and Cape Town: HSRC Press.

6 Cohen, Tanya. 2019. "Business Unity South Africa (BUSA) Remarks at ILO and IOE International Women's Day Event." A Quantum Leap for Gender Equality: For a Better Future of Work for All. Geneva.
Reddy, Vijay, Haroun Bhorat , Marcus Powell, Mariette Visser, and Fabian Arends. 2016. Skills Supply and Demand in South Africa. Labour Market Intelligence Partnership , Pretoria: Department of Higher Education and Training

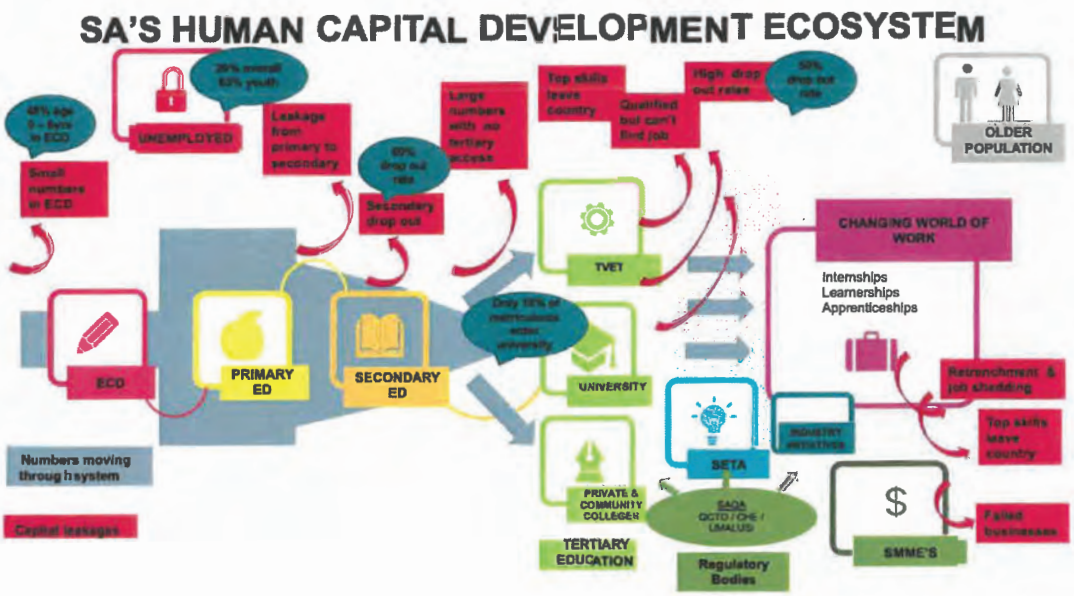
7 World Economic Forum . 2018. The Future of Jobs Report. Cologny/Geneva: Centre for the New Economy and Society

While the net outlook for jobs is predicted to be positive, the reality is that there will be an initial displacement of jobs and a transition period in which government, business and labour need to urgently prioritise re-skilling the current labour force for the future of work, consider relevant policy and social protection interventions and identify the levers which could provide opportunities to accelerate growth.

A South African strategy has to acknowledge that many of our sectors are still operating in the 3IR space. A human capacity strategy needs to focus on the future areas of work while strengthening current sectors for maximum job retention, job creation and a transition from the current to future-ready scenarios.

Investments must be made in current focus sectors such as advanced manufacturing, tourism and agriculture, while at the same time investing in economic areas which are emerging sectors in 4IR economies such as the digital economy, the green or circular economy, the social economy, the gig economy and the creative economy.

To adequately and sustainably address the need for a massification of skills and industry uptake of such i.e. creating onramps for large groups of youth and the unemployed to be skilled to participate in the economy, relevant digital and future skills need to be identified and AI-driven technology platforms designed to support skills pipeline development which is informed by industry.



In the current climate of slow economic growth and high unemployment levels, a social dialogue is critical and the consideration of social protection mechanisms to ensure a just transition for workers and employers must be investigated.

Coordination within and between labour and business for a response to 4IR which prioritises growth and leverages job creation potential is required. The Institutions of work require a renewed engagement for a social contract and the accompanying social protection systems in the context of 4IR and the changing world of work. Entirely new areas of labour and tax laws need to be engaged in regulating, for example, the gig economy and work done electronically across geographical borders.

The image below shows a possible adaptation of the framework developed by the Global Commission on the Future of Work[8], to make it more relevant to a South African context.

CREATING AN ENABLING ENVIRONMENT

CAPITAL MARKETS AND FINANCING

The 2008 global financial crisis has transformed the interaction between banking, capital markets, politics and economics. Global regulation has become tighter and effort has been made in developing capital markets that co-exist with a bank-based financial system. Central banks are generally playing a more pivotal role in the financial system. Technology is changing the face of finance globally.

Capital markets mobilise capital for productive long-term investment and are specifically important in emerging economies, to fund future growth and ensure the global competitiveness of the economy. Firms with high growth potential and the ability to scale receive funding from startup and early-stage finance and these are of importance in 4IR.

In South Africa, startup and early-stage finance is a large, but closing, gap compared to other countries. Startups have access to capital through an emerging Venture Capital (VC) and Private Equity (PE) sector, and a growing angel investor network, as well as growing interest from international investors. In addition, South Africa faces challenges in long-term finance, specifically in the infrastructure sector. With weak economic growth, it is challenging for public capital to address the infrastructure financing gap.

South Africa has the strongest financial market development in Africa.[9] As South Africa looks to mobilise capital for it's 4IR strategy, it needs to address policy and regulation challenges relating to policy uncertainty and governance; alignment of government efforts; exchange control and intellectual property laws that attract investment; tax inefficiencies and complexities; and competition regulation.

8 International Labour Office. 2019. *Work for a Brighter Future - Global Commission on the Future of Work*. Geneva: ILO. https://www.ilo.org/wcmsp5/groups/public/---dgreports/---cabinet/documents/publication/wcms_662410.pdf

9 Official Monetary and Financial Institutions Forum OMFIF produced the Absa Africa Financial Market Index

The country needs to develop a 4IR innovation pipeline (from ideation to commercialisation) and this requires innovative and sustainable funding happening through innovative Public-Private Partnerships that respond to the country's current fiscal position. We should seek to keep our innovators in this country while allowing our innovations to cross borders and allow capital flow into the country.

The ease of doing business needs to be improved alongside establishing South Africa as the financial centre for Africa to stimulate above-average economic growth through innovation centres that attract top firms, top talent and serious capital to the country.

The entrepreneurial ecosystem provides an innovation pipeline for funding opportunities and mandates. Business Development Support access should be widened, while developing skilled business support across business type, stage and potential to scale. SMMEs that are already, or have potential to build 4IR-aligned business models, products and services should be aggressively supported, funded and scaled for growth.

More early-stage risk capital should be made available to small and growing businesses to narrow the funding gap and new innovative funding models should be explored (e.g.: funding in stages allowing funders to invest in smaller amounts and reduce risk and providing the entrepreneurs with an opportunity to test the market).

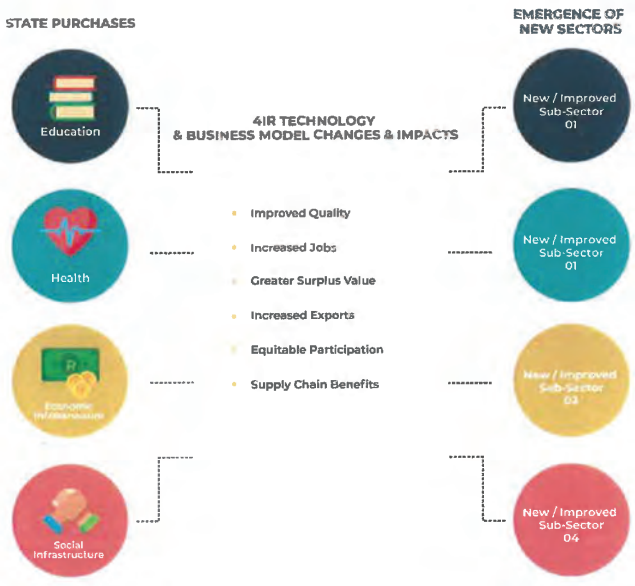
A 4IR-specific risk capital fund should be established as a public-private-partnership. The fund should focus on areas where current private-industry solutions are not meeting demand such as early-stage and series B and C funding stages.

Funding initiatives should be evaluated for their effectiveness and scaling up of those programmes/funds that are performing well should be actively explored to defragment the funding ecosystem.

THE GOVERNMENT AS DIRECTOR OF TECHNO-INDUSTRIAL OUTCOMES

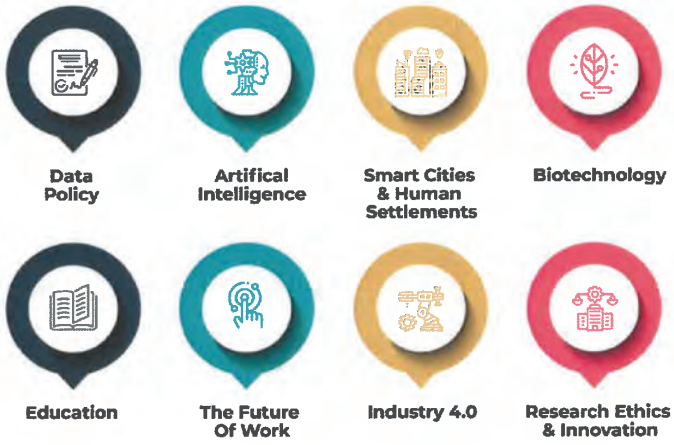
In its capacity as a direct role player in the 4IR, the state is characterised by its identity as the largest and most powerful purchaser in the country. To this end, the state's budget is predominantly spent on Education, Health, Social and Economic Infrastructure as well as Policing Services. This consumptive power is an opportunity for the state to determine the forms of 4IR production it is willing to reward/incentivise through procurement. In so doing, the state as procurer, can directly determine the emergence of 4IR industries that respond to its consumption appetite as well as the national economic development objectives.

It is envisaged that through this lever, the state can trigger industries as conceptualised in the image below:



THE GOVERNMENT AS REGULATOR OF TECHNO-INDUSTRIAL OUTCOMES AND SOCIO-ECONOMIC IMPACTS

It is clear that government's regulatory role will have to address the following areas of life in the 4IR:



The Process For Policy Development

Globally, efforts are under way to adopt policy and regulatory regimes to harness the 4IR to achieve national and international goals. The USA, the EU, China, and Russia, amongst many others, are accelerating policy and legislative reforms to harness technological change to meet national objectives. In South Africa, the process is under way, and the PC4IR plays a critical role: providing recommendations to guide the actions of both legislators and policy makers within government to implement a coherent national response.

Within the Commission, debate and stakeholder consultations have led to an emerging set of principles that will guide the development of policy and legal recommendations. The 4IR must be steered to create an inclusive, innovative and resilient society. An integrated data policy is required – all initiatives by various departments must be reviewed and aligned.

01 **Policy must be inclusive in its process:** so that all members of society can participate in the policy formation. This is imperative for inclusivity in the outcomes.

02 **Integrated infrastructure framework:** Duplication and fragmentation of infrastructure development must be avoided.

03 **Financial incentives:** Policies and laws must be drafted with South African entrepreneurs in mind. For example, firms (both local and foreign) who invest in rural, underserved and marginalised communities' small businesses, entrepreneurs, youth, women and people with disability should be incentivised through policy instruments.

Adaptiveness: SA requires an agile, flexible approach to determining policy and regulation in a 4IR. The core of any national response to the 4IR must be an increased capacity to be responsive to technological change - to sense changes in the global and local technological environments, to interpret these changes in terms of their relevance to economies, society, institutions, and policy. This intelligence must be systematically used to inform a coherent and dynamic policy cycle. It is imperative to remain flexible, since by the time the policy cycle has turned, it is likely that new technological dynamics will be at play. While contemporary policy must indeed seek to leverage specific technologies such as artificial intelligence, additive manufacturing (3D printing), or the industrial internet of things, it must also develop the overall adaptive capabilities of systems to harness and steer technological change towards meeting developmental agendas – for example by strengthening the capabilities of universities and firms to interact and exchange information about future skills demand and supply, or by developing intelligence about frontier technologies in order to inform future-oriented policy.

Social Economic Impact Assessment System (SEIAS): SEIAS consultation is vital as is extensive stakeholder consultation and review of existing policies and new policies or regulation being proposed. SEAIS is mandated to review policies and regulation. Cabinet decided on the need for a consistent assessment of the socio-economic impact of policy initiatives, legislation and regulations in February 2007 and in 2015. This decision was ratified by Parliament. Policies and Regulations that are internally signed by Ministers should be subjected to SEIAS. SEAIS aims to minimise unintended consequences from policy initiatives, regulations and legislation, including unnecessary costs from implementation and compliance as well as from unanticipated outcomes, and to anticipate implementation risks and encourage measures to mitigate them.

INFRASTRUCTURE

A distinction between Industry 4.0 and 4IR is essential for framing this report. Industry 4.0 (i4.0) - is the digitisation of manufacturing utilising new technologies of IoT, robotics, cloud computing and data management. This is the model that Germany and many other countries have used to frame their technological innovations.

There is also the concept of the Second Machine Age by Erik Brynjolfsson and Andrew McAfee involving the automation of cognitive tasks that make software-driven machines perform human tasks so much better that they end up being substitutes and taking the place of humans.[9]

In his book, The Third wave - Steve Case presents a picture of a world that is on the cusp of what he calls the third "Internet revolution". This wave was preceded by the 1st wave to get people online and the second wave to build solutions on the internet. In the third wave, Case contends the Internet is integrated into our every day life in every aspect.[10]

The 4IR builds on the ongoing digital revolution as a result of the growing access to and use of the Internet and digital technology and enhances it with smart and autonomous systems fueled by data and machine learning.[11]

Alta van der Merwe and Aurona Gerber describe a conceptual framework of 4IR: "These aspects include technologies, technology fusion (in the middle because they drive change), surrounded by the specific profession (or domain), digital disruption and digital transformation."[12]

The Fourth Industrial Revolution (4IR) promises substantial economic and social value for our country and its people. Digitisation is seen as an opportunity for low-income developing countries to leapfrog into the 21st century given the required infrastructure, human capital and a supportive regulatory environment.[13]

The Commission assessed Digital infrastructures, as infrastructure that can collect, store, and make digital data available across a number of systems and devices. We also reviewed how traditional infrastructure will be impacted by digital technologies resulting in the new models of digitally enabled infrastructure.

According to the World Bank Group[14]:

"In 2016, the global digital economy was worth some $11.5 trillion – equivalent to 15.5 percent of the world's overall GDP.

9 https://medium.com/of-all-things-tech-progress/summary-of-the-second-machine-age-28f5ad99c7bb

10 https://paulminors.com/blog/third-wave-steve-case-book-summary-pdf/

11 https://www.foreignaffairs.com/articles/2015-12-12/fourth-industrial-revolution

12 https://www.itweb.co.za/content/6GxRKqY8p1JMb3Wj

13 https://www.brookings.edu/wp-content/uploads/2018/01/foresight-2018_chapter-5_web_final1.pdf

14 Draft World Bank Group report: Digital economy for Africa dated June 2019, page 6

It is expected to reach 25 percent in less than a decade, quickly outpacing the growth of the overall economy. However, countries like South Africa are still currently only capturing a fraction of this growth and need to strategically invest in the foundational elements of their digital economy to keep pace."

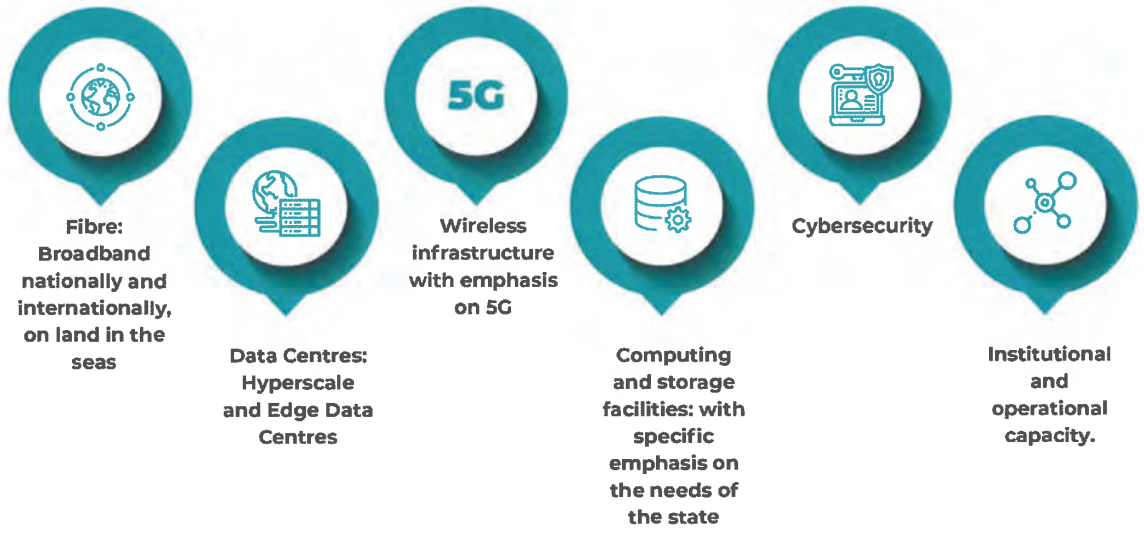
The drive to connect people and businesses to the Internet with digital infrastructure is urgent and imperative, if South Africa is to prepare for 4IR adequately. Sociologist Robert Merton coined the term "Matthew Effect" in 1968 describing a phenomenon where early advantage increases over time. Today the advancing impact of technology is unquestionable and we see that early adopters (innovators) have gained the lead and will continue to advance even further and further ahead of the rest. We, therefore, cannot afford to allow the digital divide to deteriorate further into a digital chasm by continuing to lag behind technological progress.

According to the new UN report, "countries in Africa are trailing 'considerably behind' developed markets in their share of the digital economy, a trajectory that is likely to continue, fueling a growing global digital divide."[15] According to McKinsey, African countries on average spend about 1.1% of GDP on investment in 'going digital' (including Internet infrastructure and networks), while developed countries spend 3.2% of GDP.[16] The latest International Telecommunications Union (ITU) data reveal that some 52% or 3.7 billion of the world's population currently remain unconnected (ITU, 2018). The ITU also estimates that connecting the next 1.5 billion people will cost USD 450 billion.[17]

This section proposes actions that need to be taken to be part of the 4IR race starting in the context of infrastructure development.

Infrastructure is indeed the cornerstone of modern society consisting of a grid-like network of roads and rail, water supply, electrical grids, the built environment and digital networks. In the past, we talked of analogue infrastructure but today we speak of digital infrastructure. Future infrastructure is software-based, data-enabled and has cloud access. Digital infrastructure is set to improve access to information and thereby promote transparency of government processes and activities and in turn, build interconnected empowered communities.

Key infrastructure components and related resources covered in this report include:

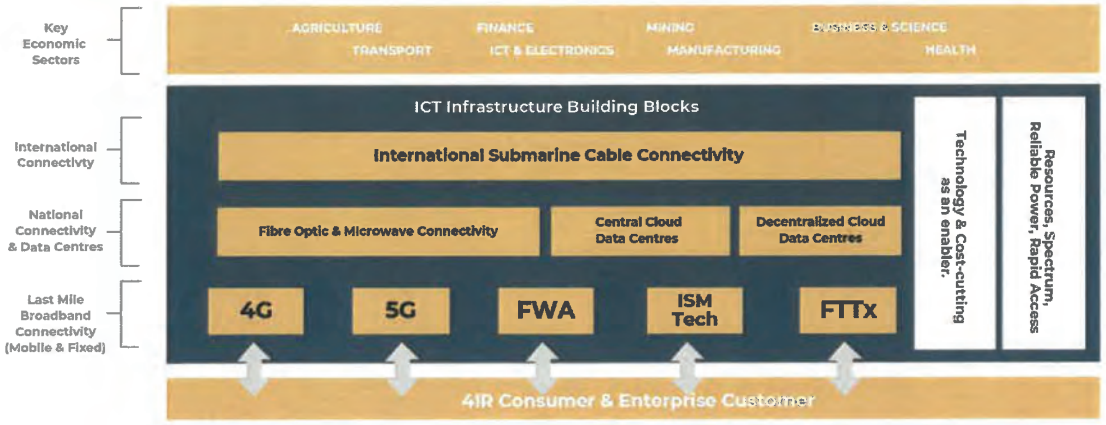


15 https://unctad.org/en/PublicationsLibrary/der2019_en.pdf

16 https://www.mckinsey.com/~/media/mckinsey/industries/high%20tech/our%20insights/lions%20go%20digital%20the%20internets%20transformative%20potential%20in%20africa/mgi_lions_go_digital_full_report_nov2013.ashx

17 https://www.itu.int/dms_pub/itu-s/opb/pol/S-POL-BROADBAND.19-2018-PDF-E.pdf

The figure below provides a high-level view of the relevant ICT infrastructure and resources. Furthermore, the relevant 4IR technologies to optimally manage infrastructure supporting the key economic sectors are reflected.



It will be crucial that we build institutional and operational capacity to participate in the full scope of global 4IR innovation through a restructuring of current state resources (physical and institutional) and investing in new resources, with optimal participation of local, international, public and private partnerships.

Findings thus far highlight the importance of *global integration and best practice* as a lens through which we look to design and implement the roll-out of the 4IR infrastructure.

A second issue identified by the Commission is the need to *innovate*, as we cannot continue implementing past approaches into the future. We need a fundamental mind shift. There is a new industrial organisation developing as digital platforms reconfigure new value-creating ecosystems. Connectivity is moving from human-to-human connectivity to human-machine-machine interconnection. We cannot approach today in the same way we have always done.

A World Bank Group draft report[18] states: *"The Digital Moonshot target of 100% of population covered by mobile broadband networks is almost reached."* However, it goes on to state[19] that *"...rural areas are being left behind. As extending mobile broadband coverage is becoming a less important issue, the divide is explained more by affordability and characterised by quality of access."*

It then expands on the **digital divide**[20]: *"But since 2010, the regulatory, policy and business environment has been less conducive to private investment. Regarding digital infrastructure specifically, notable constraints to private investment in digital infrastructure include delays in allocating high demand spectrum and policy uncertainty around the Wireless Open Access Network (WOAN). Moreover, based on the findings, in specific areas such as broadband roll-out or government service digitalisation, the government appears to rely excessively on its resources and capacities, at times leading to inefficient, expensive and incomplete project implementation. Overall, there is room to consider leveraging more private investment and expertise in key areas such as infrastructure deployment, skills development and the roll-out of e-government platforms. This is especially pertinent in the context of the South African Government's commitment to fiscal consolidation."*

Hence going forward issues requiring change include (but may not be limited to):

I. *Radical innovation* to deliver the required speed in enacting legislation which enables extraction of maximum economic and societal value from our

18 Draft World Bank Group report: Digital economy for Africa dated June 2019, page 13
19 Draft World Bank Group report: Digital economy for Africa dated June 2019, page 14
20 Draft World Bank Group report: Digital economy for Africa dated June 2019, page 19

resources such as spectrum and established infrastructure, e.g. established wayleaves, roads, etc.

II. A *restructuring of resources* to eliminate the duplication of infrastructure and resources, e.g. the networks in state-owned enterprises (SOEs) such as Broadband Infraco, Sentech, etc., and

III. A restructuring of ICT governance bodies to better align with the trends in technology which e.g. reduces differences between broadcasting and Internet services.

Broadband internet and data are foundational to the digital economy. Four areas of Fibre deployment need to be considered: In-building Fibre, Capillary (Metro) Fibre access, Inter-city Fibre, and Ocean fibre (Submarine cables).

Data Protection is paramount in the 4IR era and it usually sits in Hyper-Scale Data Centres. South Africa should look to attract submarine cables to its coastlines" thus attracting HSDC for computing power.

South Africa should not delay the 5G process because the country is playing catch-up in 4G. South Africa must implement the 5G licensing process through a 5G Express Policy.

The Centre for High-Performance Computing (CHPC) infrastructure serves as a foundation upon which to build a government on-premise super cloud unit with a national grid of High-Performance Computing capacity.

Alongside this, South Africa needs to strengthen its cybersecurity policies and capabilities.

As South Africa plans for how we manage the growth of the digital economy, we need to think about how we generate and consume electricity. Exploring power consumption in the digital economy and 4IR and looking at how South African can find innovative ways to serve the growing electricity demand, is necessary.

South Africa finds itself at a decision-moment. The first phase of the Commission's work concerned itself with the current and historical position. Going forward, the work of the Commission should be integrated into existing and future institutions to achieve sustained change.

It is important to keep in mind the following key features of the path forward:

PART 05
WAY FORWARD

4IR TECHNOLOGY IS NASCENT

The majority of 4IR technologies are still nascent. This means that our current task is not necessarily to deploy them but rather to participate in their development. This also allows the country to prepare itself for the deepening effects of the 4IR. This pertains specifically to the development of human capital; infrastructure, technologies and the entrepreneurial capacity to localise 4IR industries.

THE STATE IS REQUIRED TO BE FISCALLY CREATIVE

The country's fiscal position is currently weak, with the future growth outlook projected well below the NDP target of 6%. This limits the state's capacity to directly invest in and take ownership of the industries it may choose to support. This however, is a creative challenge – requiring the state to rethink its leverage and build in long-term negotiating options.

CLIMATE CHANGE MITIGATION & ADAPTATION MUST BE INTEGRATED INTO ALL PLANNING

A central constraint in the future we are contemplating is Climate Change.

Global calls for greater environmental-sustainability have placed climate mitigation at the centre of this century's economic and industrial development regime. The Sustainable Development Goals have heightened the urgency of industrial transitions that are climate-sensitive, placing human and environmental wellbeing at the heart of global development activities. Within this context, South Africa's climate performance is worrying:

- Coal remains the country's leading source of energy, accounting for 85% of the electricity production in 2016 (DPME, 2019). It is therefore not surprising that the country's carbon dioxide emissions remain above recommended thresholds.
- Furthermore, the country's Green-House Gas (GHG) emissions have been on an upward trajectory
- The costs of air pollution on human health and economic growth in South Africa have yet to be determined. That said, fine particulate matter (PM) is one of the most lethal poilutants, higher concentrations of which are known to increase human and animal mortality, not to mention adverse effects on the biosphere.
- Areas with increased industrial growth, such as Richard's Bay in Kwazulu-Natal and the platinum belt stretching between the North West, across Limpopo, and into parts of north-west Mpumalanga are at particular emergent risk of poor air quality.
- Government priorities in terms of improving air quality, have prioritised the following actions:
  - » Continued implementation of the Air Quality Act and its National Framework
  - » Managing listed emissions activities
  - » Launching a Health Study in the Highveld Priority Area
  - » Undertaking Cost-Benefit Analyses in air quality management

As we consider the future of South Africa, the work is to analysis of the **choices** that confront the country.

It is essential to embrace the language of choice as it also references a crucial difference in the way in which we will participate in the future, as free and fully informed protagonists in our future.

Indeed, there are dilemmas to be resolved: who ought to be prioritised; what sacrifices should be made; what innovations are needed to leapfrog beyond our current constraints; who leads and who follows? These are not simple **dilemmas**. They are compounded by the urgency imposed upon us by our grand challenges.

MAKING CHOICES: DEVELOPMENT DILEMMAS AND SA'S 4IR FUTURE

This report has emphasised a choice framework, recognising that there are dilemmas to be resolved regarding who ought to be prioritised; what sacrifices should be made and by which segments of society; what innovations are needed to leapfrog beyond our current constraints and with what social and economic consequences; who leads and who follows? The urgency to resolve our grand challenges against the backdrop of the uncertainties and unknown risks of new and emerging technologies compounds the above dilemmas.

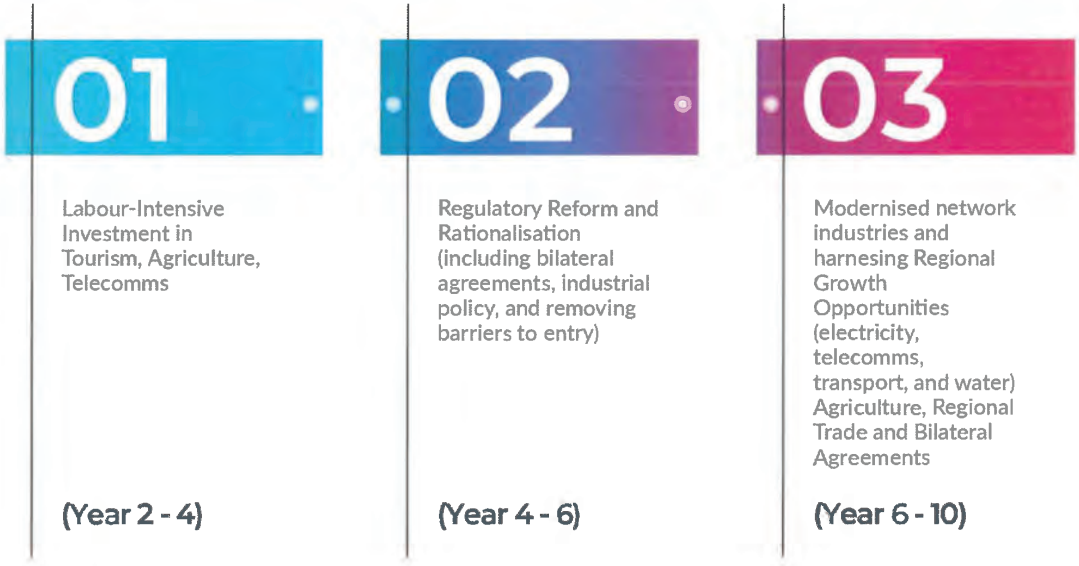
The Commission seeks to emphasise the requirement for difficult decisions to be made as this will ensure realism in our planning and execution. Rather than frame the 4IR as a wholesale government delivery programme, it ought to be positioned as a set of initiatives led and regulated by the state to unlock the potential and power of citizens. This, therefore, means that thinking through the lens of foundational principles is more instructive for understanding what is required. An example of this is in the education system. Rather than deploy a suite of technological artefacts to schools, the Commission sees greater potential in insisting on a curriculum that teaches computational thinking, as this cognitive skill better prepares learners to develop mastery over technology.

It matters that we embed technology research and development capabilities within the state and institutions of learning. Similarly, in prioritising state implementation, the use of technology to enhance service delivery should rank above other aims. Difficult choices must be made, however with finite choices will come clarity, for all sections of society.

PRIORITISING ECONOMIC SECTORS AND SOCIAL INDICATORS

The recently-released *Economic Transformation, Inclusive Growth, and Competitiveness: Towards an Economic Strategy for South Africa* (ETIGC) by National Treasury highlights what is required to improve South Africa's socio-economy. It is, in effect, the blueprint for the South African government over the next few years to resuscitate ailing segments of the economy, including industrial sectors (i.e. energy) and open new areas of economic activity through the development of Small, Micro and Medium Enterprises. The document notes the unsustainability of the prevailing situation given the combination of low economic growth and rising unemployment. The ETIGC has opted for a scenarios approach along with a time series.

Rather than mapping three or four alternative or competing futures, Treasury has identified short-, medium-, and long-term actions to set the country on a human-centred, high-growth and globally-competitive path. Seeing the Baseline scenario as the impetus for government action and intervention, what have been identified by the Commissioners' expert session as three alternatives can logically be plotted as sequential steps towards the ultimate goal of a regionally-connected and a responsive economy that harnesses innovative solutions and technologies to supply to the rest of the continent. This time-series(ed) approach hinges on sequential and incremental change, with monitoring and feedback loops to consolidate learning through pilot implementation.



4IR IMPLICATION OF LONG TERM ACTIONS

Light Up and Power Africa (Energy);

Nourish Africa (Agriculture);

Industrialise Africa (Industry and Services)

Wellbeing for Africa (Health, Education, Smart Cities and Governments)

Indeed, there has been a recognition that much of the post-apartheid growth trajectory, although not necessarily one that has centred around technological advancement as a lever for the economy, has nonetheless been characterised by joblessness.

Thus, among the challenges that the ETIGC and the DTI's Industrial Policy Action Plan (IPAP) have identified, foremost "are a lack of policy coherence and programme alignment; the concentration of ownership and control; high private sector input costs (electricity, water supply and availability, transport and logistics) and a skills deficit/mismatch as the main constraining features to the country's industrial development."

The five broad thematic priorities and reform programmes of the ETIGC have been identified as follows:

Complementarily, the DTI's IPAP had identified programmes within its sphere of influence, that can spur economic growth through industrialisation. Chief among these are:

1. Public procurement and local content

1.1 SA government (Treasury) should create a data repository on government procurement spending to allow evidence-based government-led product selection.

1.2 Align and enforce local content procurement processes at all levels of government.

1.3 Capacitate the South African Bureau of Standards (SABS) to conduct local content verifications.

2. Industrial Financing

3. Developmental (and flexible) trade policy

4. Science and Technology Innovation (STI), especially:

4.1 investtment and knowledge generation

4.2 Technology absorption and diffusion

4.3 Harmonisation of innovation support initiatives

4.4 Establishment of a Sovereign Innovation Fund (SIF) that can administer Technology Development Grants (TDGs) (R1billion has already been committed by treasury 2019/2020 to support SMME innovation)

4.5 Technology Localisation through Firm-level Technology Assistance Packages (FTAPs) and Sector-Wide Technology Assistance Package (SWTAP)

4.6 Experiential Training Programmes

The ETIGC and the IPAP are the government's key economic policy and industrial policy instruments which furnish a foundation (their limitations notwithstanding) for the development of a coherent 4IR strategy with the best chance of implementation by the state, the private sector, and society at large. We must bear in mind and take seriously the President's emphasis that the country's 4IR strategy must be people-centred, harnessing the talents of all South Africans, especially women and the youth. According to the ILO's Future of Work report (2019), a people-centred future enabled by the development and deployment of new and emerging technologies prioritises:

Investment in people's capabilities, which includes educational, nutritional, and overall health improvements;

Investment in the institutions of work with a view to engendering an ethic of technology for decent work;

Investment in decent and sustainable work.

Thus, while we may take our cue from the ETIGC and the IPAP in terms of the industrial and economic future that the government envisages, our task is to elaborate the technological and linked human developmental, institutional, and regulatory programmes that will realise this vision.

RECOMMENDATIONS

In keeping with the ethos of the South African Constitution, the 4IR must become a citizens' initiative, rooted in communication amongst sectors of society, to ensure awareness, inclusive participation and collaborative construction of the desired path forward. There is also a need for youth participation in this revolution and the mandate of the NYDA should be expanded to drive this.

More broadly, the Commission's recommendations align with the fundamental ideas emerging out of critical international and local research efforts.

These include but are not limited to the International Labour Organisation's 'Work For a Brighter Future'; NEDLAC's 'Futures of Work'; the government gazetted 'Policy On High Demand Spectrum and Policy Direction on The Licensing Of a Wireless Open Access Network' as well as the Department of Trade and Industry's work commissioned to Trade and Industrial Policy Strategies (TIPS) dealing with the country's industrial readiness for the 4IR. The recommendations also have to be executed with consideration for environmental sustainability, climate change and the circular economy.

Collectively, these reports reflect the key recommendationsof the Commission, namely:

INVEST IN HUMAN CAPITAL.

South Africa's greatest opportunity and greatest resource is her people. The 4th IR gives us a rallying point of urgency and an opportunity to redesign, streamline and align the education system through a coordinated, robust, multi-stakeholder process. The purpose of the next version of our skills ecosystem will be to leapfrog our youth into productive work and reskill current workers for job retention and ongoing productive work in the economy. The skills demands of the 4IR era require stackable competencies which are micro-credentialled, industry aligned and allow people to enter and exit the system at multiple points as part of a lifelong learning process. The redesign of the ecosystem should be facilitated at the Human Resources Development Council as a priority project for 2020 i.e. have a timeframe associated to the deliverable, assisted by the 4IR Commission and driven by the Digital & Future Skills Forum. Linked to this, there is a need to invest in strategic projects for mass skills development which can be scaled for exponential skills pipeline development and labour market absorption. The manufacturing, agricultural and tourism sectors and the creative industries provide immediate opportunities for such programmes. In sum, all sections of society need to be prepared to not only reskill but to approach skilling is a continuous process. Refining problem-solving skills, deepening computational abilities, thinking systematically and most importantly, mastering the social world are critical to succeeding in the 4IR.

ESTABLISH AN AI INSTITUTE.

Artificial intelligence (involving the theory and development of computer systems to perform tasks usually requiring human intelligence), is a bedrock technology in the 4IR, underpinning the growing connections in cyber-physical and biological systems. Research and Development, as well as implementation capabilities in AI are thus critical and must be embedded within the state. This will enable the generation of new knowledge and creative technology applications in sectors such as health, agriculture, education, energy, manufacturing, tourism & ICT, amongst others. The institute's mandate should also include training, to be delivered across various sections of society, as well as ensuring positive social impact.

ESTABLISH A PLATFORM FOR ADVANCED MANUFACTURING AND NEW MATERIALS.

The revival of South Africa's manufacturing sector is a core concern of the Industrial Policy Action Plan given the centrality of the sector to job creation and global competitiveness. To be successful in the context of the 4IR, it is imperative that the manufacturing sector be supported by a state-led research initiative focused on advanced manufacturing and new materials. This should incorporate the Science and Technology Department's existing Advanced Manufacturing Technology Strategy, with a view to provide tangible support to its aims. This structure will guide South Africa in growing the manufacturing sector, develop and apply new materials through the technologies of the 4IR in areas such as agriculture, construction, housing, health, energy storage, environmental sustainability and electric vehicles, to name a few.

04

SECURE AND AVAIL DATA TO ENABLE INNOVATION.

The principal opportunity in the 4IR is the storage of large sums of data. Reliable, accurate, standardised, integrated and easily accessible citizen data is critical for building e-government services across sectors such as health, transport and justice. However, this opportunity must be safeguarded by securely organising public data through the bolstering of cybersecurity capacity and capabilities. It must be recognised that data also presents an opportunity for productive exchange, through which the state can make available anonymised open datasets to collaborate with different stakeholders in society to solve service delivery challenges and enable innovation. Standardising data is crucial for effective processing. The state's existing cybersecurity company, Comsec, is thus to be strengthened to execute its mandate in a manner that is relevant for the requirements of the 4IR. The appointment of a Chief Data Officer within the state should also be explored.

05

INCENTIVISE FUTURE INDUSTRIES, PLATFORMS AND APPLICATIONS OF 4IR TECHNOLOGIES.

For the industries of the future to emerge, new forms of incentives are required, incorporating subsidies and tax breaks, to support the acquisition and application of advanced technologies in the manufacturing of goods and delivery of services. The DTI acknowledges the country's position as a laggard in digital or smart industries and will require support to develop SMMEs into globally competitive industrial players, as well as enable existing 4IR enabled SMMEs to experience an enabling environment for growth. It is envisaged that the emerging SMMEs, working in technology fields such as blockchain, 3D printing, Internet of Things and operating competitive platform businesses will develop solutions that address South Africa's development challenges. It is therefore critical that the ease of doing business is improved, including such tasks as registering a patent, reducing the cost of 4IR businesses (customs, taxes) and enabling ease of global competitiveness and expansion. The state, as the largest and most powerful purchaser in the country, has a significant role to play in the adoption of 4IR technologies across priority sectors. In line with this, the state also needs to ensure that appropriate regulation (and taxation) of foreign platform and other businesses is achieved.

06

BUILD 4IR INFRASTRUCTURE.

It is important to incorporate 4IR infrastructure into the overall planning for infrastructure development and deployment. Biotechnology, 3D printing and the digital economy all require an infrastructure base. However, 4IR infrastructure does not stand alone. It ought to integrate with existing economic and social infrastructure. Just as a road is required to access a cell phone tower, cell phone signal is required to call emergency services. Therefore, the generation and delivery of energy; the extension and improvement of water infrastructure; health and educational infrastructure are required for a coherent and comprehensive infrastructure network. Building and accelerating 4IR infrastructure rollout is imperative and should cover mobile, physical, computational and digital infrastructure.

07

REVIEW AND AMEND (OR CREATE) POLICY & LEGISLATION.

To achieve the above changes, the regulatory environment must be adapted to enable the desired progress. The generation of intellectual property rights stands out in this context as the principle of a creative economy implies the rapid production of new technologies, artefacts and processes for commercialisation and scale. This exercise requires the legislature and the state executives to be trained to become 4IR and science literate in order to implement changes that are holistic, integrating the specific logics of technologies, the industries they impact, the people who will both consume and produce them and the policy and legislative agility required to compete on a global stage. Platform businesses also require a regulation and taxation regime that fosters fair competition. Acts such as the Space Affairs Act of No. 84 of 1993; South African National Space Agency Act, No 38 of 2008; Sentech Act No 63 of 1996; Disaster Management Act of 2002 and the South African Weather Service Act No 8 of 2001 are but some of the pieces of legislation that must be reviewed for possible amendment, with a consideration for the co-ownership of closed data.

08

ESTABLISH 4IR STRATEGY IMPLEMENTATION COORDINATION COUNCIL IN THE PRESIDENCY.

It is envisaged that the Coordination Council will interface with government departments that will be responsible for the implementation coordination, resource unlocking, accountability and policy coherence of 4IR programmes. Importantly, the council will coordinate initiatives across the public and private sectors, labour, academia and SMMEs to ensure synergy and drive efficiency through minimising duplication and enabling collaboration. There is also a requirement to ensure that existing institutions of state are revived and reenergised, where needed, to deliver on the 4IR strategy. This will require a combination of training efforts to ensure 4IR understanding and skills, and the possible consolidation of teams and budgets to reduce duplication and optimise delivery. This is a critical step to ensure that work on the 4IR can be successfully monitored and evaluated.

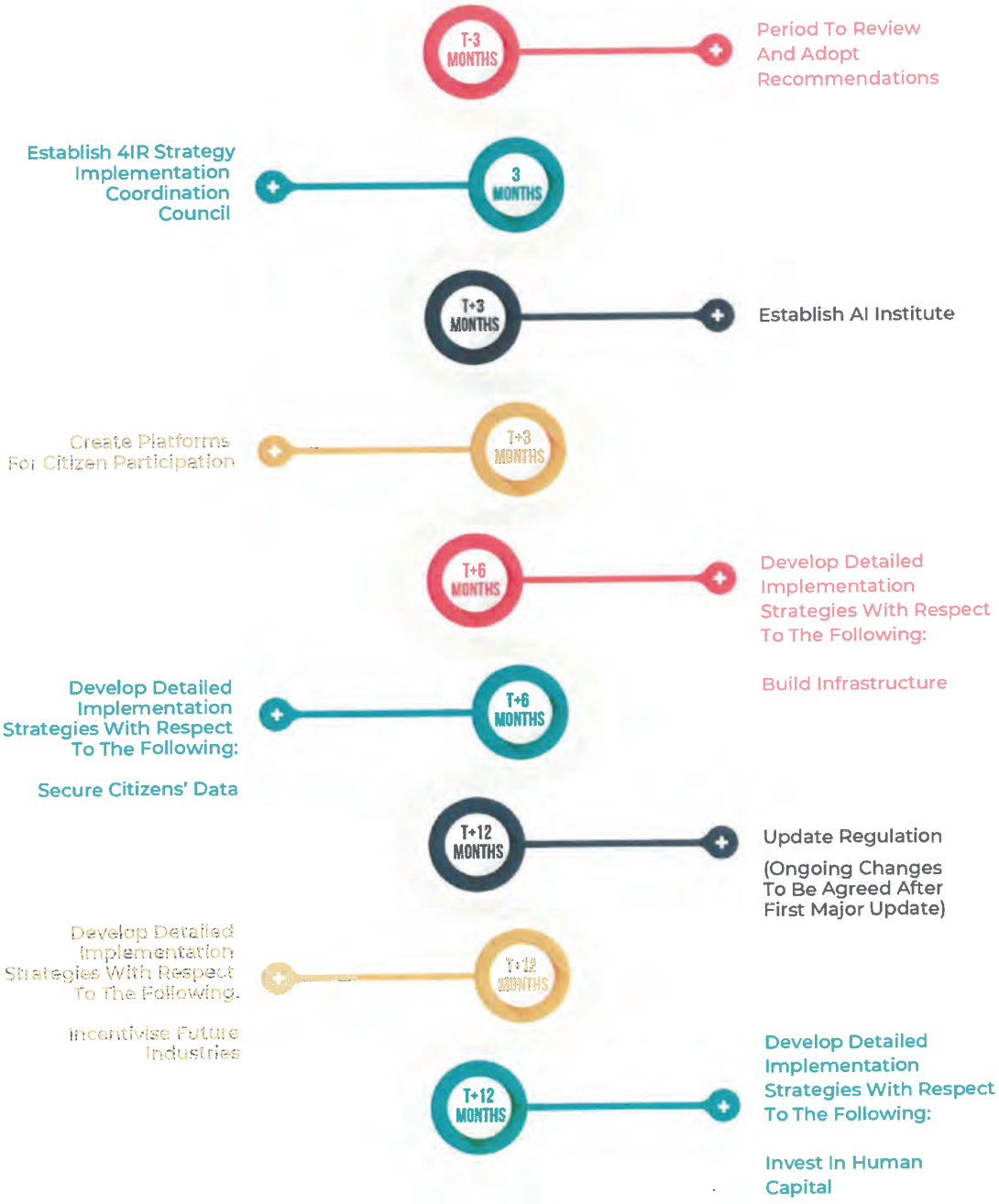
CONCLUSION

In analysing global best practice, a framework emerged comprised of 8 pillars of 4IR strategy, which include amongst others, a focus on service delivery and establishing the country as a global leader in a targeted area. The commission recommends that all entities charged with programmatic implementation refer to this framework, articulated in detail in this paper.

A key consideration for the Commission is urgency and accountability. The 4IR is not in the future, it is the present. It is therefore imperative that the country reorganises itself to ensure that citizens are positioned to benefit from the opportunities it presents. To achieve this, there must be clear accountability for implementing the recommendations within a timeframe that can be monitored by all stakeholders in society. To this end, a proposed implementation roadmap is proposed.

In all, the Commission's analysis has led to the conclusion that the 4IR is an opportunity for South Africa to integrate itself into the broader African market as envisaged in the long-term economic recovery plan. We recognise this moment as containing within it, the potential to use technology to address the most challenging development problems faced by South Africa and the rest of the continent. By supporting SMMEs to develop technology that will optimise the delivery of services in sectors such as health, education and transport, we can simultaneously enhance the wellbeing of our citizens and become globally competitive.

Socio-economic integration, specifically within the African continent, is thus the 4IR implication of South Africa's current development trajectory. By doing this, we can catalyse dramatic socio-economic improvements in South Africa, a tide that must be intentionally directed to lift our compatriots across the continent of Africa. That means not only resolving the triple challenge through technology but using technology as an instrument through which to achieve a much bolder development vision in which South Africa is not emerging but rather accomplished, amongst nations. The 4IR is an opportunity to achieve South Africa's Vision 2030 and beyond. **Let us Build!**


T-3 MONTHS
Period To Review And Adopt Recommendations
Establish 4IR Strategy Implementation Coordination Council
3 MONTHS
T+3 MONTHS
Establish AI Institute
Create Platforms For Citizen Participation
T+3 MONTHS
T+6 MONTHS
Develop Detailed Implementation Strategies With Respect To The Following:
Build Infrastructure
Develop Detailed Implementation Strategies With Respect To The Following:
Secure Citizens' Data
T+6 MONTHS
T+12 MONTHS
Update Regulation
(Ongoing Changes To Be Agreed After First Major Update)
Develop Detailed Implementation Strategies With Respect To The Following:
Incentivise Future Industries
T+12 MONTHS
T+12 MONTHS
Develop Detailed Implementation Strategies With Respect To The Following:
Invest In Human Capital

ANNEXURE A: TERMS OF REFERENCE

The Presidential Commission's terms of reference are[29]

- Develop an integrated country strategy and plan to respond to 4IR including detailed interventions to be carried out achieving global competitiveness of the key economic sectors (agriculture, finance, mining, manufacturing, ICT, and STI);
- Advise on a technology research and development program to advance 4IR;
- Advise on strategies for skills development and future of work;
- Make recommendation on enabling relevant infrastructure for SA to participate in the digital economy;
- Make recommendations on an institutional framework and mechanism to coordinate 4IR programs;
- Make recommendations on approaches to address inclusivity and digital divide;
- Make recommendations on interventions to enable innovation and entrepreneurship, and for SMMEs to take advantage of the 4IR;
- Advise on strategies to mobilise resources to support the 4IR interventions; and
- Make recommendations on mechanisms to measure the impact of interventions on 4IR.

The Commission's method of work is:

- The Commission must endeavour to align their activities to ensure alignment with the NDP.
- The Commission may establish its own Working Groups as it deems necessary and exercise discretion to invite experts and other stakeholders to participate in its meetings.
- The Commission should review and make recommendations on its terms of reference on a regular basis.

21 https://www.gov.za/documents/presidential-commission-fourth-industrial-revolution-members-and-terms-reference-9-apr


PRESIDENTIAL COMMISSIONS ON
IKE E: /XARRA //KE
THE FOURTH INDUSTRIAL REVOLUTION

THE PRESIDENCY
REPUBLIC OF SOUTH AFRICA

DIAGNOSTIC REPORT OF THE

PRESIDENTIAL COMMISSION ON THE FOURTH INDUSTRIAL REVOLUTION

MARCH 2020

TABLE OF CONTENT

GLOSSARY

1IR	First Industrial Revolution
2IR	Second Industrial Revolution
3-D	Three Dimensional
3GPP	3rd Generation Partnership Project
3IR	Third Industrial Revolution
4IR	Fourth Industrial Revolution
5G	Fifth Generation
5GPP	5th Generation Partnership Project
AET	Adult Education and Training
AI	Artificial Intelligence
AIDS	Acquired Immunodeficiency syndrome
APAC	Asian Pacific
API	Application programming interface
AR	Augmented Reality
ARV	Antiretroviral
ASEAN	Association of Southeast Asian Nations
AWS	Amazon Web Server
BERD	Business Expenditure on Research and Development
BRICS	Brazil, Russia, India, China and South Africa
BUSA	Business Unity South Africa
CAICT	China Academy of Information and Communications Technology
CAPS	Curriculum Assessment Policy Statements
CCMA	Commission for Conciliation, Mediation and Arbitration
CCUS	Carbon Capture Utilisation and Storage
CDE	Centre for Development and Enterprise
CEDAW	Convention on the Elimination of all Forms of Discrimination Against Women
CEO	Chief Executive Officer

CETC	Community Education and Training Centers
CIPC	Companies and Intellectual Property Commission
CIT	Coporate Income Tax
CLS	Cable Landing Station
COGTA	Cooperative Governance and Traditional Affairs
CSIR	Council for Scientific and Industrial Research
CTP	Converging Technologies Platform
DBE	Department of Basic Education
DBSA	Development Bank of Southern Africa
DHET	Department of Higher Education and Technology
DoC	Department of Communications
DoEd	Department of Education
DPME	Department of Planning, Monitoring and Evaluation
DPSA	Department of Public Service and Administration
DST	Department of Science and Technology
DTPS	Department of Telecommunications and Postal Services
ECD	Early childhood development
ESSA	Electromagnetic Spectrum South Africa
ETSI	European Telecommunications Standards Institute
EU	European Union
FET	Further Education and Training
GBV	Gender Based Violence
GCI	Global Connectivity Index
GDP	Gross Domestic Product
GER	Gross Enrolment Rate
GHG	Green-House Gas
GII	Gender Inequality Index

GIS	Geographic Information System
GNP	Gross national product
GPI	Gender Parity Index
GSMA	Global System for Mobile Association
HCI	Human Capital Index
HIV	Human Immunodeficiency Virus
HLEG	High-Level Expert Group
HPC-AI-HPDA	High-performance Computing-Artificial Intelligence-Data analytics
HSDC	Hyper-Scale Data Centres
ICANN	Internet Corporation for Assigned Names and Numbers
ICASA	Independent Communications Authority of South Africa
ICT	Information and Communications Technology
IDC	Industrial Development Corporation
IDP	Inclusive Development Platform
IETF	Internet Engineering Task Force
IIoT	Industrial Internet of Things
ILO	International Labour Organisation
IoT	Internet of Things
IPR	intellectual property right
IQ	Intelligence quotient
IT	Information Technology
ITU	International Telecommunication Union
Li-ion	Lithium Ion
LiPF6	Lithium Hexafluorophosphate
M2M	Machine to Machine
ML	Machine Learning
MTSF	Medium-term Strategic Framework

NACI	National Advisory Council on Innovation
NaTIS	National Administration Traffic Information System
NDP	National Development Plan
NECSA	Nuclear Energy Corporation of South Africa
NEET	neither in employment nor in education
NFV	Network Function Virtualisation
NGO	Non-Govermental Organisation
NHI	National Health Insurance
NRDS	National Research and Development Strategy
NSA	National Skills Authority
NSF	National Skills Fund
NSI	National System of Innovation
OECD	Organisation for Economic Co-operation and Development
ONF	Open Network Foundation
OSSA	Open Source South Africa
P2P	Peer-to-Peer
PanSALB	Pan South African Language Board
PGM	platinum group metals
PIRLS	Progress in International Reading Literacy Study
PIT -	Personal Income Tax
PM	Particulate Matter
PMU	Power Management Unit
POP	Point-of-Presence
POPI	Protection of Personal Information
PPA	Power Purchase Agreements
PPP	Purchasing Power Parity
PRASA	Passenger Rail Agency of South Africa

PSET	Post School Education and Training
PtL	Power-to-Liquids
R&D	Research and Development
RDI	Research, Development, and Innovation
RDP	Reconstruction and Development Programme
RFID	Radio-Frequency Identification
RSA	Republic of South Africa
SA	South Africa
SADC	Southern African Development Community
SAFE	South Africa Far East
SALGA	South African Local Government Association
SANRAL	South African National Roads Agency
SAP	Structural Adjustment Programs
SDG	Sustainable Development Goals
SDN	Software Defined Networking
SEIAS	Social Economic Impact Assessment System
SETA	Sector Education and Training Authorities
SITA	State Information Technology Agency
SII	South Africa Innovation Index
SME	Small and Medium Enterprises
SMME	Small, Micro and Medium Enterprises
SOE	State Owned Enterprise
StatsSA	Statistics South Africa
STEAM	Science, Technology, Engineering, Art and Mathematics
STEAMIE	Science, Technology, Engineering, Art, Mathematics, Innovation and Entrepreneurship
STEM	Science, technology, engineering, and mathematics
STI	Science, Technology, and Innovation

TB	Tuberculosis
TVET	Technical and Vocational Education and Training
TYIP	Ten-year Innovation Plan
UAS	Unmanned Aerial Systems
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
UN	United Nations
UN-HDI	Human Development Index
USD	United States Dollar
VAT	Value Added Tax
VPN	Virtual Private Network
VPP	Virtual Power Plants
VR	Virtual Reality
W3C	World Wide Web Consortium
WEF	World Economic Forum
Wi-Fi	Wireless Fidelity
ZADNA	za Domain Name Authority
ZAR	South African Rand

FOREWORD

We are extremely proud of the tremendous strides South Africa has made over the past twenty-five years in the post-apartheid era. We have overcome many challenges through the enduring and innovative South African spirit. Now, we are facing the global phenomenon known as the Fourth Industrial Revolution, which brings about an immense set of challenges. But this revolution also offers boundless and exciting opportunity for the country. The establishment of the Presidential Commission on the Fourth Industrial Revolution is an affirmation of Government's commitment to addressing the aforementioned challenges while simultaneously seizing the opportunity to improve the lives of South Africans. This document sets out a vision for chartering the way forward for South Africa in the Fourth Industrial Revolution. Our vision is:

South Africa will have a globally competitive, inclusive and shared economy with the technological capability and production capacity that is driven by people harnessing the Fourth Industrial Revolution to propel the country forward towards its social and economic goals.

The Fourth Industrial Revolution offers prospects for South Africa to its revolutionise energy, water, mining, manufacturing, agriculture, financial services, public administrations sectors, amongst others, in a way that will benefit all South Africans. This document formulates and critiques these prospects, and it is expected that 4IR strategic policies and programmes emerging from this document will create an inclusive economy to stimulate growth within the country.

Lastly, let us work together in creating a South African legacy within the realm of the Fourth Industrial Revolution. Let us create a legacy that is characterized by the enduring and innovative South African spirit.

March 2020

Prof. Tshilidzi Marwala (Vice-Chancellor, University of Johannesburg)

Deputy Chairperson: Presidential Commission on the Fourth Industrial Revolution

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PC4IR Commissioners: Prof Chris Adendorff, Ms Beth Arendse, Mr Mpho Dagada, Dr Thulani Humphrey Dlamini, Mr Abdul Razak Esakjee, Dr Bernard Lewis Fanaroff, Mr Michael Gastrow, Mr Xolile Christopher George, Ms Charmaine Houvet, Dr Prince Senyukelo Jaca, Mr Tervern Liaan John Jaftha, Mr Mohamed Shameel Joosub, Ms Nomso Kana, Ms Marinda Kellerman, Mr Baxolile Mabinya, Mr Rendani Mamphiswana, Ms Lindiwe Matlali, Ms Nomvula Mkhonza, Mr Vukani Mngxati, Mr Joseph Ndaba, Mr Andile Ngcaba, Dr Nompumelelo Happworth Obokoh, Mr Rendani Praise Ramabulana, Mr Leon Desmond Rolls, Mr Rob Shuter, Dr Sibongiseni Tunzelana Thotsejane, Mr Aubrey Tshabalala, Mr Gerhard Van Deventer, Mr Ben Venter, Ms S'onqoba Vuba (resigned), Mr. Calvo Mawela.

PREFACE BY CHAIRPERSON OF THE PC4IR

AUGUST 2020

When I addressed the African Union Assembly in February 2020 on the occasion of the assumption by South Africa of the position of AU Chair, I said:

"The Fourth Industrial Revolution presents our continent with great opportunities. The uptake of digital technologies will lead to improved competitiveness and provides fresh opportunities for inclusive growth."

In line with this sentiment and to ensure we take advantage of the opportunities presented by this digital era, South Africa established the Presidential Commission on the Fourth Industrial Revolution in 2019.

Comprised of 33 eminent individuals from various sectors, the Commission was formed to advise government and society on both the opportunities and risks presented by the Fourth Industrial Revolution.

The Commission is divided into eight workstreams, each with their own strategic focus. Over the past few months, each workstream has been consulting relevant stakeholders across society on how South Africa can make best use of the opportunities of rapid technological change. The workstreams have also reviewed global best practice by studying the experiences of other countries.

This era calls for enhanced state capacity to seize the opportunities of the digital economy. South Africa must remain abreast of the exponential growth in technological change and ensure that no citizen or community is left behind.

The Commission's report recommends interventions to ensure that we extract the greatest benefits from these revolutionary technological advances. For South Africa to achieve inclusive growth and social development in the digital era, the country must find ways of integrating scientific and technological innovations into the economy.

The recommendations in the Commission's report will help South Africa reinvigorate its industrialisation aspirations and significantly improve its global and continental economic competitiveness.

I am therefore pleased to receive this report and express my sincere gratitude to the Commissioners.

President Cyril Matamela Ramaphosa Chairperson PC4IR President of Republic of South Africa

President Cyril Matamela Ramaphosa
Chairperson PC4IR
President of Republic of South Africa

REMARKS BY MINSTER

The Government of the Republic of South Africa, under the leadership of His Excellency President Cyril Ramaphosa, has taken a bold and decisive step in seeking to transform the South African economy by emphasising digital communication and technologies as the foundation for building an inclusive, economically vibrant society. This approach is contained in the mandate of the Fourth Industrial Revolution (4IR).

To achieve this milestone, the President announced in his 2018 State of the Nation Address (SONA) that the then Department of Telecommunications and Postal Services (DTPS) would establish a Presidential Commission on the 4th Industrial Revolution (PC4IR). In summary, the mandate of the PC4IR, which was to be chaired by the President, was to provide the Government with a Report on how the envisaged digital revolution of the local economy can be achieved. The President thereafter directed the Office of the Minister: Department of Telecommunications and Postal Services to oversee and lead the work of the PC4IR, and to later finalise an implementation plan for the achievement of the anticipated findings under the Report.

Ms Stella Tembisa Ndabeni-Abrams Minister of Communications and Digital Technologies

In December 2018, DTPS established the Terms of References (TORs) for the work of the PC4IR, which was published in the Government Gazette together with requests for applications by qualifying candidates to undertake the work of the PC4IR. Approximately 700 applications were received by the Department, which were duly considered, thereby culminated in the appointment of 33 Commissioners.

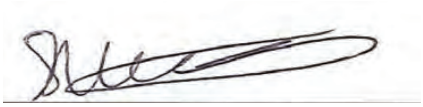
With the Terms of Reference established, and the Commissioners duly appointed, the PC4IR was ready to commence its work. It was at that juncture that the President delegated his role as the Chairperson of the PC4IR to my office while at the same time directing me to provide the resources necessary for this crucial project, including but not limited to the assembling of the Secretarial Services to support the work of the PC4IR. Working with the Commissioners, we were able to table an initial diagnostic Report on 4IR to the President on 07 November 2019. Thereafter, PC4IR guided the Government during the January 2019 Cabinet Lekgotla on various elements of the 4IR, as contained in the diagnostic Report.

I am therefore pleased to announce that the PC4IR has now finalised its Report, and that the Report has been approved by the President. The Report recommends eight (8) principle work-streams for the achievement of the ideals under the 4IR, with profound findings on how the opportunities presented by the 41R can be exploited in the building of an inclusive, economically vibrant digital society.

I am further pleased to announce that the Department has also commenced with the momentous task of developing a comprehensive implementation plan for the achievement of the findings under the Report, including setting out milestones for the implementation work and timelines for achieving those milestones.

I would like to extend my sincere appreciation to the esteemed Commissioners for their praiseworthy effort in the undertaking of their duties to the Nation and completing the Report in a timely manner. I would also like to thank the officials in my Department that provided the necessary support for the work of the PC4IR over and above their daily work activities.

The journey towards making South Africa digitally competitive on a global scale while at the same time preparing an inclusive economy through the digital communication and technologies has now begun in earnest. The PC4IR Report is the founding document for this work, while being at the centre of guiding the work of Government for many years to come.



Ms Stella Tembisa Ndabeni-Abrams
Minister of Communications and Digital Technologies

FOREWORD BY THE DEPUTY CHAIRPERSON

We are extremely proud of the tremendous strides South Africa has made over the past twenty-five years in the post-apartheid era. We have overcome many challenges through the enduring and innovative South African spirit. Now, we are facing the global phenomenon known as the Fourth Industrial Revolution, which brings about an immense set of challenges. But this revolution also offers boundless and exciting opportunity for the country. The establishment of the Presidential Commission on the Fourth Industrial Revolution is an affirmation of Government's commitment to addressing the aforementioned challenges while simultaneously seizing the opportunity to improve the lives of South Africans. This document sets out a vision for chartering the way forward for South Africa in the Fourth Industrial Revolution. Our vision is:

South Africa will have a globally competitive, inclusive and shared economy with the technological capability and production capacity that is driven by people harnessing the Fourth Industrial Revolution to propel the country forward towards its social and economic goals.

The Fourth Industrial Revolution offers prospects for South Africa to its revolutionise energy, water, mining, manufacturing, agriculture, financial services, public administrations sectors, amongst others, in a way that will benefit all South Africans. This document formulates and critiques these prospects, and it is expected that 4IR strategic policies and programmes emerging from this document will create an inclusive economy to stimulate growth within the country.

Lastly, let us work together in creating a South African legacy within the realm of the Fourth Industrial Revolution. Let us create a legacy that is characterized by the enduring and innovative South African spirit.

March 2020

Prof. Tshilidzi Marwala (Vice-Chancellor, University of Johannesburg)

Deputy Chairperson: Presidential Commission on the Fourth Industrial Revolution

Professor Tshilidzi Marwala
(Vice-Chancellor
University of Johannesburg)

**Deputy Chairperson:
Presidential Commission
on the Fourth
Industrial Revolution**

PC4IR Commissioners: Prof Chris Adendorff, Ms Beth Arendse, Mr Mpho Dagada, Dr Thulani Humphrey Dlamini, Mr Abdul Razak Esakjee, Dr Bernard Lewis Fanaroff, Mr Michael Gastrow, Mr Xolile Christopher George, Ms Charmaine Houvet, Dr Prince Senyukelo Jaca, Mr Tervern Liaan John Jaftha, Mr Mohamed Shameel Joosub, Ms Nomso Kana, Ms Marinda Kellerman, Mr Baxolile Mabinya, Mr Rendani Mamphiswana, Ms Lindiwe Matlali, Ms Nomvula Mkhonza, Mr Vukani Mngxati, Mr Joseph Ndaba, Mr Andile Ngcaba, Dr Nompumelelo Happworth Obokoh, Mr Rendani Praise Ramabulana, Mr Leon Desmond Rolls, Mr Rob Shuter, Dr Sibongiseni Tunzelana Thotsejane, Mr Aubrey Tshabalala, Mr Gerhard Van Deventer, Mr Ben Venter, Ms S'onqoba Vuba (resigned), Mr. Calvo Mawela.

WORKSTREAMS REPORT SIGN-OFF

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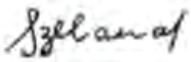
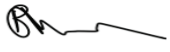
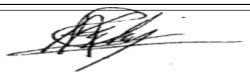
2. Dr. Andile Ngcaba	
3. Mr. Shameel Joosub	
4. Ms. Nomso Kana	
5. Mr. Xolile George	
6. Dr. Bernard Fanaroff	
7. Dr. Thulani Dlamini	
8. Mr. Vukani Mngxati	
9. Mr. Rendani Ramabulana	
10. Mr. Joseph Ndaba	
11. Dr. Nompumelelo Happworth Obokoh	
12. Dr. Busisiwe Mbuyisa	
13. Dr. Sibongiseni Tunzelana Thotsejane	
14. Mr. Leon Rolls	
15. Prof. Chris Adendorff	
16. Mr. Calvo Mawela	
17. Ms. Beth Arendse	

18. Dr. Senyukelo Jaca	
19. Mr. Baxolile Mabinya	
20. Mr. Ben Venter	
21. Ms Lindiwe Matlali	
22. Mr. Abdul Razak Esakjee	
23. Ms. Nomvula Lindiwe Mkhonza	
24. Mr. Tervern Jaftha	
25. Mr. Rendani Mamphiswana	
26. Ms. Sonqoba Vuba	
27. Ms. Charmaine Houvet	
28. Mr. Gerhard van Deventer	
29. Dr. Michael Gastrow	
30. Mr. Rob Shutter	
31. Mr. Aubrey Tshabalala	
32. Mr. Mpho Dagada	

ACKNOWLEDGEMENTS

In producing this diagnostic report, the Presidential Commission on the Fourth Industrial Revolution, has been facilitating consultation sessions and holding meetings to engage on the areas of focus required. Organisations, departments and individuals that we have and continue to consult with are listed below. They however form just the starting point as we continue consultations on the road to the development of a South African Fourth Industrial Revolution strategy.

1	Absa	2	Abundance Dusty Velvet
3	Acacia Economics	4	Adv Jean Pierre Syndiers (Private)
5	African Leadership Academy	6	Agricultural Business Chamber (ABC)
7	Allan Gray Orbis Foundation	8	Alliance 4 African Intelligence (A 4ai)
9	Altron / Nexus	10	Amazon Web Services (AWS)
11	Ambledown Financial Services	12	American Chamber of Commerce in SA
13	Angel Hub	14	Anglo American South Africa
15	Animation SA	16	Armaments Corporation of South Africa SOC Ltd (ARMSCOR)
17	Banking Association of South Africa (BASA)	18	BBBEE ICT Sector Council
19	BitbyByte	20	Black Business Council
21	BMIT	22	Bon Com Group
23	Bowline Security Pty	24	Broadband Infraco SOC Ltd
25	Broadxcess	26	BT
27	BUA Microtronix	28	Bunang Holdings
29	Cape Innovation and Technology Initiative (CiTi)	30	Cathseta
31	Cell C	32	Centre for Development of Information Technology Policy (CDITP).
33	CISCO	34	City of Tshwane, Office of the Mayor
35	City Power	36	Cloanywhere

37	Cosatu, Naledi	38	CPITP
39	CRC	40	Create Your Creativity
41	CSIR	42	Dark Fibre Africa (Pty) Ltd
43	Data Infosys	44	Data Intensive Research Initiative of South Africa (DIRISA)
45	DCDT	46	Decision Intelleqt
47	Deloitte	48	Department for Basic Education
49	Department of Agriculture Forestry and Fisheries	50	Department of Basic Education
51	Department of Basic Education, KZN Province	52	Department of Economic Development
53	Department of Economic Development, Gauteng – Creative Industries	54	Department of Higher Education and Training, 4IR Ministerial Task Team
55	Department of Higher Education and Training, TVET Colleges	56	Department of Justice and Constitutional Development
57	Department of Mineral Resources, Small-Scale Mining	58	Department of Planning, Monitoring and Evaluation
59	Department of Public Service and Administration	60	Department of Rural Development & Land Reform

We would like to thank the following organisations that assisted the Presidential Commission with resourcing needs leading up to the publication of this Diagnostic Report:

- MTN Group,
- University of Johannesburg,
- University of Pretoria,
- Vodacom South Africa

Thanks also goes to the members of our Secretariat in the Department of Telecommunications and Postal Services, led previously by Ms Jeanette Morwane and currently led by Mr Alfred Mashishi.

CHAPTER ONE: Executive Summary

We are currently in the initial phase of the fourth industrial revolution. The world has witnessed three industrial revolutions over the past two hundred and fifty years. Any industrial revolution brings in a significant shift and affects the society immensely in various ways.

The Fourth Industrial Revolution is a result of the meeting of multiple technologies, as well as multiple broad domains coming together which were relatively independent before. It is often said to be the convergence of the technologies bringing the digital/ cyber, physical and biological worlds together. It is also about developing new technologies and business models. History has shown us that for a country to progress, it should be an active participant in the industrial revolutions to reap the benefits of it early. South Africa was not an active participant in the first three industrial revolutions due to various reasons. This hindered the growth of South Africa.

President Cyril Ramaphosa has formed the Presidential Commission on the Fourth Industrial Revolution (PC4IR) and also, has named individuals from the Commission with the undertaking to help the government in making the most of the open doors exhibited by the current modern upheaval. The errand of the Commission, which is being led by the President, is to distinguish relevant policies, systems and action plans that will position South Africa as a focused worldwide player. The President set the tone of the country towards the Fourth Industrial Revolution by stating - "Unless we adapt, unless we understand the nature of the profound change that is reshaping our world, and unless we readily embrace the opportunities it presents, the promise of our nation's birth will forever remain unfulfilled". The thirty-member Presidential Commission on the Fourth Industrial Revolution comprises eminent persons from different sectors of society and reflects diversity in youth, gender, business and labour, including digital start-ups founders and digital entrepreneurs.

"Unless we adapt, unless we understand the nature of the profound change that is reshaping our world, and unless we readily embrace the opportunities it presents, the promise of our nation's birth will forever remain unfulfilled."

President Cyril Ramaphosa

Many countries around the world have already begun to develop strategies, policies, resources, and legislation to exploit the benefits of the Fourth Industrial Revolution – which is reviewed in this report. Technologies of the Fourth Industrial Revolution are already impacting different economies globally. South Africa is not immune to this trend. There are vast opportunities available for South Africa to exploit if resources are effectively allocated and utilised through a well-defined strategy.

There is a necessity to look at all these contributing sectors with a 4IR lens, to understand the likely growth and relevance of these sectors in the global 4IR context. In addition, South Africa would need to assess strengths and opportunities it possesses to position itself for growth in key industries and growth in its local and international contribution to 4IR focus sectors.

A key strategy for South Africa is to ensure the preparation of the younger generation for jobs of the future that may not exist at this moment in time. Through the process of upskilling youth about the Fourth Industrial Revolution it will ensure South Africa will have the necessary skills for the future. Furthermore, the youth could use these skills gained to follow an entrepreneurial path that would allow them to be job providers and not job seekers. This will add an advantage to the South African economy.

In 2013, South Africans articulated a development vision, Vision 2030, encapsulated in the National Development Plan (NDP) as the latest iteration in the continuing quest to ensure security and welfare for all. Explicitly aimed at removing the triple scourge of poverty, inequality, and unemployment by 2030, Vision 2030 recognised that the country's socio-economic transformation is central to entrenching a vibrant democracy in which all South Africans can meaningfully and actively participate. Since 1994, the state has actively engaged in the design of policies aimed at addressing South Africa's historical legacy of an excluded and under-served majority. It has also sought to have an over-arching policy framework that gives direction to all facets of the state and attendant programmes. Given a constantly evolving local and global context, these policies have been adapted over time to emphasise themes requiring critical attention. In the Fourth Industrial Revolution, this adaptability is now more critical than ever before.

The Presidential Commission on the Fourth Industrial Revolution encourages South Africa to adopt an adapted definition of the Revolution that ensures a human-centric approach defined as:

> *The 4th Industrial Revolution is an era where people are using smart, connected and converged Cyber, Physical and Biological systems and smart business models to define and reshape the social, economic and political spheres.*

In light of the defining characteristics of the Fourth Industrial Revolution and the South African need to place the human at the centre, as a country, we also need to ensure that the Revolution is used as a means to an end towards our economic and social needs and goals, as unpacked in this document. A focus on this Revolution or Technology purely for the sake of it would be a lost opportunity in moving the country forward and in improving our global competitiveness while driving inclusive growth and addressing our poverty, inequality and unemployment challenges.

The Commission has rallied its efforts and work to produce a strategic plan that is centred on a dream that assists us in focusing our efforts. The proposed dream of South Africa in a Fourth Industrial Revolution world is:

> *South Africa will have a globally competitive, inclusive and shared economy with the technological capability and production capacity that is driven by people harnessing the 4IR to propel the country forward towards its social and economic goals, instead of falling behind.*

Given the Fourth Industrial Revolution and the opportunity it presents, if harnessed by South Africa to make progress towards the country's economic and social goals, this report clearly identifies the main drivers of a South African 4IR Strategy and plan. These drivers would result in key scenarios for the country being developed, which can be tested and projected to understand their likely impact on the country, assessed for likelihood, and for the development of implementation plans.

Given the assessment of South Africa's reality and preparedness for the 4IR, as discussed in this document, five key pillars are focused on that relate to developing a South African 4IR strategy. These five pillars map closely to the NDP Approach To Change, which speaks to a focus that looks at Conditions, Opportunities, Capabilities working in a virtuous cycle with Employment, Growth, Poverty Reduction, and Rising Living Standards. The key pillars are Technology, Invention and Innovation; People and Skills; Infrastructure, Resources, and Natural Environment; Economic Growth and Inclusivity; Stakeholder Relations and Governance.

After extensive research, analysis, consultations, and stakeholder engagements – as detailed in this document – a number of recommendations arise. The Presidential Commission on the Fourth Industrial Revolution has categorised these recommendations as major and minor, in relation to their priority levels. The major recommendations include: Establishment of a National Institute for Artificial Intelligence; Establishment of a National Data Centre; Review, amendment and/or updating of all legislations in line with the developments in Fourth Industrial Revolution; Ensuring competitive connectivity; Incentivising of the applications of Fourth Industrial Revolution technologies; Preparation of South Africa for the future of work; Establishment of a

National Cybersecurity Institute; Adoption of a major theme around policy of data by the National Research Foundation. The details of several minor recommendations – relating to these major recommendations – are also included in this document.

CHAPTER TWO: Terms of Reference

2.1 INTRODUCTION

We are currently in the initial phase of the fourth industrial revolution. The world has witnessed three industrial revolutions over the past two hundred and fifty years. Before the three industrial revolutions Mapungubwe, consisting of modern-day Zimbabwe, Botswana, and South Africa contained within it, various industrial capabilities. The figure below (Figure 1) provides insight into these industrial capabilities from as early as the 1st century.

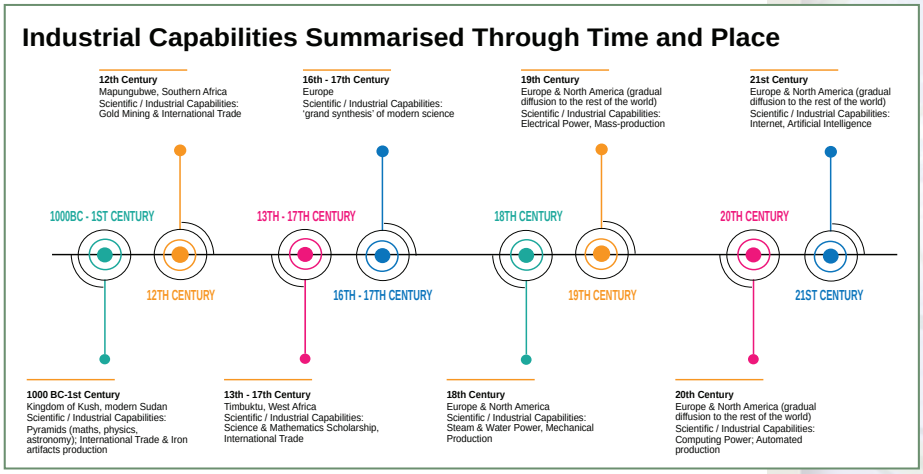


Figure 1: Africa Industrial capabilities summarised through time and place

Any industrial revolution brings in a significant shift and affects the society immensely in various ways. The First Industrial Revolution started in the late eighteenth century with the use of steam to power different processes. Before this revolution, human and animal power was used for production. One of the significant inventions, which symbolizes this revolution, is the steam engine. Steam power was also used for driving weaving mills. This led to increased and localised production in factories. Due to industrialisation, there was an effect on the social structure; people started moving from villages to the cities where industries were located. We began slowly moving away from an agriculture-based society to an industry-based society. The First Industrial Revolution took place in England and it took about a century for different parts of the world to benefit from this revolution.

The Second Industrial Revolution took place about a century after the First Industrial Revolution. One of the significant inventions that was a driving force for the Second Industrial Revolution was the invention of electricity. During this revolution, steam power was replaced by electric power. Slowly industries started to be driven by power generated by electricity. During this revolution, another major invention was that of electric motors, which led to assembly lines and the mass production of goods and services. The invention of electricity changed society in a significant way. Due to electric lights, it was now possible to have social activities even after sunset. It became easier for industries to be operational at night thus increasing the production capacity and outputs of the industries.

The Third Industrial Revolution started in the second half of the twentieth century approximately a century after the Second Industrial Revolution. One of the major driving forces behind this revolution was the advancement in the semiconductor industry. Transistors were invented in 1947 at the bell labs in USA. The invention of transistors brought in a significant change as information could now be digitised and stored easily. The Third

Industrial Revolution also saw the advent of computers leading to the automation of industries, thus increasing production and efficiency. Another important invention of this revolution was the internet. The invention of the internet allowed the world to connect virtually. The figure below (Figure 2) illustrates the four industrial revolutions.

The Fourth Industrial Revolution (4IR) is not an extension of the third industrial revolution, with an increase in computing power and better connectivity. The Fourth Industrial Revolution is a result of the meeting of multiple technologies, as well as multiple broad domains coming together which were relatively independent before. It is often said to be the convergence of the technologies bringing the digital/cyber, physical and biological worlds together[1]. It is also about developing new technologies and business models. In the Fourth Industrial Revolution more meaningful information is being extracted from available data using different algorithms and high computational capacity and capability. Some of the technologies driving this revolution are blockchain, artificial intelligence (AI), biotechnology, nanotechnology, cloud computing, internet of things, 3D printing and autonomous vehicles. Huge progress has been made in the area of Artificial Intelligence over the past decade. This is mainly due to the increased computational power that has become available at a lower cost and the availability of massive amounts of data. The data of the world is growing at a swift rate. It is forecasted that by 2025 the world will have about 163 trillion gigabytes of data[2]. Thus, as more technology is being used to process and make sense of data, the more popular it will become in the near future.

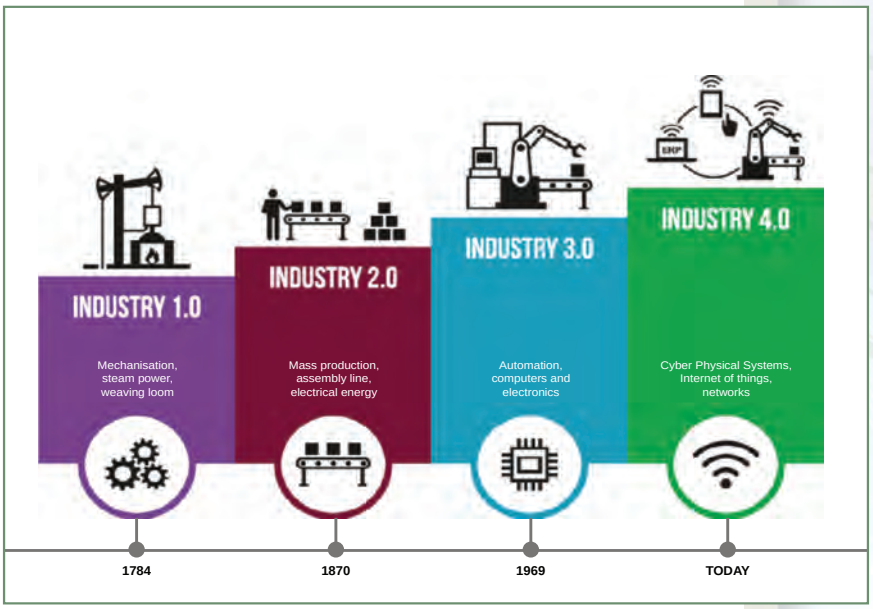


Figure 2: Industrial revolutions timeline[3]

History has shown us that for a country to progress, it should be an active participant in the industrial revolutions to reap the benefits of it early. South Africa was not an active participant in the first three industrial revolutions due to various reasons. This hindered the growth of South Africa. For example, the first steam engine came to South Africa sixty years after it was invented in Britain[4]. Similarly, the first commercial flight in South Africa flew sixty years after it did in the United States of America (USA). It took about seven years for the internet to come to South Africa. We cannot afford to lose on benefiting from the current industrial revolution. To do that, South

1 https://www.weforum.org/about/the-fourth-industrial-revolution-by-klaus-schwab
2 https://assets.ey.com/content/dam/ey-sites/ey com/en_gl/topics/workforce/Seagate-WP-DataAge2025-March-2017.pdf
3 https://www.seekmomentum.com/blog/manufacturing/the-evolution-of-industry-from-1-to-4
4 https://www.sahistory.org.za/dated-event/first-railway-line-south-africa-between-durban-and-point-officially-opened

Africa needs to be an active participant of the Fourth Industrial Revolution and to have a national strategy in this regard on how to steer the country to actively participate and reap the benefits of the current industrial revolution.

Some caution South Africa's ambitions of being an active participant in this revolution, however, the reduction of global boundaries, as well as the fast pace of this revolution, means that access to the opportunities of this revolution is more readily available and can more quickly be leveraged.

2.2 THE PRESIDENTIAL COMMISSION ON THE FOURTH INDUSTRIAL REVOLUTION OVERVIEW

President Cyril Ramaphosa has formed the Presidential Commission on the Fourth Industrial Revolution (PC4IR) and also, has named individuals from the Commission with the undertaking to help the government in making the most of the open doors exhibited by the current modern upheaval. The errand of the Commission, which is being led by the President, is to distinguish relevant policies, systems and action plans that will position South Africa as a focused worldwide player. The President set the tone of the country towards the Fourth Industrial Revolution by stating - "Unless we adapt, unless we understand the nature of the profound change that is reshaping our world, and unless we readily embrace the opportunities it presents, the promise of our nation's birth will forever remain unfulfilled"[5]. The thirty-member Presidential Commission on the Fourth Industrial Revolution comprises eminent persons from different sectors of society and reflects diversity in youth, gender, business and labour, including digital start-ups founders and digital entrepreneurs.

The possibilities and prioritisation of pathways presented by the 4IR are given material direction and purpose within the South African National Development Plan (NDP) towards 2030. The NDP, South Africa's long-term development strategy, contains critical targets for the eradication of poverty and the reduction of unemployment and extreme inequality. Thus, in evaluating the socio-economic impacts and opportunities of the 4IR, there is an opportunity to address the core concerns of the NDP and in so doing, provide a policy-embedded path towards our constitutional objectives in the context of a significantly improved and altered future.

The Presidential Commission was appointed in April 2019 with the following terms of reference:[5]

- Develop an integrated country strategy and plan to respond to 4IR including detailed interventions to be carried out in achieving global competitiveness of the key economic sectors (agriculture, finance, mining, manufacturing, ICT, and Science, Technology, and Innovation);
- Advise on strategies for skills development and future of work;
- Advise on a technology research and development program to advance 4IR;
- Recommendation an institutional framework and mechanism to coordinate 4IR programs;
- Recommend enabling relevant infrastructure for SA to participate in the digital economy;
- Make recommendations on approaches to address inclusivity and the digital divide;
- Advise on strategies to mobilise resources to support the 4IR interventions;
- Recommend mechanisms to quantify the impact of interventions on 4IR; and
- Recommend on interventions to enable innovation and entrepreneurship, and for SMMEs to take advantage of the 4IR;

5 https://www.dtps.gov.za/index.php?option=com_content&view=article&id=811:president-cyril-ramaphosa-appoints-commission-on-fourth-industrial-revolution&catid=13&Itemid=138

The Commission's method of work includes the following:

- The Commission must seek to adjust their exercises accordingly to guarantee alignment to the NDP.
- The Commission may set up its very own Working Groups as it considers essential and exercises restraint to welcome specialists and different stakeholders to take part in its gatherings.
- The Commission should audit and make suggestions on its terms of reference regularly.

CHAPTER THREE: Global Perspective

3.1 INTRODUCTION

The Fourth Industrial Revolution, also commonly known as Industry 4.0, has arrived. The term Industry 4.0 was first introduced in 2011 at the Hannover Messe Trade Fair in Germany by Henning Kagermann (an SAP founder), Wolfgang Wahlster (a professor of AI), and Wolf-Dieter Lukas (a German Federal Ministry of Education and Research Official) (reference A). Over time, several definitions and descriptions for this revolution have come about.

According to the WEF, "The Fourth Industrial Revolution is about more than just technology-driven change; it is an opportunity to help everyone, including leaders, policy-makers, and people from all income groups and nations, to harness converging technologies in order to create an inclusive, human-centred future".[6]

WEF also describes the Fourth Industrial Revolution as being "characterized by a range of new technologies that are fusing the physical, digital and biological worlds, impacting all disciplines, economies and industries, and even challenging ideas about what it means to be human."[7]

Simply put, the Fourth Industrial Revolution is based on a convergence of multiple technologies. A driver of the fourth industrial revolution is the tremendous increase in the data processing capabilities of computers, while World data is projected to grow at 40% rate per year. Additionally, the emergence of data lakes and cloud computing has played a role in reducing the cost of data processing due to the use of shared infrastructure and on-demand provisions. Some of the rapidly growing technologies of the Fourth Industrial Revolution are artificial intelligence (AI), big data analytics. machine learning (ML), robotics, quantum computing, biotechnology, additive or 3D printing, nanotechnology, internet of things (IoT), cyber-physical systems (CPS), blockchain, driverless vehicles, Machine to Machine (M2M) communication, and other new technologies. Moreover, as these individual technologies are evolving at an exponential rate, they are also playing a role in the development of other new technologies. These technologies are already disrupting companies, industries, small and big businesses, and governments around the world. Most sectors, among other things healthcare, financial services, transport, trade, energy are being affected in the Fourth Industrial Revolution. The effects and impacts of the disruptions brought about by the revolution are both broad and deep.

A major common thread through many of the different technological pillars of the Fourth Industrial Revolution is data. For example, cloud computing deals with the processing of data by servers which may be located at remote locations; IoT deals with collection of data using different types of sensors and processing them locally or in the cloud to get meaningful information; cybersecurity mainly deals with ways of storing and transferring of data in a secure mode.

Data is the new gold in the age of the Fourth Industrial Revolution. It is the true invisible hand behind 4IR, a critical feedstock of macro-economic development, and requires acceleration to drive a rapid rate of knowledge generation (Gleason, 2018).

Studies have forecasted that by 2025, the global datasphere will grow to 163 zettabytes (trillion gigabytes) (Figure 3). These data sources consist of social media, like Twitter and Facebook, emails, webpages, online searches etc. In general, any activity in the digital world creates data. Various sectors such as health, utilities, mining, manufacturing, transport and many more, tend to generate massive amounts of data. Globally, these data are one of the critical drivers of the Fourth Industrial Revolution. The internet also provides a considerable amount of data that can be useful to various organisations, governments, businesses, and researchers, etc. Companies and governments around the world are now investing in Big Data infrastructure in order to mine insights from these data. For example, data analytics can be used to strategically inform government's resource planning and deployment.

6 https://www.weforum.org/focus/fourth-industrial-revolution
7 https://www.weforum.org/about/the-fourth-industrial-revolution-by-klaus-schwab

Several countries around the world have recognised the importance of data resources and have thus already implemented data protection laws. Additionally, the data ecosystem also brings about the critical need for policy and legislation relating to the use of data, including ethics and security. Several countries have already put in place policies and legislation that extend beyond basic laws on the protection of personal data.

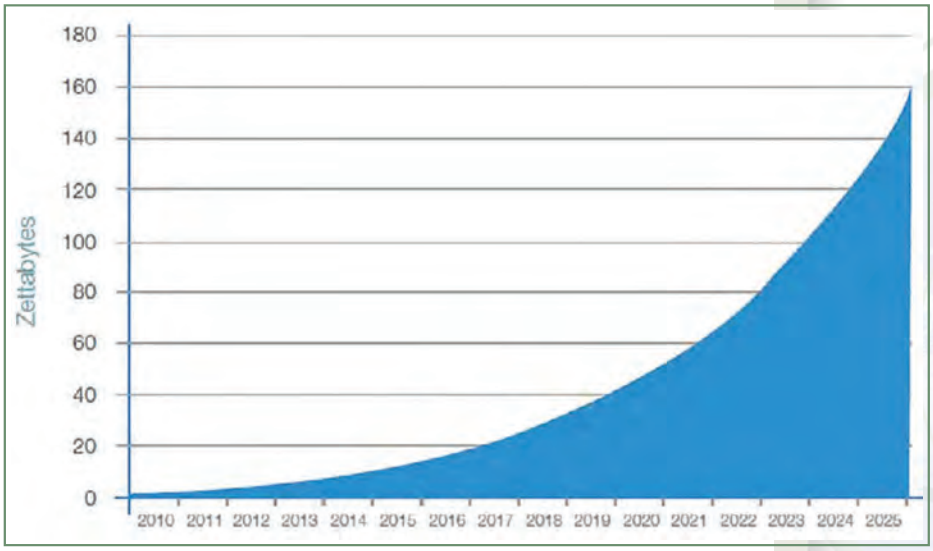


Figure 3 : Projected yearly increase in global data

Source: IDC's Data Age 2025 study, sponsored by Seagate, 2017 [UJ_4]

The key to this analysis is the understanding that data is undeniably the central, productive force of the 4IR. In other words, the economic value to be derived from this age is located in the ownership and management of data. Furthermore, as we contemplate the technological artefacts and capabilities of the 4IR, we are compelled to examine data as a separate force and the ultimate determinant of how social and economic value will be accessed and experienced in the coming age. Put differently, as we contemplate South Africa in the 4IR, we must keep at the centre of our understanding the following key concepts:

- The dominant logic of the emerging future is one in which science and capital are fused. In other words, the system of capitalism has produced the kind of technology future we are experiencing, in which personal data has been commodified and brought into the market.
- It is not scientific knowledge nor its technological artefacts that will determine the future, but rather the use of the 4IR's core capital, data, that will determine the extent to which advantages are created, protected, and reproduced.

This rationale is not beyond the state's governance. Instead, it compels the country to take a more central role in the collection, dissemination, and analysis of data, understanding that key economic advantages are contained within it, but perhaps more importantly, that fundamental human rights are now intertwined with the protection of data. On a commercial level, the questions we should therefore ask are not merely about the integration of technologies into production processes, but of the ownership of critical intellectual property and data rights that are intertwined with technology use. Appreciating that machines can indeed liberate humans from arduous manual labour, we must also understand that the realm of economic control for human beings is precisely in the human capabilities that will enable the design, deployment, and management of artificial intelligence, which will pervade human experience.

3.2 GLOBAL 4IR STRATEGIES

Many countries around the world have already begun to develop strategies, policies, resources, and legislation to exploit the benefits of the Fourth Industrial Revolution. The following figure highlights the critical activities of some of these countries (Figure 4).

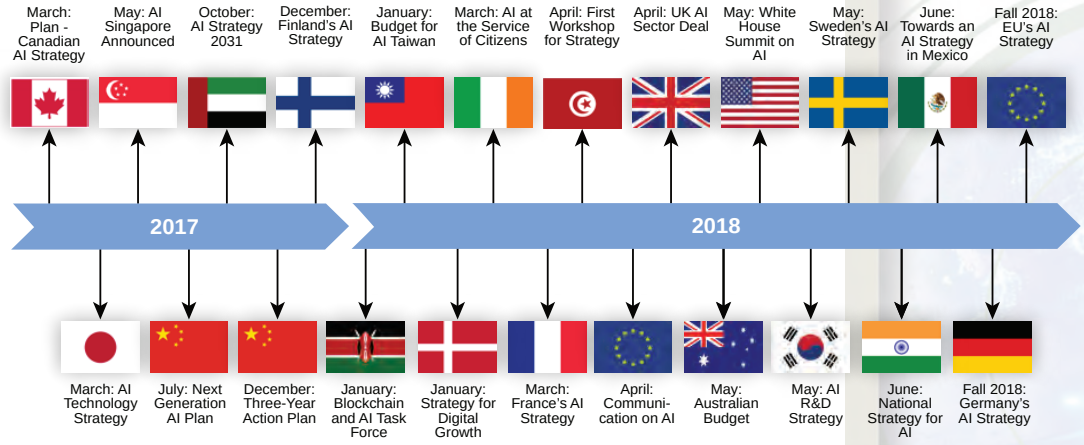


Figure 4: An Overview of National Strategies[8]

The discussion below will provide a more in-depth insight into the various countries' strategies with regard to the fourth industrial revolution with a specific focus on the following countries; India, United Kingdom, United States of America, China, Japan, and Singapore. After that the discussion will provide snippets of the following countries' strategies; Mexico, Malaysia, Kenya, Australia, Canada, Russia, and Tunisia.

3.2.1 India

India's National Program on AI, intended to pursue *Transformational AI*, was launched in 2018, the implementing custodian of which is the National Institute for Transforming India.[9] Essentially a government think-tank, the entity designs the long-term policies and programmes at central and State-level. It is a high-level structure whose Council is chaired by the Indian Prime-Minister with the Chief Ministers of each State serving as Council-members.

In its current phase, NITI-Aayog's AI focus involves three main activities, all of which have been selected based on desired and optimal social impact:

- Exploratory proof-of-concept AI projects
- Developing a national strategy to build an AI ecosystem
- Partnerships between the government and technology companies to implement AI projects in critical policy areas like agriculture and health

8 http://www.jaist.ac.jp/~bao/AI/OtherAIstrategies/An%20Overview%20of%20National%20AI%20Strategies%20%E2%80%93%20Politics%20+%20AI%20%E2%80%93%20Medium.pdf

9 India, 2018 http://niti.gov.in/writereaddata/files/document_publication/NationalStrategy-for-AI-Discussion-Paper.pdf

In this regard, AI (and technology in general) is seen as the lever for social transformation, human development, and inclusive growth that, in the process, will democratise access to new technologies. To these ends, the principles informing India's #AIforAll strategy are:

- address the country's skills shortage;
- test-out and implement AI solutions (whether in the form of applications, research, development, technology, or responsible AI) that can be scaled for implementation in other emerging economies;
- harness collaborations and partnerships, domestically and internationally.

More concretely, the following social and human development emphases have been prioritised for the implementation of #AIforAll[10]:

- **Healthcare:** expanded access and moderateness of value human services.
- **Agriculture:** improved farmers' pay, expanded farm profitability, and decrease wastage.
- **Education:** improved access and nature of instruction.
- **Smart Cities and Infrastructure:** productive and availability for the expanding urban population.
- **Smart Mobility and Transportation:** more astute and more secure methods of transportation and better traffic and blockage issues.

Transformative AI (#AI4ALL) is principally a technology-led social transformation and human development strategy. As a social strategy that seeks to deploy technology to address the country's pressing challenges to human wellbeing and, in the case of farmers, livelihoods, #AI4ALL is an ambitious data-driven technological response that will need secure data-collection and -sharing not only between government departments and across all three levels of the state, but between the public and private sector.

The section on the demographic profile of Indian society noted, among a range of features, that less than a fifth of India's working population is classified as skilled. Of this, an even smaller proportion possesses the requisite IT skills to be able to participate in the country's AI transition. As such, one of the recommendations from #AI4All is a drive to upskill Indian workers. Given the size and urgency of the task, the strategy also recommends the recognition and standardisation of informal training institutions as a way of bolstering government capacity to provide training. This should be coupled with the creation of open platforms for learning, which can facilitate self-directed, online learning opportunities. Finally, the strategy identifies a need to create financial incentives for employers to invest in employee skills-upgrading.

In light of the Indian economy's shift away from agriculture to services, the strategy highlights the need for government incentives to encourage private sector investment to support the AI solution-development value chain. The idea is to generate jobs that include tasks like data annotation, image classification, or speech transcription services, which are both labour intensive and do not require a high level of IT skills capability.

Overall, the strategy identifies the totality of the Indian education, skills, and training ecosystem as the cornerstone for realising #AI4All. Within the formal schooling and higher education segments, the following are some of the recommendations from the AI strategy:

- Introducing AI / Machine Learning (ML) in schools
- The development of useful bridging courses, at post graduate level, for graduates in non-AI / IT fields to acquire the requisite proficiency;

10 India, 2018 http://niti.gov.in/writereaddata/files/document_publication/NationalStrategy-for-AI-Discussion-Paper.pdf

- Creating incentives for post-graduate students to research in local institutions (as opposed to going overseas where some of the most talented students remain to pursue work or research-careers);
- Embedding cross-disciplinary education and research collaboration, including industry-academy partnerships.

In order to promote the 'AI+X' paradigm where AI researchers work in collaboration with researchers in other domains like healthcare, manufacturing, agriculture, etc., India has identified the strategy of co-locating inter-disciplinary teams consisting of university research departments, start-ups, social and policy-practitioners in working towards solutions-oriented research.

3.2.2 United Kingdom

The UK's industrial strategy builds on the public consultations that began in February 2017 on the Building our Industrial Strategy Green Paper. The final strategy document, Industrial Strategy: Building a Britain Fit for the Future was released in November 2017 and forms the blueprint for the UK government's intervention in the economy.[11]

Central to the UK's industrial strategy is making improvements in the following areas (i.e., five foundations of productivity; Figure 5):

- Ideas and Innovation;
- Worker skills, with an emphasis on young people and enhancing their access to jobs of the future;
- Infrastructure;
- Business environment in order to make the UK a destination of choice for starting new businesses;
- Shared prosperity across the UK.

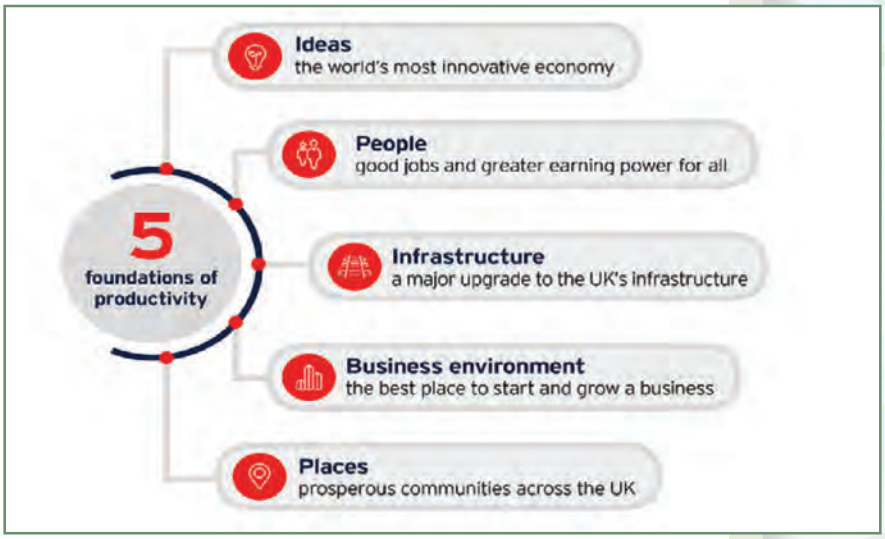


Figure 5: The five foundations of productivity [UJ _5]

11 United Kingdom 2017, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/664563/industrial-strategy-white-paper-web-ready-version.pdf

Four levers have been identified to drive the targeted improvements as depicted in the figure below in, namely: AI and the data economy, environmentally sustainable growth, transportation, and logistics, as well as addressing the challenges linked to an aging society (Figure 6).

Figure 6: Levers to drive Targeted Improvements [UJ _6]

This overarching Industrial Strategy has been broken down into ten sector deals for the following sectors: Aerospace, Artificial Intelligence, Automotive, Construction, Creative industries, Life sciences, Nuclear, Offshore wind, Rail, Tourism. Each of these sector deals has its strategies and targets as part of the UK's industrial strategy.

Additionally, the British Innovation Principle has placed obligations on all public-sector bodies that the influence on innovation as a driver for jobs and growth is assessed alongside any potential risks from technological development (ConservativeHome, 2017). The United Kingdom was ranked first in 2017 in the Government Readiness Index developed by Oxford Insights. In its efforts to be the leader in Artificial Intelligence, the United Kingdom has placed emphasis on the productivity and earning power of its citizens through an industrial strategy.

3.2.3 United States of America

The United States of America published its first National Artificial Intelligence Research and Development Strategic Plan in 2016 as a result of the recognition of the vast potential of AI and the need to continue its advancement.[12] The plan itself served as a strategic framework for leveraging and further developing America's AI capabilities as well as ensuring that these capabilities are optimally employed in delivering prosperity, security, and improved quality of life for their citizens.

This plan set out several key areas of focus, including[37]:

- Continued long-term interests in AI;
- Practical strategies for human-AI joint effort;
- Understanding and tending to the moral, lawful, and cultural ramifications for AI;
- Ensuring the well-being and security of AI;
- Developing shared open datasets and situations for AI training and testing; estimating and assessing AI advancements through guidelines and benchmarks, and better understanding the Nation's AI R&D workforce needs.

12 United States of America 2019, https://www.whitehouse.gov/wp-content/uploads/2019/06/National-AI-Research-and-Development-Strategic-Plan-2019-Update-June-2019.pdf

Recognising the rapid progress and global developments, and the need to keep up with technological advancements and evolving landscape, the American Administration initiated an update to the plan in 2019. The sole focus of the update was AI Research and Development. This updated National AI Research and Development Strategic Plan was released in June 2019 as a guide for federal investments in AI Research and Development. The update itself was not intended to recommend policy or regulatory frameworks, but rather to address the research and development priorities allied to advancement in AI technologies, which would then inform policy and regulation. The plan sets out eight key strategies[37]:

a) Make long-term financing available to look into AI;

b) Develop robust strategies for human-AI cooperation;

c) Understand and address the moral, lawful, and cultural ramifications of AI;

d) Ensure the well-being and security of AI frameworks; Strategy;

e) Develop shared open datasets and conditions for AI training and testing;

f) Measure and assess AI advancements through measures and benchmarks and Strategy

g) Better comprehend the national AI R&D workforce needs; and

h) Expand public-private organizations to quicken movements in AI.

The American AI initiative was launched in January 2019, and is guided by five principles[37]:

- Driving innovative achievements,
- Driving the improvement of proper specialized measures,
- Training labourers with the aptitudes to create and apply AI innovations,
- Protecting American qualities including universal freedoms and security and cultivating open trust and trust in AI advancements,
- Protecting US advantages in their advanced position in AI while advancing a worldwide domain that supports development.

Other notable developments in the United States of America include the holding of an AI summit for the American Industry, featuring of AI in the National Security and National Defence Strategies, and establishment of an AI caucus in Congress, introduction of AI-specific Acts pertaining to various implications including impacts on labour, economy, trade, rights, international cooperation etc., and presentation of AI-related bills at state and local levels.

3.2.4 China

In 2016, China initiated its first of two three-year strategic plans – the first being a Three-year Guidance for Internet and Artificial Intelligence plan for 2016-2018, and the second, the Three-Year Action Plan for Promoting Development of a New Generation Artificial Intelligence Industry for 2018-2020. In July 2017, China released a comprehensive plan to become the leading power in AI by 2030. Several specialised projects have since been deployed by the state, including intelligent manufacturing and intelligent next-generation internet. The latest plan of China – Three-Year Action Plan for Promoting Development of a New Generation Artificial Intelligence Industry – aims to seize their historical advantage in Artificial Intelligence capability, set the global development trend for AI globally, and ensure "economic and social development, support national security, and promote the overall competitiveness of the country and leapfrog development." [13]

13 https://flia.org/wp-content/uploads/2017/07/A-New-Generation-of-Artificial-Intelligence-Development-Plan-1.pdf

The Chinese strategic approach is guided by the principles "of the 18th CPC National Congress, as well as the third, fourth, fifth, and sixth plenary sessions of the 18th CPC Central Committee." [14] The approach includes three basic principles:

1. Systematic Layouts: A targeted systematic development strategy characterized by basic research, technology development, industrial development, and industry application.
2. Market-oriented: Adherence to rules of the market and firm commitment towards developing a competitive advantage. Managing the role of government in the marketplace in terms of planning guidance, policy support, security, "regulation, environmental, construction, ethical regulations and, other aspects." [15]
3. Open Source: Promoting the concept of open source and sharing of the production, research, and innovation. Commitment to providing innovative resources on a global scale.

According to China's strategic plan, the goals are divided into three steps – according to timeframes 2020, 2025, 2030. The first goal seeks to keep up with the overall technology and application of AI, particularly as a growth point in industry. The second goal aims to achieve significant breakthroughs in AI basic theory, with world-leading applications thereof in industry thereby assisting with the Country's industrial upgrading and economic transformation. Finally, by 2030, China aims to be a leading innovation centre for AI, intelligent society and economy, and at the forefront of the world's economic powers.[16]

3.2.5 Japan

The anchor idea behind Japan's 4IR strategy, 'Society 5.0' is that the economy should become more people-centric[17]. Japan aims to leverage its success in the third industrial revolution, what they refer to as the 'manufacturing of things' in order to make machines work for people. Their economic outlook is centred around human benefit, identifying the following as the goals of transition:

- Improved healthcare
- Improved social connection
- Reduced impacts of geographic isolation
- Tailored consumption

The Japan strategy is the product of a collaboration between government, academia, and industry that determined that science and technology should be at the centre of the economy. To this end, investment in research & development has seen a considerable increase, making technology, chiefly, Artificial Intelligence (AI) central, rather than supportive of the national development strategy. Therefore, their vision for the place of people in economic production pertains to human beings as producers of cutting-edge technology, wholly removed from manual labour.

Japan also intends to invest in the following forms of infrastructure:

- Smart mobility (self-driving public transport)
- Smart/ e-government
- Financial technology (removing cash from society)
- Smart healthcare

14 https://flia.org/wp-content/uploads/2017/07/A-New-Generation-of-Artificial-Intelligence-Development-Plan-1.pdf
15 https://flia.org/wp-content/uploads/2017/07/A-New-Generation-of-Artificial-Intelligence-Development-Plan-1.pdf
16 https://flia.org/wp-content/uploads/2017/07/A-New-Generation-of-Artificial-Intelligence-Development-Plan-1.pdf
17 https://www.gov-online.go.jp/cam/ s5/eng/index.html

Japan intends to place people at the centre of consumption. Their outlook is about optimising technology for the benefit of people. The jobs that are emphasised are jobs that are at the centre of controlling machines i.e., jobs that are founded on science, technology, engineering, and mathematics competencies. While recognising the need to work in STEM fields in the 4IR, Japan also sees it as an opportunity to de-emphasise the impact of its aging population by using technology to increase economic productivity.

3.2.6 Singapore

Launched by Prime Minister Lee Hsien Loong in November 2014, Singapore's Smart Nation initiative was among the first country strategies seeking to better harness and incorporate the development and deployment of digital and other smart technologies to improve the lives of citizens. Smart Nation can be understood as an attempt to harness information and communications technologies, networks, and big data to create tech-enabled solutions in all domains of society.[18]

Smart Nation is not just a sudden technological drive. Instead, it has to be understood historically as the culmination of at least four decades of technology-related and ICT-driven master-planning by the island nation. The diagram below provides an overview of the policy evolution since the early 1980s. Smart Nation comprises three pillars: Digital Economy, Digital Government, and Digital Society. In terms of the economy, the government of Singapore aims to digitise industries to improve business efficiency and drive job creation.

Digital Government refers to using data, connectivity, and computing to inform and transform the services provided to citizens and businesses. Also, the Digital Government is intended to unlock the productivity and efficiency of civil servants while automating some functions to "provide a personal touch in a way that enriches the citizen's experience." In moving towards Digital Government, the government of Singapore has prioritised making all government departments digitally-enabled workplaces and has invested in creating a digitally-competent workforce

For the latter, the government has set a target of training 20,000 government employees (approximately 14% of the total number of civil servants) in data science and data analytics while all civil servants will be required to have a basic level of digital literacy. By 2023, all government ministries and agencies will be necessary to have one Artificial Intelligence (AI) project underway for either service delivery or for policy development. The Digital Government Blueprint outlines a five-year roadmap for the Singapore government to harness digital technologies towards these service ends.

At the societal level, Digital Society articulates the government's mission to foster digital inclusion, ensuring all Singaporeans have access to technology that can enhance their everyday lives. In addition, through its emphasis on digital inclusion, the government has prioritised equipping its citizens with digital literacy and the capacity to use technology safely. At the heart of Digital Society is the desire to ensure that all Singaporeans[19]:

- can maximise the opportunities of a digital society;
- improve their lives;
- become and remain connected to the world; and
- have an equal chance to succeed.

The discussion will now provide snippets of the following courtier's strategies; Mexico, Malaysia, Kenya, Australia, Canada, Russia, and Tunisia.

18 https://www.nrf.gov.sg/programmes/artificial-intelligence-r-d-programme
19 https://www.nrf.gov.sg/programmes/artificial-intelligence-r-d-programme

3.2.7 Mexico

Mexico published a white paper towards developing an AI strategy in 2018. A notable feature of Mexico's approach is the use of making a Google sheet of the report available online for public comment[20].

3.2.8 Malaysia

Malaysia has developed its Industry 4WRD strategic plan for the Digital transformation of manufacturing with the aim of improving manufacturing efficiency and productivity to drive economic growth.[21]

3.2.9 Kenya

The Kenyan government established a task force in 2018 to recommend to the government on harnessing Blockchain and AI technologies over the next five years. Some examples of the application areas of interest include public service delivery, cybersecurity, financial inclusion, and election processes.[22]

3.2.10 Australia

The Australian government has already committed close to $30 million in 2018-2019 towards enhancing the country's AI efforts, including the development of a national AI Ethics Framework, technology roadmap and set of standards. The Australian Government also released an innovation and science agenda that notably commits plans of the Government to lead by example through embracing innovation and technology. The agenda has set out several comprehensive initiatives ranging from attraction of talent to reformed funding arrangements for university research.[23]

3.2.11 Canada

The Canadian Government made an early roll-out of and investment in its AI strategy in 2017. A coordinated group of AI research and development institutes has been established.[24]

3.2.12 Russia

In January 2019, the Russian Government was instructed to develop a national AI strategy. However, several initiatives about AI development had already been effected in 2018.[25]

3.2.13 Tunisia

Tunisia is currently developing a national strategy on AI. A task force was established in 2018.

3.3 LESSONS FOR SOUTH AFRICA

Some critical learnings for South Africa from these country cases can be summarised as follows:

1. 4IR strategy based on and responds to service delivery challenges as well a social and human development / wellbeing priorities.
2. A high-level inter-departmental / inter-ministerial, multi-stakeholder governance, and coordination structure should be the custodian of the 4IR strategy.

20 https://docs.google.com/document/d/1Lq4o7_MXzRh6wBeloRSVdAAB867MwdZqTvm7MmMyz4s/edit#heading=h.gjdgxs
21 http://www.mpc.gov.my/industry4wrd/
22 https://futureoflife.org/ai-policy-kenya/
23 https://www.industry.gov.au/strategies-for-the-future/boosting-innovation-and-science
24 https://www.cifar.ca/ai/pan-canadian-artificial-intelligence-strategy
25 https://futureoflife.org/ai-policy-russia/

3. A focus on Regulation, Ethics, and Cultural aspects of the internet is key not only to create an enabling policy environment to support firms and government but to ensure ethical and transparent use of these new technologies (for example, Japan's High-Level Expert Group on Artificial Intelligence (AI HLEG), "Draft Ethics Guidelines for Trustworthy AI").

4. Malaysia's Industry4WRD Readiness Assessment Guidelines (assess industry's state of readiness for 4IR) is a useful tool to determine the baseline of technological capabilities. Based on these assessments,

    a) Firms can develop a roadmap to transition to greater use of (and possibly development) of 4IR technologies. South Africa's Sector Education and Training Authorities (SETA's) can be one of the institutional mechanisms that support and collect (and collate) sectoral assessments.

    b) The government can formulate strategies and policy instruments (regulation, tax incentives, and infrastructure development) to support firms.

    c) A Government 4IR Readiness instrument should also be developed to help determine how government departments can incorporate technology to improve their overall service delivery.

5. The strategy must leverage and harness capabilities in the private sector to find scalable and profitable solutions that simultaneously unlock social and economic value. Society at large can also play a role in contributing to 4IR-driven social and human development (see, for example, Malaysia's citizens' contributions to the wellbeing of the aged).

6. All three countries have an emphasis on employee capacity development and reskilling to enhance their chances of transitioning into the jobs of the future.

    a) South Africa already has a skills landscape (the Sector Education and Training Authorities (SETAs) and the National Skills Levy that can be leveraged to drive 4IR-related skills development.

    b) While this is necessary for South Africa as well, the country's high unemployment requires a strategy that focuses on those who are neither in employment nor in education (NEETs) as well.

    c) Another key aspect of capacity development relates to educational and curriculum reform. Some innovative approaches to consider include Japan's shift away from "pass or fail in a grade" to subject-specific progression. This means that students can progress in some subjects while remaining "behind" in others in order to improve and get to the required level of subject proficiency.

    d) Removing subject and discipline boundaries in favour of inter-disciplinarity to encourage complex thinking.

Additionally, to the above, there are a number of digitization risks that could face South Africa, included amongst others are the following:

- The digitization of government strategies, while necessary and warranted, nonetheless poses cybersecurity risks and the threat of large privacy breaches by both the state as well as by other entities.
- Digitisation also increases the surveillance capacity of the government and firms in ever more areas of individuals' lives.

CHAPTER FOUR: South Africa

4.1 INTRODUCTION

Technologies of the fourth industrial revolution are already impacting different economies globally. South Africa is not immune to this trend. There are vast opportunities available for South Africa to exploit if resources are effectively allocated and utilised through a well-defined strategy.

Governments spearheading 4IR strategic planning have typically restructured the state to place science, technology, and higher education at the centre of the state, along-side such central functions as fiscal management/national treasury.

The specific failures of Structural Adjustment Programs (SAPs), which regressed much of Sub-Saharan Africa's post-colonial socio-economic gains, make it clear that economics alone cannot be trusted to solve development problems. It also suggests that Development cannot be articulated and addressed through the lens of any discipline that offers a cure-all. Similarly, as the 4IR rises in stature as the conceptual lens through which to understand the future, it remains essential to understand its outputs, robotics, and artificial intelligence, as examples, not as panaceas but as optional pieces to a broader puzzle about South Africa's progress.

To this end it is prudent to provide an overview of the South African economy so as to position the various 4IR technologies in order to progress South Africa as a country globally.

4.2 SOUTH AFRICAN ECONOMY

The GDP of South Africa was worth 366.30 billion US dollars in 2018 per the World Economic Forum data. South Africa reached an all-time high of GPD in 2011 at 416.42 USD Billion. However, if a comparison of year on year is performed of GDP growth the South African economy has seen a steady decline in GDP growth with 2009 experiencing negative growth. The graph below (Figure 7) provides a graphical representation of the South African economy from 2007 to 2018.

Figure 7: GPD Growth (Annual %)

Source: World Economic Forum

The post-apartheid period (1994 -1999) had seen an inflow Foreign Direct Investment (FDI) that had driven growth in South Africa. [2] This FDI investment facilitated construction and infrastructure development that lead to higher GDP Growth. During the period 2000 – 2008 there was strong demand for commodities lead by China that had facilitated higher GDP Growth.[2] In 2009, the Global financial crisis had an effect on South African GDP and thus the negative growth.[2] For the period 2010- 2018 fluctuations in commodity prices had added to South Africa's low GDP Growth.[2] The economy was not diversified sufficiently to counter the effect of commodity fluctuations and thus the GDP growth is has steadily declined.[2]

South Africa's economic growth for 2019 was revised to 1.5% from an estimated 1.7% in 2018. The weaker economic growth is due to slow improvement in the production and employment segments of the country. However, in the medium-term outlook for 2021, it is estimated to increase to 2.1% due to better confidence in public infrastructure spending and a better commodity price outlook [26] Furthermore, within the long-term it will be essential for South Africa to reduce unemployment and increase the GDP growth. Additionally, this would lead to raising the necessary revenues for social and economic developments. These developments will have a positive impact on the much-needed structural reforms within South Africa. These structural reforms could include the following but are not limited to [27],

- Increased access to advanced education;
- A more grounded and reasonable work showcase;
- Greater interest in provincial markets;
- A condition for business people and independent ventures to flourish.

These structural reforms will have an impact on the South African economy. The structural changes mentioned above will benefit from clear policies within government to boost economic growth and reduce the exclusion of many South Africans from economic participation. The policies that the government provides to aid these structural reforms will be the backbone for economic growth. It is at this point in time where the South African government needs to be cognisant of the Fourth Industrial Revolution and how this revolution, through policy creation and a clear coordinated strategy, can aid inclusive economic growth in South Africa.

Before this discussion provides insight into how policies, coupled with the Fourth Industrial revolution could add value to economic growth, it is essential that pertinent points of the South African economy, are understood. The figure below provides a summary of key points about the South African economy.

Furthermore, an understanding of the economy from both a positive and negative reference is required. The discussion below provides insight into the critical strengths and weaknesses of the South African economy. It is in this context that South Africa can identify how the Fourth Industrial Revolution can be incorporated to either build onto existing strengths or aid in correcting the weaknesses of the South African economy.

4.2.1 Strengths

a) South Africa is a wealthy country with regard to natural resources (gold, platinum, coal, chromium) (Figure 8). The extraction of these resources could stimulate economic growth in South Africa.[12]

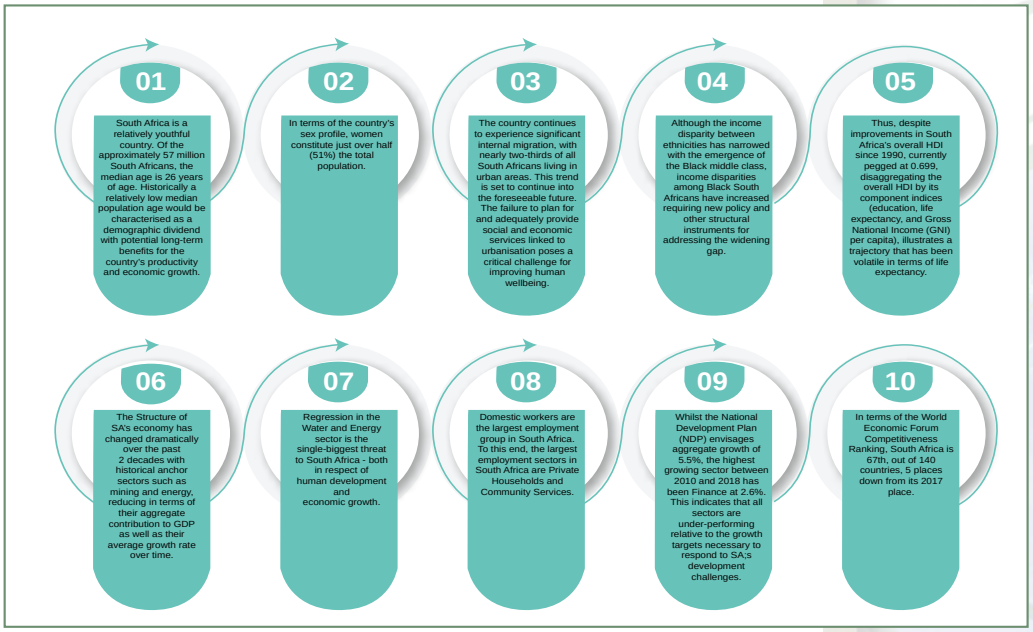
b) Secondly, South Africa is a regional/continental economic and political powerhouse. This allows South Africa to provide policy and decision making on key strategic objectives in the region.[12]

c) Thirdly, South Africa's financial services sector is a mature, developed sector of the economy. This sector is backed by a sound regulatory and legal framework. There are several local and foreign institutions that form part of this sector.[12]

26 http://www.treasury.gov.za/documents/national%20budget/2019/review/Chapter%202.pdf; https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=ZA

27 https://www.imf.org/en/News/Articles/2019/06/03/pr19191-south-africa-imf-staff-concludes-visit-to-south-africa

Figure 8: Assessment of the South African Economy



4.2.2 Weaknesses

a) One of the critical weaknesses of the South African economy is the decline in its competitiveness globally. "A country's economic competitiveness measures its ability to efficiently produce and trade goods and services." [28] South Africa, compared to other African nations has slowly declined as shown in the diagram below (Figure 9). A higher ranking is an indication of poor performance. Kenya, for example, had implemented e-visa, and this has promoted tourism to assist their ranking.

Figure 9: Global Competitiveness Index

Source: World Economic Forum [UJ_1]

28 World Economic Forum, 2018, The Global Competitiveness Report 2018. Online available at http://www3.weforum.org/docs/GCR2018/05FullReport/TheGlobalCompetitivenessReport2018.pdf

b) Another critical weakness that is evident in the South African economy is the ease of doing business in South Africa- identified as one of the critical elements to ensure economic growth for a country. The ease of doing business measures the ability among the cost, time, and procedures to start a business, dealing with construction permits, getting electricity, registering property, getting credit, paying taxes, ease of export and import, enforcing contracts, and resolving insolvency.[29]

c) A key driver for economic reform is electricity. South Africa has an aging infrastructure producing and providing this electricity to businesses and citizens. This aging infrastructure has an impact on economic growth. This is evident by a World Bank report that places South Africa lower than other African countries such as Namibia, Kenya, on the variable of "getting electricity." Furthermore, this variable has an impact on a social level for many South Africans[30].

d) The inequalities evident in the South African economy due to the legacy of apartheid has led to a high level of poverty in the country. South Africa has a dual economy: "on the one hand it is a small high-skilled, high-productivity economy and on the other hand, a large low-skilled, low-productivity one"[9]. This has an impact on the socio-economic problems that face South Africa.

e) The inequalities in the South African economy, coupled with the weakness in its economic "growth has resulted in high unemployment rates in the country." [31] These high unemployment rates have added to the strain on the economy.[32]

f) Coupled with the high unemployment, another weakness for economic growth is shortages in the skilled labour force that could aid economic reforms.[12]

From the discussion above, with regard to the weaknesses and strengths of the South African economy, the fourth industrial revolution can aid in the following instances. Firstly, the Fourth Industrial Revolution can assist the country in increasing its ability to efficiently produce and trade goods and services. This would increase the competitiveness of the country globally. Secondly, the Fourth Industrial Revolution can be used to enhance certain aspects of the ease of doing business in the country, such as getting electricity, registering property and starting a business. Thirdly, the Fourth Industrial Revolution can build onto a robust financial services sector to aid economic reform. Lastly, The Fourth Industrial Revolution can assist in the commercialisation sector of the country, through using tools that allow for faster innovation commercialisation.

The opportunities presented by the Fourth Industrial Revolution as shared above can assist in economic, social, industrial, and commercial reform in South Africa. Identifying international strategies with regard to the Fourth Industrial Revolution will also be a source of insight for South Africa.

The various major sectors of the South African economy will be discussed below with insight provided to the benefit that could be achieved through 4IR implantation.

4.2.3 Mining

The mining industry could benefit immensely from the digital migration that the Fourth Industrial Revolution will bring, which could have a positive impact on the country's ability to efficiently produce and trade goods. The mining industry contributes over 18%, directly and indirectly, to the GDP of South Africa. Mining will be an essential sector for the South African economy. The continuation of this industry will lie in its ability to self-sustain. The modernisation of mines will have an impact on processes, skill sets, social, and environmental aspects within the mining industry.

29 World Bank Group, 2019, Doing Business Report. Online available at https://www.doingbusiness.org/content/dam/doingBusiness/media/Annual-Reports/English/DB2019-report_web-version.pdf
30 World Bank Group,2019, Doing Business, Online available at https://www.doingbusiness.org/en/data/exploretopics/getting-electricity
31 Coface for tarde,2019, Online available at https://www.coface.com/Economic-Studies-and-Country-Risks/South-Africa
32 Coface for tarde,2019, Online available at https://www.coface.com/Economic-Studies-and-Country-Risks/South-Africa

Some of the significant technologies that are used in the mining sector are provided in the diagram below (Figure 10). These technologies are used to increase efficiency in production and aid the social impacts of mining through worker safety, and the impact mining has on the environment.

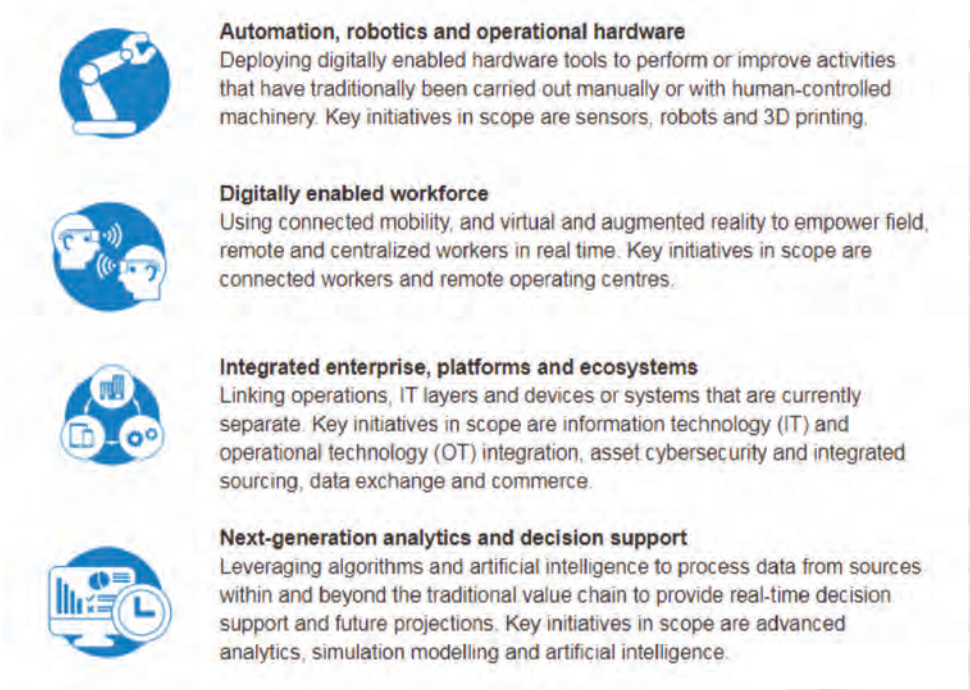


Figure 10: Significant Technologies for Mining

Source: World Economic Forum [UJ_ 2]

Previously, machines had limited autonomy and only carried out specific tasks with a human guiding the process.[33] However, with the use of 4IR technologies, today's machines can carry out tasks over extended periods of time with very little human intervention. These technologies include; robotic trucks, trains and diggers, autonomous stockpile management; automated exploration drones; autonomous robots for recovery of recycling material, and pit drones.[12] These technologies can learn new ways of performing tasks and gather information for miners in potentially dangerous situations. Additionally, creating a digitally enabled workforce in the mining industry will add tremendous value to efficiently produce goods[34]. Lastly, there is untapped data from mining companies that could add value to the economy. This comes in the form of structured and unstructured data. Advanced analytics with algorithms could assist mining companies in making better and faster decisions that are more accurate.[12] This data can also support the sector in better understanding and predicting the impact of their activities and approaches on the environment, enabling better decision making.

33 World Economic Forum ,2018 ,Shaping the Sustainability of Production Systems: Fourth Industrial Revolution technologies for competitiveness and sustainable growth Online available at: http://www3.weforum.org/docs/WEF_Shaping_the_Sustainability_Production_Systems.pdf

34 World economic Forum,2019, Mining and metals https://www.weforum.org/agenda/archive/mining-and-metals/

4.2.4 Agriculture

The agriculture sector has four critical elements, as noted by the World Economic Forum that would need to be addressed to produce efficiency and at the same time promote trade. These four elements are as follows: "1) Inclusiveness, ensuring economic and social inclusion for all food systems actors, including smallholder farms, women and youth 2) Sustainable, minimising negative environmental impacts, conserving scarce natural resources, 3) Efficient producing adequate quantities of nutritious and healthy foods for global needs while minimizing loss and waste 4) Nutritious and healthy produce to aid in providing and promoting the consumption of diverse nutritious and safe foods for a healthy diet."[35]

A few of the technologies that could have an impact on these points that the government could consider in policy implementation include using mobile service delivery to small-farm holders or precision agriculture for input and water use optimisation. South Africa has a long history of Agriculture, and the 4IR presents opportunities to leverage this experience to increase yield and raise exports globally.

4.2.5 Manufacturing

According to the Indian government, manufacturing will be one of the largest sectors to be impacted by the fourth industrial revolution (Figure 11). One of the recommendations provided to the Indian government with regard to the manufacturing industry is to create specific industry guidelines with regard to privacy, security, and ethics due to the use of the Fourth Industrial Revolution technologies[36]. The World Economic Forum has observed that the following technologies will have an impact on the manufacturing industry-specific to automotive and electronics.[37]

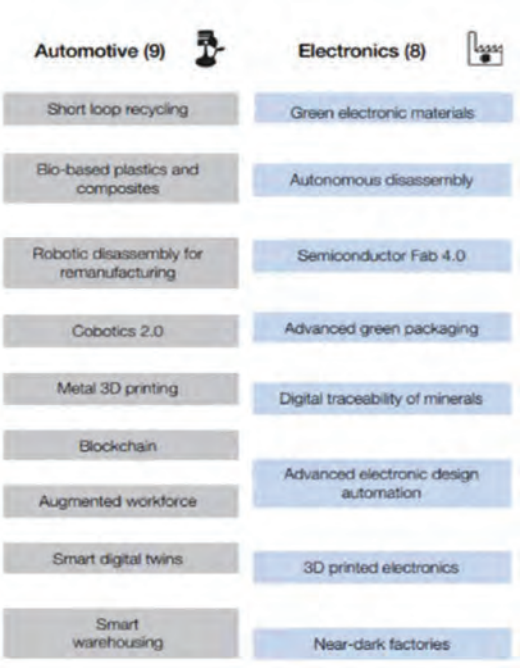


Figure 11: Significant Technologies for Manufacturing

Source: World Economic Forum[23]

The South African manufacturing sector has been shrinking due to global alternatives at lower costs. The use of 4IR technologies can aid in driving prices down in this sector to improve global competitiveness and/or the identification of niche manufacturing areas where South Africa can compete.

4.2.6 Financial Services Sector

The next sector that has an impact on the South African economy and will impact the pace of industrialisation is the financial services sector. Even though this sector is robust and one of the strengths of South Africa, the 4IR will and is already playing a role in this sector. The World Economic Forum has identified the following areas set to impact the Financial Services Sector (Figure 12).

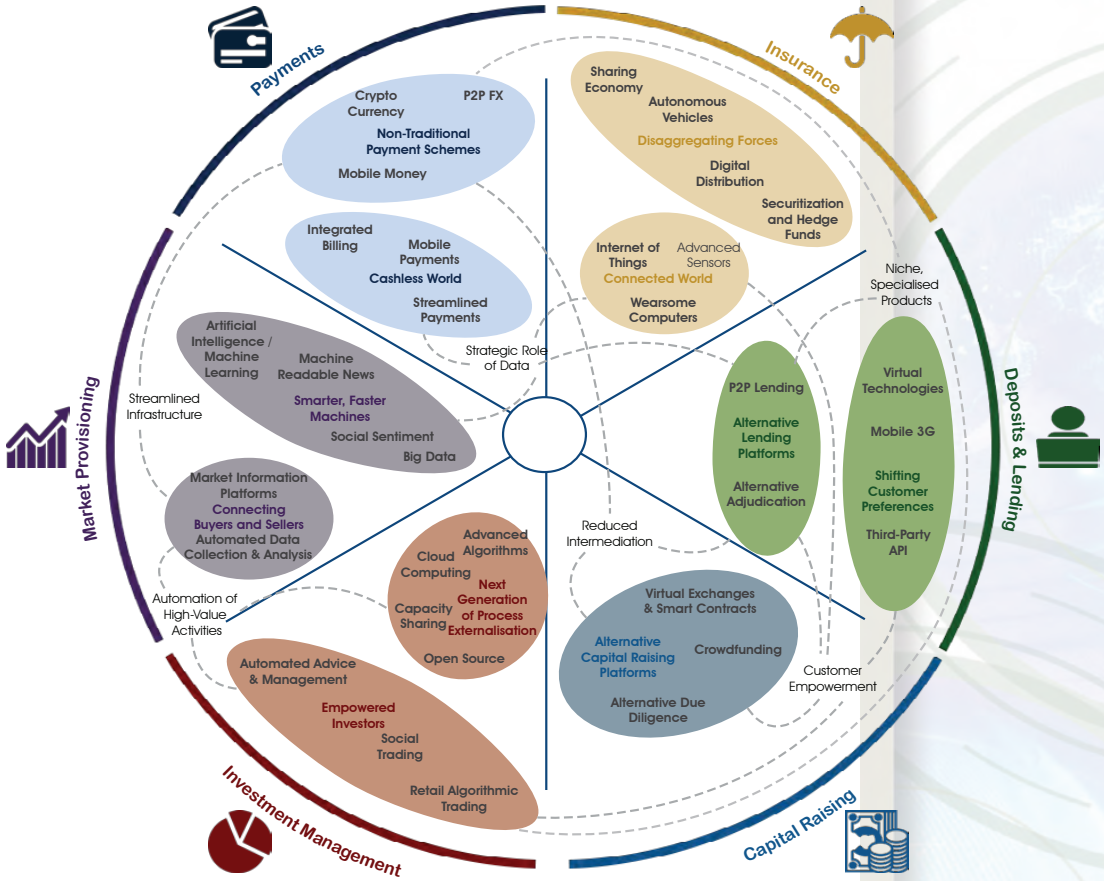
35 World Economic Forum ,2018 ,Shaping the Sustainability of Production Systems: Fourth Industrial Revolution technologies for competitiveness and sustainable growth Online available at: http://www3.weforum.org/docs/WEF_Shaping_the_Sustainability_Production_Systems.pdf

36 National Strategy for Artificial Intelligence, Online available at https://niti.gov.in/writereaddata/files/document_publication/NationalStrategy-for-AI-Discussion-Paper.pdf

37 World economic Forum,2019, A New Era of Manufacturing in the Fourth Industrial Revolution: http://www3.weforum.org/docs/WEF_The_New_Era_of_Manufacturing_in_the_Fourth_Industrial_Revolution.pdf

Figure 12: Financial Services Impact Areas

Source: World Economic Forum [UJ _3]



The South African Financial Services sector continues to contribute substantially to the country's GDP. However, there are continuous disruptions in this sector, fuelled by 4IR technologies and business models, which have resulted in a large number of job losses.

This sector is also vital in enabling, through funding, the development or growth of critical sectors aligned to 4IR opportunities. 4IR and its different business models require, at times, more innovative financing and capital solutions that do not rely solely on the traditional risk management and measurement frameworks that have and continue to exist in previous industrial revolutions.

The figure below (Figure 13) compares the GDP of the different BRICS nations, and Nigeria (another major economy in Sub-Saharan Africa), over the last few decades. South Africa shows muted GDP growth against these peers and is challenged to leverage the 4IR to drive growth in its key sectors (Figure 14).

Figure 13: GPD (current US$)

Source: World Bank and OECO

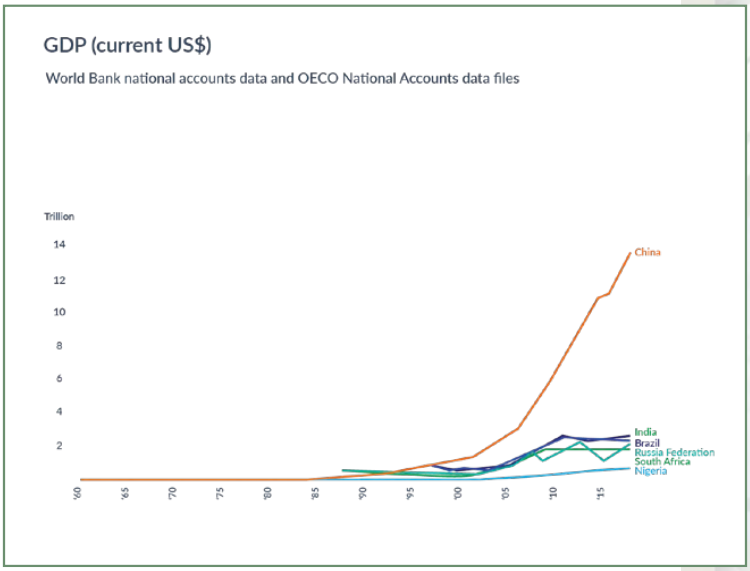
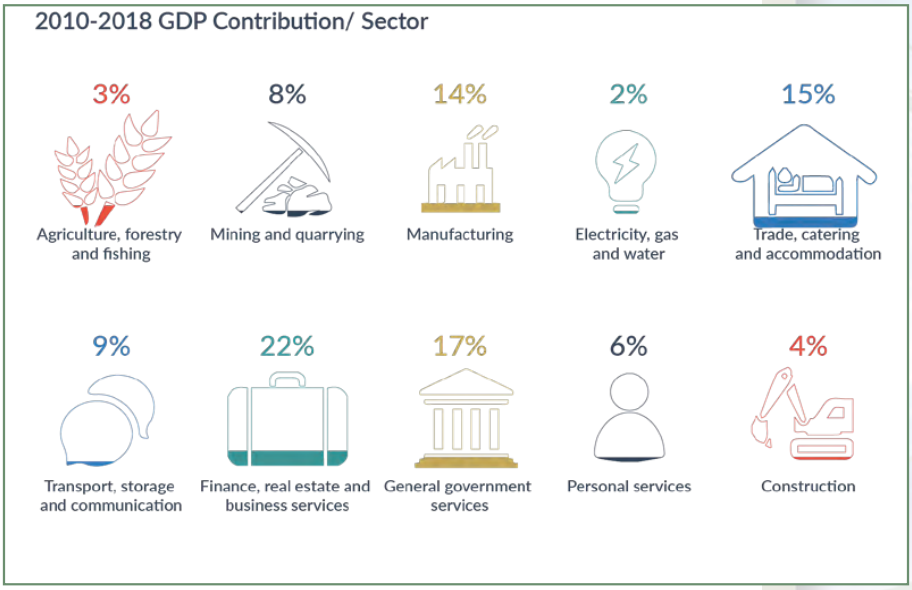


Figure 14: An overview of the GDP per the various sectors in South Africa

Source: Statistics South Africa



In South Africa, the largest sector by GDP contribution is Finance, Real Estate, and Business Services. Government services; Trade & Accommodation and Manufacturing sectors are the next largest sectors. The smallest sector by GDP contribution is Electricity, Gas, and Water. Agriculture, forestry, and fishing; Construction and Personal Services also contribute under 5% each to the total GDP.

There is a necessity to look at all these contributing sectors with a 4IR lens, to understand the likely growth and relevance of these sectors in the global 4IR context. In addition, South Africa would need to assess strengths and opportunities it possesses to position itself for growth in key industries and growth in its local and international contribution to 4IR focus sectors. More of this is unpacked in section 9 of this report.

4.2.7 Commercialisation

Commercialisation is the process of bringing new products or services to market, moving technology or a product/service from concept to the marketplace. It entails production, distribution, marketing, sales, customer support, and other vital functions critical to achieving the commercial success of the new product or service.

Funding is a crucial driver of commercialisation and is usually obtained through the following strategies: licensing with development funds, leveraging strategic alliances for funding, obtaining equity investors in the parent company, obtaining equity investment in a spin-off or an Initial Public Offering (IPO).

Commercialisation if implemented incorrectly, will lead to a few in the industry holding the rights over others. This will lead to increased disparity in the socio-economic situation of the country. This will ultimately lead to many in the country not benefiting from innovations created.

All of the points discussed have risks associated with the use of the various technologies. A few of the risks are elaborated in the points to follow.

4.2.8 Risks

A Few risks that need to be addressed by the policy of the government are stated below.[38]

a) The expansion of AI depends on consumers been adequately educated on how to use various technologies.

b) The cost of production of various components and final AI technologies need to decrease. This will be achieved through mass production.

c) If data used to inform decision-making is inaccurate, this could cause harm to various individuals or institutions.

d) Tremendous computing power is required to run systems such as blockchain, which could be costly.

e) Data ownership could provide unfair advantages to specific individuals or companies.

f) If the IP only remains with a few, this will create new monopolies in the economy and could have an impact on benefiting the broader population.

38 World Economic Forum ,2018 ,Shaping the Sustainability of Production Systems: Fourth Industrial Revolution technologies for competitiveness and sustainable growth Online available at: http://www3.weforum.org/docs/WEF_Shaping_the_Sustainability_Production_Systems.pdf

4.3 SOUTH AFRICAN KEY PERFORMANCE INDICATORS OVERVIEW

The figure below provides insight into the current state of South Africa's key performance areas ranked out of 140 countries globally (Figure 15).

According to the given indicators, the worst-performing indicators of the South African economy are Health, Innovation and ICT adoption. Also, below the 60 levels are Skills, Institutions and Product Market. Based on this evaluation, SA's priorities in respect to the 4IR and attendant economic competitiveness ought to be human capital development as well as the deployment of technology infrastructure and ICT. These two aspects are co-related, requiring simultaneous investment to produce the desired outcome. Given the urgency of SA's development challenges, radical shifts are necessary to achieve tangible changes that are in step with the global community.

4.4 CONCLUSION – SOUTH AFRICA

A key strategy for South Africa is to ensure the preparation of the younger generation for jobs of the future that may not exist at this moment in time. The starting point of this preparation is a review of the curriculum of our schools. This curricular would need to be aligned to the Fourth Industrial Revolution with topics such as Machine Learning.

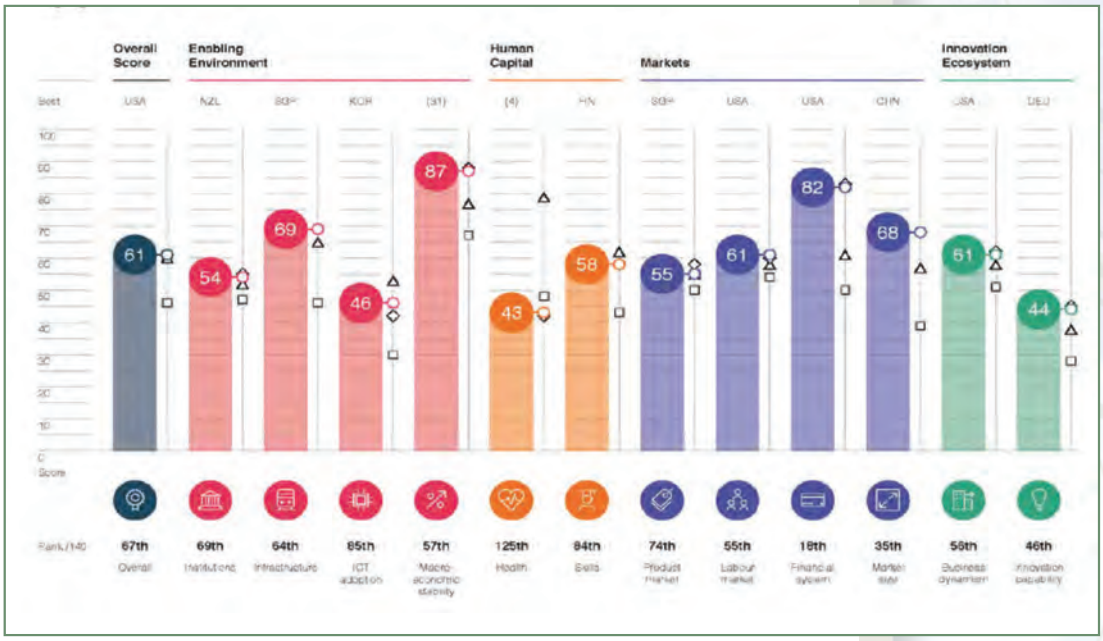


Figure 15: Key Performance Areas for South Africa[39]

Robotics, and Artificial Intelligence, etc. Through the process of upskilling youth about the Fourth Industrial Revolution it will ensure South Africa will have the necessary skills for the future and thus not required to obtain these skills from outside countries. Furthermore, the youth could use these skills gained to follow an entrepreneurial path that would allow them to be job providers and not job seekers. This will add an advantage to the South African economy. Within higher education, new technologies need to be brought into the curriculum. Furthermore, multi-disciplinary qualifications should be developed that incorporate various aspects of the fourth industrial revolution by higher education institutions.

Information and Communication Technology (ICT) is an important aspect to enable the Fourth Industrial

39 http://www3.weforum.org/docs/WEF_TheGlobalCompetitivenessReport2019.pdf

Revolution. Thus, affordable broadband available to all citizens that live in the Republic of South Africa. Additionally, for South Africa to become an active participant in the Fourth Industrial Revolution requires home-grown inventions and knowledge production. This will require investments in research and innovations. Furthermore, these home-grown inventions will aid the economy as well as promote inclusive growth. Another aspect to consider is to empower the current workforce for the Fourth Industrial Revolution. This can be achieved by creating continuous education programs for various sectors of the economy. Lastly, Small Micro and Medium Enterprises (SMME's) must be enabled in the Fourth Industrial Revolution.

CHAPTER FIVE: Assessment Of South Africa: Current Status Quo

5.1 SOUTH AFRICAN POLICY FRAMEWORKS 1994- DATE

Throughout human history, the search for human wellbeing has been an enduring and foundational concern. In response to this fundamental human conundrum, in 2013, South Africans articulated a development vision, Vision 2030, encapsulated in the National Development Plan (NDP) as the latest iteration in the continuing quest to ensure security and welfare for all. Explicitly aimed at removing the triple scourge of poverty, inequality, and unemployment by 2030, Vision 2030 recognised that the country's socio-economic transformation is central to entrenching a vibrant democracy in which all South Africans can meaningfully and actively participate.

Since 1994, the state has actively engaged in the design of policies aimed at addressing South Africa's historical legacy of an excluded and under-served majority. It has also sought to have an over-arching policy framework that gives direction to all facets of the state and attendant programmes.

Given a constantly evolving local and global context, these policies have been adapted over time to emphasise themes requiring critical attention. Below (Figures 16a-e) is an outline of the emphasis of each of the key over-arching policy frameworks that have been implemented since 1994.

Figure 16: Key Policy Frameworks for South Africa

5.2 SOUTH AFRICA TODAY: SOCIO-ECONOMIC AND HUMAN DEVELOPMENT OVERVIEW

The work of contemplating the socio-economic impact of the Fourth Industrial Revolution (4IR) is principally about contemplating South Africa's development trajectory historically and, most importantly, prospectively. Having outlined the various post-apartheid macro-strategic policy statements through which the government has pursued the vision of a better life for all South Africans, we now paint a picture of South Africa's current socio-economic situation, which is, in part, the outcome of the government's post-apartheid strategies and investments in enhancing the capabilities of its citizenry. Indeed, it is worth stating that the concerns at the heart of this project are not explicitly, the technological artefacts; the digital systems or even the transformation of bio-physical realities. Instead, this exercise seeks to respond to fundamental concerns, which predate and will outlive the details of the 4IR: namely, South Africa's economic competitiveness and the wellbeing of its people. To this end, the following section outlines the country's social and human development profile.

The approach taken in painting a portrait of South Africa today is one that recognises that the economy is embedded in, is shaped by, and in turn shapes the social world that characterises South Africa, the experiences of its citizens, and their material and well- or ill being. To be precise, society and the economy are connected at the level of human experience. It is, in essence, this human experience and reality that is outlined in what follows. A broad overview of social and human development indicators in South Africa between 2002 and 2018, this segment of the report is based on data from StatsSA; the Department of Planning, Monitoring, and Evaluation (DPME), which is located in the Presidency; and from the United Nations' (UN) Human Development Index (UN-HDI) (2018)[40].

The United Nations (UN) Human Development Index (HDI) reports, in conjunction with the UN's 17 Sustainable Development Goals (SDGs), represent the global framework for ranking UN member states' performance in terms of human development. In terms of their relationship, the SDGs can be understood as the priority areas of intervention to drive economic development in tandem with improved human development. Thus, while the HDI, a composite statistical index, is an instrument for measuring performance on human development, the SDG's identify priority levers towards economic security and human welfare. For more details on the technical specification and computation of the Index, refer to the Technical Notes on Human Development Indices and Indicators: 2018 Statistical Update[41].

The HDI is the result of the UN's computation of three development factors, namely:

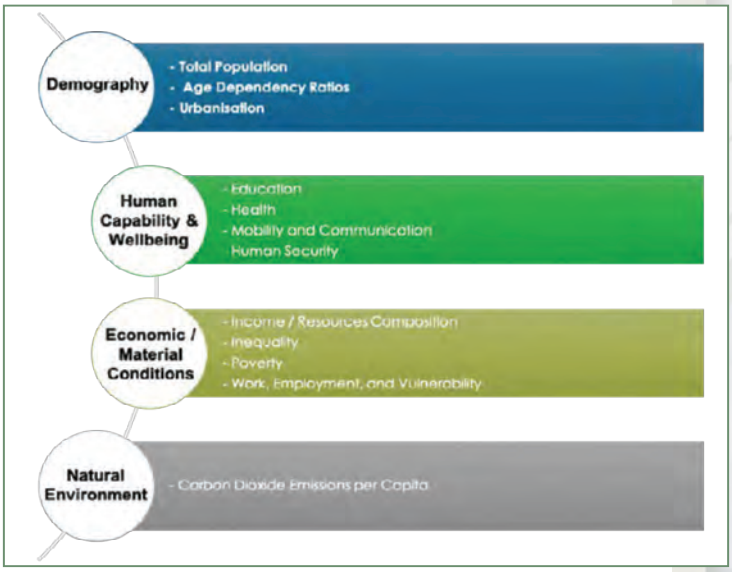
- Economic,
- Social and
- Demographic.

It provides a comparative snapshot of individual country performance in human wellbeing while also indicating the level of global convergence or divergence in human development outcomes.

As a statistic composite index (Stanton, 2007), the HDI can be disaggregated into thirteen (13) broad indicators that can be classified in terms of four overarching categories (Figure 17): Demographic profile; Human Capability and Wellbeing; Economic / Material Conditions; and the Natural Environment. In turn, each of these broad indicators can be further disaggregated into a further ten or more sub-indicators. For instance, under the overarching category of Human Capability and Wellbeing is nested indicators pertaining to a country's educational performance, the population's health status, and human security.

40 http://hdr.undp.org/sites/default/files/2018_human_development_statistical_update.pdf
41 http://hdr.undp.org/en/content/human-development-index-hdi

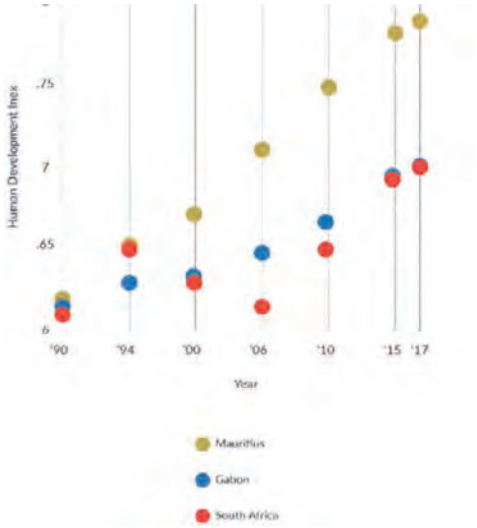
Figure 17: HDI Categories[42]



The highest HDI possible is 1.0, or 100% (Norway: 0.955, Australia: 0.938, US: 0.937, Netherlands: 0.921, Germany: 0.92, South Africa: 0.699) South Africa's 2017 HDI of 0.699 is above the average of 0.645 for countries in the medium human development group (UN-HDI, 2018).

When compared to countries whose HDI ranking was at a similar level in 1990 (i.e., Gabon and Mauritius), South Africa's performance human developmentally is markedly lower (when compared to Mauritius) and at around the same level as Gabon despite South Africa having a much higher GDP of $742,6billion (2017) compared to Gabon's $34,45billion in the same year (calculated in terms of purchasing power parity (PPP)) (United Nations Development Programme , 2018) (Figure 18).[43]

Figure 18: HDI Comparisons[44]



42 http://www.hdr.undp.org/en/2019-report
43 http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/ZAF.pdf
44 http://www.hdr.undp.org/en/2019-report

Within Sub-Saharan Africa, countries which are close to South Africa's 2017 HDI rank of 113, and which have a comparable population size are Congo and Namibia, which have HDIs ranked 137 (with an HDI 0.606) and 129 (with an HDI of 0.647) respectively. Nevertheless, these countries have a significantly lower GNP per capita and far less social protection measures (Ibid.).

When benchmarked against Brazil, Russia, India, China (BRICS) between 1980 and 2011, despite an HDI ranking that, in 1980, was comparable to that of Brazil and higher than that of China, by 2005 not only had South Africa's HDI trajectory diverged from that of Brazil, but it was overtaken by China.

When South Africa's 0.699 HDI value is discounted for inequality (IHDI), "the HDI falls to 0.467, a loss of 33.2 percent due to inequality in the distribution of the HDI dimension indices."[45]

5.2.1 Demography

The demographic profile of a country tells us a number of critical things: the size of the population as well as the sex and age profile of this population. It allows us to consider the geographic spread of the population and, in particular, the population density and its rural / urban breakdown. These population features are essential in that, at a glance, we can begin to glean required government services (particularly in dense, urban settings with growing populations from domestic and international migration). These demographic features can also hint at the burden of the state in terms of expenditure on such social goods as education and healthcare (particularly where there are significant segments of the population that are children or sections of the aged that may be growing in numbers). The sex-distribution of the population is an essential basis for evaluating the extent – or lack – of gender parity in educational access and completion, as well as in political participation and representation, as well as access to critical healthcare services such as ante- and post-natal care, which affects the immediate wellbeing of women and children and, over time, lays the foundation on which other lifelong human capabilities can be built.

Using data from the 2018 UN-HDI report, the demographic highlights for South Africa are as follows:

- South Africa is a relatively youthful country. Of the approximately 57million South Africans, the median age is 26 years of age. Historically a relatively low median population age would be characterised as a demographic dividend with potential long-term benefits for the country's productivity and economic growth if linked to improvements in the youth population's educational attainment (Lutz, et al., 2019).
- That said, in terms of the country's age profile, there has been a steady and continuous decline in the proportion of South Africa's youth population. Currently, just under a fifth of all South Africans are aged between 15 and 24 years (18,7%)[46]. This can be attributed to the declining birth rate, which now sits at 2,4 births per woman in 2017 down from just under 5 births per woman in 1980.
- In terms of the country's sex profile, women constitute just over half (51%) the total population
- South Africa's total population currently stands at 58,8million (Statistics South Africa, 2019).
- Current projections estimate a peak population size of 80million by 2080, at which point growth levels will flatten and begin to taper down (United Nations World Population Prospects, 2019).
- In terms of population density, which measures the number of people per square kilometre, South Africa is at the lower end with a population density of under 50 people per square km[47].
- Nearly two-thirds of all South Africans (65,8%) live in urban areas; projected to 80% by 2050 (Gardner, 2018). In 2018, urbanisation on the African continent stood at approximately 40% with Egypt (43%) and

45 http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/ZAF.pdf
46 https://youthexplorer.org.za/profiles/country-ZA-south-africa/
47 http://worldpopulationreview.com/countries/south-africa-population/

Tunisia (69%) being the only other countries with as comparable a level of urbanisation as South Africa (United Nations Population Division, 2018).

- While rising urbanisation places a significant strain on urban health, housing, education, and other resources, it does afford the opportunity for mixed-use urban planning that optimises higher population densities towards more significant redistribution and cross-subsidisation.
- Of course, with population density come the risks in the spread of communicable diseases, mainly where access to decent housing, health care, potable water, and sanitation is inadequate.
- These demographic shifts in birth rates are the consequence, among other things, of the government's family planning programmes, including the roll-out of free contraceptives, in public primary health facilities. They are probably also the consequence of increased female enrolment rates in education as well as improved retention and completion rates. As Laurie DeRose and Øystein (2007) have demonstrated, a woman's educational attainment is strongly correlated with both delayed and lower childbearing levels.

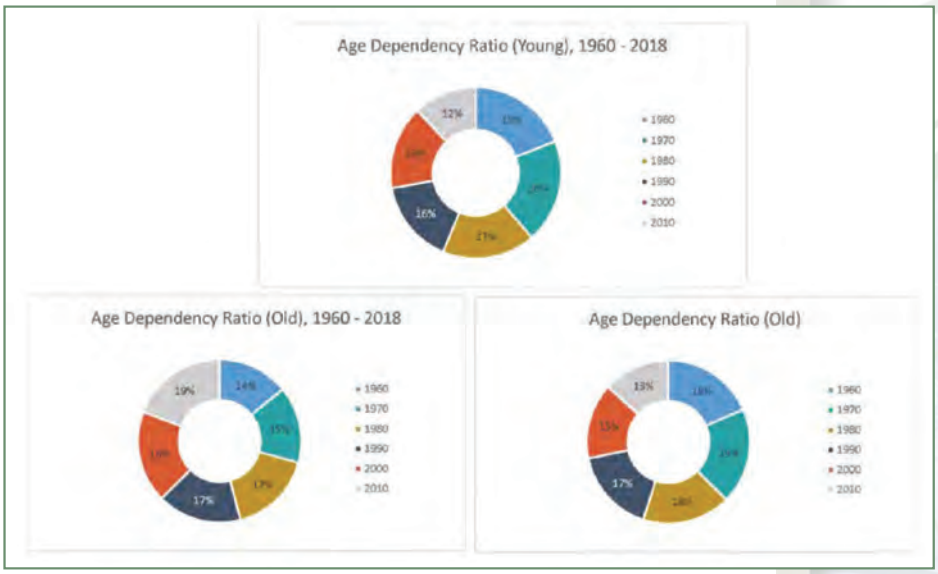
5.2.2 Median Population Age, Young Age Dependency Ratio, Old-Age Dependency Ratio and Population Age Cohorts

Understanding the age structure of a society is an essential aspect in, among other things, understanding the constraints to as well as the need and/or opportunities for employment-creation in a given society. In addition, it can signal epidemiological and other health risk-factors that are associated with the generational profile of a society (i.e. geriatric diseases in the context of an ageing society or immunological risks where there are large populations of children under the age of 5 years). For example, the median age is a key factor in understanding the rate at which the economy should be expected to generate jobs and for which age cohorts over the foreseeable future. It also has implications for the country's age dependency ratios (i.e. those below 15 years of age and those above 64 years of age who are ordinarily not – nor expected to be – employed) (Figure 19). How – and in what combinations – the state and private households is implicated in the care for the young and the aged is a pressing social policy issue mainly when considered in relation to the size, employment status, and earnings of the working age population. All of these have a bearing on a country's social policy mix and its financing, which depends on the capacity to extract various taxes, including individual income taxes.

- The current median population age stands at 26 years old, meaning that half the country's population is under the age of 26 (UN-HDI, 2018). By contrast, the median population age for Japan, which has the world's highest number of over 65s, sits at 46 years, significantly higher than that of South Africa.
- Although still demographically favourable, given rising life expectancy levels coupled with a falling birth rate, this median age will likely increase over time.
- In light of the extended life expectancy and declining birth rate, what this means is that the ageing population will increasingly form a more significant segment of the entire population – with implications for the old age pension, the official retirement age, and healthcare readiness for geriatric illnesses.
- The declining birth rate means that, over time, the government could maintain a fairly constant child grant as a proportion of the government's social assistance expenditure while increasing the value of financial assistance per child.

Another social and development policy area that will be affected should these demographic trends continue is education. Of course, improving the quality of education for children and youth remains an urgent priority. As the country's population ages, however, enabling lifelong-learning opportunities will be key and the modes of curriculum design and delivery for the learning needs of older populations should increasingly occupy the priorities of education policy planners and educational institutions as well.

Figure 19: South Africa Age Dependency Ratio[48]



5.3.3 Gender Parity: Sex-Ratio At Birth, Sex-Ratio by Age Cohort, and Women's Political Inclusion

Questions of gender equality and, specifically, women's participation in the social, economic, cultural, and political life of their society have risen in global prominence over the past few decades. Heralded by the Convention on the Elimination of all Forms of Discrimination Against Women (CEDAW) in 1979, the UN's introduction of the Gender Inequality Index (GII) has lent further weight to calls for the promotion of women's rights and interests, including the eradication of gender-based violence (GBV). he GII is defined as "a composite measure reflecting inequality in achievement between women and men in three dimensions: reproductive health, empowerment, and the labour market"[49] (Gaye, Klugman, Kovacevic, Twigg, & Zambrani, 2010). In essence, it is a gendered recalibration of the overall HDI, indicating the extent to which women's wellbeing, political participation, and representation are comparable to that of men. In many parts of the world, particularly Asian countries, the differential social value afforded to men and women is often expressed during pregnancy with household decisions to terminate female foetuses (Arnold & Zhaoxiang, 1992; Nag, 1991). Hence the inclusion of sex-ration at birth, which can point to some sex-preference dynamics in utero. The sex ratio at birth is generally never equal, with a clear male bias at birth. In virtually all countries, boys are more likely to die in childhood than girls since they tend to be more susceptible to birth complications and infectious diseases. In light of this greater risk, biologically, more boys than girls tend to be born. However, in countries with a male-child preference, the sex-ratio is much more unequal with far higher numbers of boys to girls born; a clear indicator of pregnancy terminations based on boy-child preference and what some have argued is a form of femicide (Guilmoto, 2007; Jargin, 2018).

- South Africa has a sex-ratio at the birth of 103 male births per 100 female births compared to 105 boys per 100 girls globally. South Africa is within the accepted "natural" sex ratio range of 103-107 boys (UN-HDI, 2018).

48 https://tradingeconomics.com/south-africa/age-dependency-ratio-percent-of-working-age-population-wb-data.html
49 https://www.thehindubusinessline.com/economy/macro-economy/ensure-womens-place-in-economy-change-patriarchal-mindset/article6941239.ece

- Despite the male-biased sex-ratio at birth, as South Africans age, there are more females than there are males. South African women live longer than their male counterparts with an average "life expectancy of 67,3 years compared to 61,1 years for males" (StatSA, 2019).
- Although South Africa is ranked at 113 (out of 189 countries) in terms of its HDI (2018), it ranks significantly better in the Gender Inequality Index (GII), where it places at position 90 (out of 160).
- The share of women's political representation in legislatures has increased from 28% to 46% between 1994 and 2019 and 25% to 46% over the same period at the national and provincial levels (South African Department of Planning, 2019)[1].
- This upward trend in the number of women elected to legislative bodies is reversed at local government (municipal) level, declining from 37% and 40% in terms of Ward and overall representation respectively in 2006 to 32% for both Ward and overall (i.e. Ward and Proportional Representation seats) in 2016 (DPME, 2019).[50]
- It may be that this decline in the gender representativity of municipal councils is linked to the absorption of political parties' women candidates into the provincial and national electoral lists. That said, a failure to maintain women's representation at the local state level will likely curtail women's voices in key decision-making around infrastructural and other service delivery priorities that are determined through the municipal integrated development process.
- To be sure, women's formal political representation does not necessarily translate into gender-sensitive budgeting and decision-making. However, the chances of moving towards gender-responsive planning and budgeting, particularly at the coalface of service delivery are lower, when women are absent from these decision-making structures.

5.3.4 Gender-Based Violence (GBV)

- Although the murder rate for women has been declining from approximately 22 murders per 100,000 to just under 10 between 2002 and 2015, GBV in South Africa remains significantly higher than the global average (less than 5 women murdered per 100,000) (DPME, 2019).
- Furthermore, female-headed households experience a higher homicide rate than male-headed households at a time when homicide rates for male-headed households are declining.
- In terms of sexual violence, women continue to experience higher levels of rape and sexual harassment than men; a situation linked to the pervasiveness of violent forms of masculinity.
- The GBV statistics are important in understanding the levels of (in)security that women in a given society experience. But they are also important to the extent that they show a strong correlation between GBV incidence (particularly in the form of intimate partner domestic violence) and children's exposure to violence (including violence perpetrated against them as well).
- This has implications for childhood trauma as well as the reproduction and intergenerational transmission of all forms of violence; negatively impacting the human security and wellbeing of all members of society but especially that of women and children.

50 All references to data from the DPME (2019) is drawn and collated from the August 2019 Development Indicators available from the DMPE's online Resource Centre: https://www.dpme.gov.za/publications/Pages/Reports-and-Other-Information-Products.aspx

5.3.5 Human Capability and Wellbeing

Higher Education and Training Systems:

The inherently racially determined educational inequality characteristic of the pre-democratic education system necessitated far-reaching overhaul and rapid transformation. The transformation was facilitated through new policies that were adopted by the Democratic Government, including the merging into a single educational system and government department, the historically race-based education systems (Fiske & Ladd, 2004).

The National Commission on Higher Education, which was convened in 1996, made recommendations in transforming the higher education system. Some of these were (Monnapula-Mapesela, 2018):

- Access to higher education and training needed to be expanded;
- Higher education required to be responsive to the country's needs;
- Governmental structures of higher education and institutions needed better cooperation and partnerships at all of the different levels;
- The higher education system needed to be unified thereby forming and coordinating colleges, universities, and technikons;
- The framework for qualifications was required to provide improved accessibility, articulation, and flexibility;
- Strategic investments and funding were required to serve institutional and societal needs;
- Accreditation and auditing of institutional programmes were required to promote quality;
- Development of distance education and resource-based learning.

The South African higher education and training system is still undergoing transformation. Recently, the Department of Science and Technology was merged with the Department of Higher Education and Training (DHET). The latter, established in 2009 with the separation of the Department of Education into the Department of Basic Education (DBE) and that of Higher Education and Training, was the consequence of the 2008 African National Congress (ANC) elective conference in Polokwane (Wedekind, 2016). The formation of the DHET saw the introduction of what became known as the Post-School Education and Training (PSET) system consisting of:

- the Further Education and Training (FET) Colleges (now Technical and Vocational and Training (TVET) Colleges,
- the Adult Education and Training (AET) Centres (now Community Education and Training Centres (CETCs),
- the Universities,
- Sector Education and Training Authorities (SETAs),
- the National Skills Authority (NSA), and
- the National Skills Fund (NSF)

These more recent developments should be read in the context of and as developments from the Education White Paper (DoEd, 1997), which remains relevant today particularly even as the country seeks to create an education and training system that is responsive to the Fourth Industrial Revolution. One of the early, post-apartheid recommendations from the White Paper was devising strategies to encourage innovation and adaption in higher education; a priority that is arguably more urgent today than ever before. In other words, many of the transformative levers that are needed for the Fourth Industrial Revolution resonate and

are consistent with past and current policy priorities and pronouncements. Therefore, careful consideration of lessons from and shortcomings in the implementation of prior policies and strategies is necessary for advancing the structural and foundational transformations that will support South Africa's inclusive and human-centred transition into the 4IR.

Below, vital statistics on the country's current performance on education and training; in essence, on a critical component in advancing human capabilities for full social, political, cultural, and economic participation. This overview is based on the DPME Development Indicators data (2019).

- South Africa's adult illiteracy rate has been in a steady decline since 2002. Currently, the country enjoys an adult literacy rate of nearly 95%.
- Although generally trending upwards, the path to matriculation has, however, been inconsistent. The number of students sitting for their final matric exams dipped below 500,000 between 1999 and 2005, peaking in 2015 with nearly 650,000 matriculants sitting for the exam. This figure seems to be trending downwards at a rapid rate, although this may be due to the expansion of the Post-School Education and Training (PSET) system, which consists of Technical and Vocational Education and Training (TVET) and Community Education and Training (CETC) Colleges.
- Less than two-thirds of those who sit for their Matric exams pass, and of those who do pass, approximately 10% achieve a bachelor's pass that enables them to access post-school education opportunities in the university system.
- Initially dropping to just a quarter of all students graduating in Science, Engineering, and Technology disciplines, the proportion reached a peak at just over
- 30% of all university students graduating in STEM-related fields.
- Although South Africa's learner participation rate in education has been increasing since 1990, evident disparities in enrolment and completion rates exist along gender.
- By 2016, women's participation rate stood at just over 66%, while that of males was around 56%.
- This reflects the country's gendered demographic profile where 51% of the population is female, but it also attests to the government's focus on gender parity in education.
- That said, the ten-percentage point variance in female to male educational enrolment warrants attention to understand the dynamics underlying differential.
- The government's school feeding programmes, no-fee schools' policy for poor neighbourhoods, and, at the level of post-school education and training, the extension of free higher education has been key for interventions for supporting and enabling the increasing enrolment levels.

The Gross Enrolment Rate (GER) is the total learner per education level divided by the population of corresponding official age in the education level.

- GPI ratio measures the progress towards gender parity in education participation/learning opportunities available for females to those available to males.
- A unit of GPI equal to 1 shows the parity between females and males. A value less than 1 indicates a disparity in favour of men, while a GPI greater than 1 indicates disparity in favour of females.
- Although the GPI is skewed in favour of boys at the commencement of children's schooling, by the time children reach secondary school, the ration is biased in favour of females. This suggests a significant drop-out rate among boys.

- This trend towards greater female participation in and completion of various levels of education becomes intense at high education levels where the GPI significantly in favour of women.
- This scenario raises flags in terms of male-female gender relations, young men's access to and participation in the labour market (particularly at higher occupational levels (i.e., white-collar jobs)).

5.3.6 Health

- Since the significant drop in Life Expectancy in 2005, the country has been making steady progress to reverse this trend. By 2016, South Africans were living, on average, to 63 years compared to 53 years in 2005 (DPME, 2019).
- This massive increase over the past ten years is the result of the government's ARV roll-out programme, to date the largest HIV/AIDS government medical response to the epidemic. By 2015, 3,1million South Africans were receiving HIV treatment from the state to the tune of R23billion annually.
- Relatedly, the government's investment in antenatal care for mothers and the administration of pregnant mothers to prevent mother-to-child HIV transmission has had a positive impact on the reduction of infant and under-5 child mortality rates.
- This decline in child mortality, together with declining levels of childhood stunting and wasting, can be attributed to the high levels of child immunisation and the introduction of child grants (including grants for HIV/AIDS orphans), which have bolstered poor households' food security.
- Also, the government's push for a National Health Insurance (NHI), which is intended to provide universal health coverage especially for those who cannot afford timeously and quality health treatment and care.
- Implementing the NHI will, among other things, entail redirecting the current state subsidies enjoyed by medical aid schemes into serving the general public.

5.3.7 Mobility and Communication

Another essential service and a precondition for access to and participation in the Fourth Industrial Revolution is access to the internet (Figures 20 to 22). The goals of achieving inclusive growth and competitiveness in the Fourth Industrial Revolution necessitate the provision of expanded, reliable, and affordable internet access South African citizens, businesses and organisations. Nowadays, access to the internet is to be viewed as an essential service because the current and future endeavours of government, businesses, and organisations to provide digital services are dependent on the end-users having reliable and affordable internet access. This is especially relevant towards ensuring participation of those living outside metropolitan areas where new or upgraded infrastructure will need to be developed. In the past two decades, South Africa has developed world-class infrastructure towards this achieving this aim. These developments are ongoing and there are plans to roll-out further programmes to this end. The NDP endeavours to provide South Africa with an information infrastructure that underpins and enables an equitable and inclusive knowledge economy, by 2030. The South African Government has identified that high speed, availability and quality internet bandwidth are especially crucial to developing the country's global competitiveness. The national broadband policy South Africa Connect was thus conceived. This policy aims to realise the NDP's vision of having universally accessible broadband connectivity that meets the needs of the country with respect to cost, speed, and quality. South Africa Connect aims to achieve 100% broadband access by 2030 with speeds of 10 Mbps, 1 Gbps, 1Gbps, and 100 Mbps for general users, schools, healthcare facilities, and government facilities, respectively (DoC, 2013). The second phase of South Africa Connect is currently in progress.

There is still much progress to be made with regard to broadband access. This infrastructural challenge is indicated through the comparison of the number of fixed broadband subscriptions per 100 people in South Africa to the global average (World Bank, 2019). South Africa is well below the world average in this regard. Despite the challenges of broadband infrastructure, the number of internet users in South Africa has still significantly increased and progress with regards to South Africa's digital ecosystem has not been completely hindered. This positive trend is owing to the fact that a major portion of South Africans are using their mobile devices to access the internet. These findings are reflected in report of the study conducted by World Wide Worx in 2017 (World Wide Worx, 2017). The study also found that internet penetration would reach 40% in 2017. The World Bank data for South Africa's mobile subscriptions per 100 people also corroborates this particular finding, and a positive trend, i.e. growth in South African mobile subscriptions is markedly higher than the global average (World Bank, 2019).

The security and reliability of infrastructure and resources are also crucial to South Africa's achieving competitiveness in the Fourth Industrial revolution. For instance, a positive trend in this regard is demonstrated by World Bank data, which shows the progress in the country's ability to provide secure web servers, which is essential for secure online transactions, etc. over the last two years in particular.

Figure 20: Number of fixed broadband subscriptions per 100 people

Source: World Bank [UJ 7]

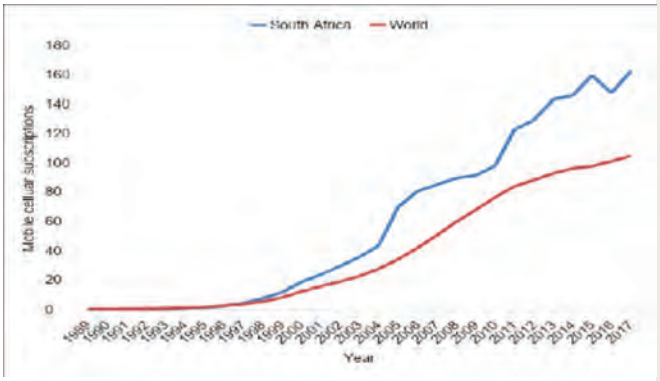


Figure 21: Number of mobile cellular subscriptions per 100 people

Source: World Bank [UJ_8]

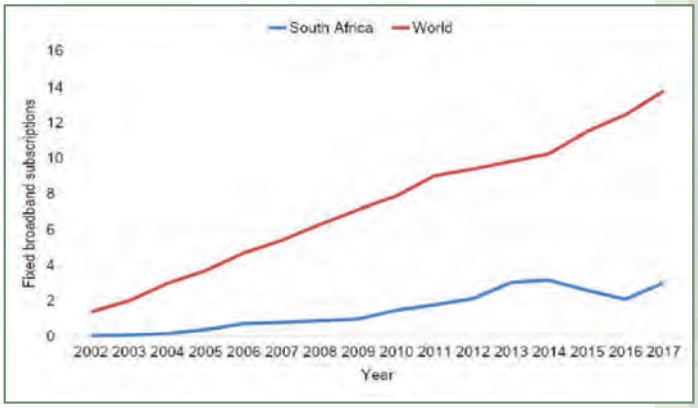
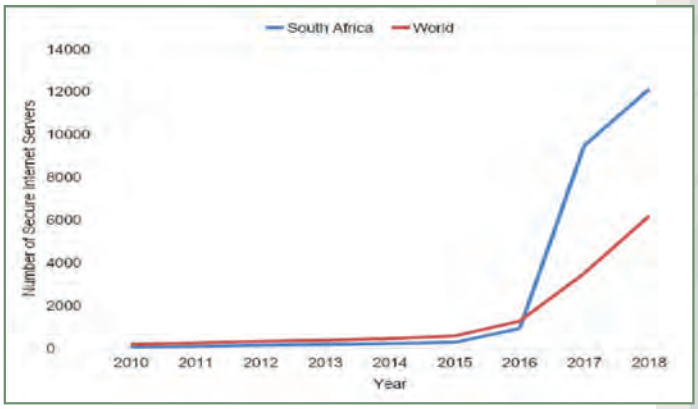


Figure 22: Number of secure internet servers per 1 million people

Source: World Bank [UJ 9]



5.3.8 Economic/Material Conditions

Having noted the co-constitution between the economic and social, we now turn to the material conditions under which South Africans live. The NDP reflects an understanding of the issues that confront the SA economy, particularly as they pertain to youth employment and water, energy, and ICT infrastructure. However, it is 11 years from its achievement deadline, and the country is grossly under- performing on all the metrics.

The key issues to contend with in respect of SA's economy are the particular tactics that will be employed to ensure that the 4IR simultaneously addresses and these are low growth and limited opportunities; capital inequality and low investment; as well as economic distance and limited social cohesion.

The starting point is an understanding of the performance dynamics of the South African economy. South Africa's GDP in 2018 was registered as USD 366 billion, which is considerably smaller than the rest of the BRICS nations, which all have economies that exceed USD I trillion. Relative to Nigeria, a similar-sized Sub-Saharan economy, South Africa has shown stronger growth over time but is only marginally larger by GDP.

The largest sector by GDP contribution is Finance, Real Estate, and Business Services. Government services; Trade & Accommodation and Manufacturing sectors are the next largest sectors. The smallest sector by GDP contribution is Electricity, Gas and Water. Regression in the Water and Energy sector is the single-biggest threat to South Africa- both in respect of human development and economic growth. Agriculture, forestry and fishing; Construction and Personal Services also contribute under 5% each to the total GDP pie. South Africa's historical characterisation as a 'minerals and energy complex' is questionable in the context of GDP data. Mining contributes 8% and Energy, 2% to GDP. Mining has grown at a rate of 0.1% and Energy has regressed by 0,4% in the period. The Finance, Real Estate & Business Sector has produced the most growth in the period. It is also the most significant contributor to national GDP at 22%. Whilst Transport & Communications is part of the bottom 5 sectors, contributing 9% to total GDP, it is the second-largest growth sector in SA at 2,2% growth in the period. South Africa's government sector continued to contribute a sizable share of GDP and increased its share substantially over the period.

The largest employment sector in South Africa is private households, followed by Community and Social Services. Neither of these sectors are explicitly captured in national GDP calculations. This indicates a large area of potential GDP under-counting. The community service sector grew the most, by labour, over the period. Agriculture & Construction have increased their share of the labour force (6% & 4%, respectively) at a rate that exceeds their GDP contribution (1,9% and 1,5%, respectively). The Finance sector, the most significant contributor to GDP, grew its labour force by 4%.

Elementary or unskilled workers comprise the largest share of the working population. Elementary workers have also grown the most as an occupational class. This growth aligns with the growth observed in the Construction and Agriculture sectors. Service workers constitute the next largest category, which aligns with the size of the Finance, Trade, Communications, and Business sectors. Professionals, along with skilled agricultural workers, form the minority of the South African work-force. Technicians and clerks/ administrators are also a small component of the total working population. **South Africa's labour force is the key cause for concern**. The majority of existing work is performed in the domestic and unskilled sectors whereas the requirements of the next industrial revolution will demand more professionals and technicians with a bias towards STEM-trained individuals. Human development, therefore, appears to be the key constraint to economic growth and development.

Poverty, Inequality, and Income

- South Africa is the world's most unequal society, with a GINI coefficient of 0.63 (Figure 23).
- 10% of the population continues to earn more than 50% of the country's total national income, with the poorest households living on less than R100,000 per annum (DPME, 2019; StatsSA, 2019; The World Bank, 2018).
- The Gini coefficient, when measured in terms of per capita expenditure, would likely be higher than the 0.65 level were it not for the government's various social protection measures such as social grants and its public works programmes, which provide short-term employment opportunities for the extremely poor.
- In terms of poverty headcounts, which measure absolute poverty levels in the country, there had been a decline across all three poverty headcount measures between 2006 and 2011.

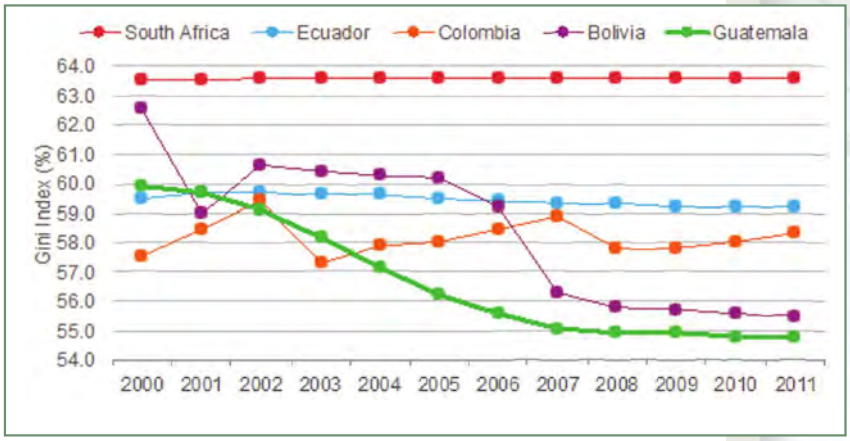


Figure 23: Top 5 Gini Index: 2000-2011

Euromonitor International from National Statistics [UJ_10]

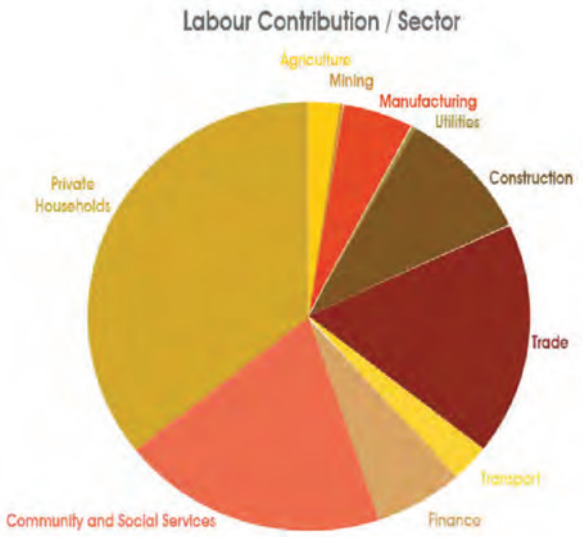
5.3.9 Work, Employment and Vulnerability

- The Structure of SA's economy has changed dramatically over the past two decades with historical anchor sectors such as mining and energy, reducing in terms of their aggregate contribution to GDP as well as their average growth rate over time (Figure 24).
- Regression in the Water and Energy sector is the single biggest threat to South Africa- both in respect of human development and economic growth.

- Whilst the National Development Plan (NDP) envisages aggregate growth of 5.5%, the highest growing sector between 2010 and 2018 has been Finance at 2,6%. This indicates that all sectors are under-performing relative to the growth targets necessary to respond to SA's development challenges.
- South Africa's labour force is the critical cause for concern. The majority of existing work is performed in the domestic and unskilled sectors. Whereas the requirements of the next industrial revolution will demand more professionals and technicians with a bias towards STEM-trained individuals. Human development, therefore, appears to be the key constraint to economic growth and development.
    - SA's priorities in respect to the 4IR and attendant economic competitiveness ought to be human capital development as well as the deployment of technology infrastructure and ICT. These two aspects are co-related, requiring simultaneous investment to produce the desired outcome.
    - Agriculture & Construction have increased their share of the labour force (6% & 4%, respectively) at a rate that exceeds their GDP contribution (1,9% and 1,5%, respectively).
    - The Finance sector, the largest contributor to GDP, grew its labour force by 4%.

Figure 24: South Africa Labour Contribution / Sector

Department of Labour, South Africa

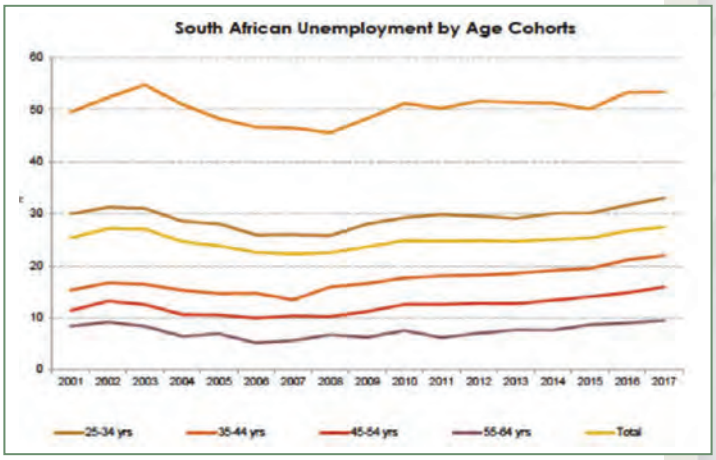


One of the main challenges facing South Africa is unemployment. Currently, the real unemployment rate stands at nearly 39%, representing more than a third of the country's working-age population (Figure 25).

The country's labour absorption rate has, between 2001 and 2017, remained largely constant between 40% and 45% while the labour-force participation rate has, in the same period, hovered between 55% and 62%.

Figure 25: South African Unemployment by Age Cohort

Department of Planning Measurement & Evaluation Development Indicators, 2019



5.3.10 Public Administration, Services, and Trends in Government Social Expenditure

In general, the pre-democratic public administration and services systems in South Africa were also disjointed and orientated towards serving the needs of a racial minority (Tshandu, 2010; Tshandu, & S. Kariuki, 2010). Consequently, public administration underwent far-reaching transformation post-1994; an agenda that was embedded in and guided by the Reconstruction and Development Programme (RDP). Similarly, as with the transformative agenda for higher education and training systems in South Africa, the Democratic Government laid out transformative agenda in the White Paper for Transformation of the Public Service Delivery (DPSA, 1997), in order to prioritise the delivery services according to the basic needs of South Africa citizens.

In the Fourth Industrial Revolution, this transformative agenda prevails, albeit on the basis of a new configuration. Globally, opportunities for the deployment of 4IR technologies to ensure effective and quality public service delivery are being pursued. Although there is no overarching strategy for transforming public service delivery in South Africa in the Fourth Industrial Revolution, Government has already undertaken to digital transition of this sector. In particular, the e-Government Strategy and Roadmap seeks to advance service and collaboration efforts through Government to Government, Government to Citizen, Government to Business, Government to Employee digitisation programmes (DTPS, 2017).

While various sectors are already benefitting from the aforementioned shift towards the digitisation of public service delivery, a collective and unified strategy – arising from policy and legislation – for nationalised digital transformation in relation to public service delivery is urgent. Without which it will be impossible to guarantee an effective, efficient, reliable, accessible, and transparent public administration to support global competitiveness and human wellbeing in the 4IR.

A key aspect of public administration relates to the collection, allocation, and disbursement of fiscal resources (Figure 26). In some economic contexts in which there is high unemployment, government social expenditure acts as an essential safety net for many households. Between 2005 and 2018, the South African government's expenditure on social benefits (such as the child, disability, and old-age pension grants) and general government services to the public (i.e. service delivery) more than doubled (DPME, 2019). This was in the context of an approximately fourfold increase in tax revenue. Government tax revenue is made up of four primary tax sources: Personal Income Tax (PIT), Corporate Income Tax (CIT), Value-Added Tax (VAT), and a range of other taxes such as income duty and sin tax. While there has been a steady increase in the value of tax receipts per tax source, the largest source of government tax revenue is personal income tax (PIT) followed

by value-added tax (VAT). Corporate taxes, on the other hand, although slightly higher in value than other tax types, represent a significantly lower proportion of the government's tax revenue as compared to PIT and VAT. What this suggests is that individuals bear much of the country's tax burden.

5.3.11 Natural Environment

Global calls for greater environmental-sustainability have placed climate mitigation at the centre of this century's economic and industrial development regime. The Sustainable Development Goals have heightened the urgency of industrial transitions that are climate-sensitive, placing human and environmental wellbeing at the heart of global development action. Within this context, South Africa's climate performance is worrying:

- Coal remains the country's leading source of energy, accounting for 85% of the electricity production in 2016 (DPME, 2019). It is therefore not surprising that the country's carbon dioxide emissions remain above recommended thresholds.
- Furthermore, the country's Green-House Gas (GHG) emissions have been on an upward trajectory.

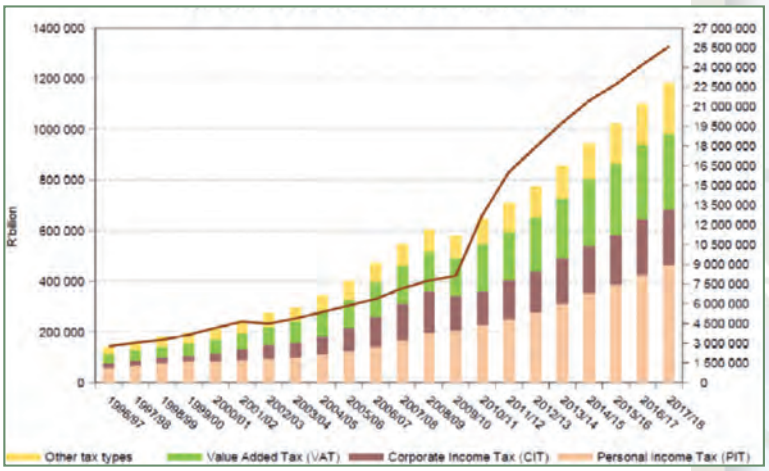


Figure 26: South African Tax Register and Revenue Collection
Sources: Department of Planning Measurement & Evaluation Development Indicators, 2019

- The costs of air pollution on human health and economic growth in South Africa have yet to be determined, That said, fine particulate matter (PM) is one of the most lethal pollutants, higher concentrations of which are known to increase human and animal mortality, not to mention adverse effects on the biosphere.
- Areas with increased industrial growth, such as Richard's Bay in Kwazulu-Natal and the platinum belt stretching between the North West, across Limpopo, and into parts of north-west Mpumalanga are at particular emergent risk of poor air quality.
- Government priorities in terms of improving air quality, have prioritised the following actions:
  - Continued implementation of the Air Quality Act and its National Framework
  - Managing listed emissions activities
  - Launching a Health Study in the Highveld Priority Area
  - Undertaking Cost-Benefit Analyses in air quality management

5.4 KEY ISSUES

The NDP demonstrates an understanding of the issues that confront the SA economy, particularly as they pertain to youth employment and water, energy and ICT infrastructure.

However, it is 11 years from its achievement deadline and the country is under- performing on some of the metrics. The key issues to contend with in respect of SA's economy are the particular tactics that will be employed to ensure that the 4IR simultaneously addresses:

Low-Growth = Limited Opportunity

- South Africa's economy has been characterised by low-growth for the assessed period, 2010- 2018, registering a per annum increase of 2%, on average.
- Low GDP growth undermines the objectives of the National Development Plan, which envisages radically altered socio-economic outcomes by 2030 on the basis of a growth outlook of a 5.4% real growth/ annum.
- Whilst GDP growth is not the sole driver of development, failure to increase the value created in the economy limits its ability to absorb economic entrants, thus compounding household poverty.

Capital Inequality = Low Investment

- South Africa's inequality level is the highest in the world. The wealthiest 10% own 71% of the wealth while the poorest 60% own a mere 7% of the wealth.
- SA's inequality is a direct consequence of its history. More recently, the liberalisation of the economy has inordinately favoured those whose initial endowments were higher, endowments subsidised by the apartheid-era government.
- The consequence of capital inequality is that the minority is unable to make investments in new value creation, depending solely on the private interests of the minority to drive total investment growth.

Economic Distance = Limited Social Cohesion

- SA's economy can thus be understood as one defined by Economic Distance, in which wealthy households are able to access social services through private providers and are thus shielded from the reality of the majority's lived experiences.
- The economic isolation of the majority is compounded by historical geography of exclusion, which raises the economic costs of participation to a level that results in economic disinterest, registered in StatsSA's Labour Force Surveys as prospective workforce participants who are no longer looking for work.

This economic distance results in unequal levels of commitment to a shared vision, which is particularly important in a free market economy, as households and firms are required to opt into the national project and not coerced.

CHAPTER SIX: PC4IR 4IR Definition and Dream

6.1 INTRODUCTION

The Fourth Industrial Revolution has been defined in previous chapters, and it is important that South Africa is clear in its definition of this Revolution and that it adopts a definition that aligns with the global narrative on the revolution and the impact it will have in a globalised world.

In this regard, the Presidential Commission on the Fourth Industrial Revolution, has compared the definitions and literature on this revolution and has noting that it is characterised by a fusion of the physical, cyber and biological worlds, unlocking a new era where intelligence- the ability to acquire and apply knowledge, will increasingly transfer to machines and human existence is fundamentally altered.

In this regard, the Presidential Commission on the Fourth Industrial Revolution encourages South Africa to adopt an adapted definition of the Revolution that ensures a human-centric approach defined as:

> *The 4th Industrial Revolution is an era where **people** are using **smart, connected and converged Cyber, Physical and Biological** systems and smart business models to define and reshape the social, economic and political spheres.*

In light of the defining characteristics of the Fourth Industrial Revolution and the South African need to place the human at the centre, as a country, we also need to ensure that the Revolution is used as a means to an end towards our economic and social needs and goals, as unpacked in previous chapters.

A focus on this Revolution or Technology purely for the sake of it would be a lost opportunity in moving the country forward and in improving our global competitiveness while driving inclusive growth and addressing our poverty, inequality and unemployment challenges.

In light of the country having an articulated Vision and key goals, through the NDP, the Fourth Industrial Revolution and the technologies, systems, and impact that it brings should be leveraged to bring us closer to the attainment of our economic and social goals.

In light of this, the Commission has rallied its efforts and work to produce a strategic plan that is centred on a dream that assists us in focusing our efforts. The proposed dream of South Africa in a Fourth Industrial Revolution world is:

> *South Africa will have a **globally competitive, inclusive and shared economy** with the technological capability and production capacity that is driven by **people harnessing the 4IR** to propel the country forward **towards its social and economic goals**, instead of falling behind.*

6.2 WORKSTREAMS

In light of the Terms of Reference as well as the South African context covered in this chapter, the Commission has established eight workstreams with defined focus areas to conduct its work[51]:

a) Infrastructure and Resources

7. Make recommendations on enabling relevant infrastructure for SA to participate in the digital economy

51 https://www.gov.za/documents/presidential-commission-fourth-industrial-revolution-members-and-terms-reference-9-apr

b) Science, Technology, and Innovation

1. Advise on a technology research and development program to advance 4IR;
2. Make recommendations on enabling relevant infrastructure for SA to participate in the digital economy;
3. Make recommendations on interventions to facilitate innovation and entrepreneurship, and for SMMEs to take advantage of the 4IR;

c) Economic and Social Impact

1. Develop a coordinated national system and plan to react to 4IR including definite intercessions to be done accomplishing worldwide competitiveness of the key commercial segments (farming, finance, mining, manufacturing, ICT, and STI);
2. Recommend approaches to address inclusivity and the digital divide;
3. Recommend mechanisms to measure the impact of interventions on 4IR;

d) Human Capital and Future World of Work

1. Advise on approaches for the development of skills and the work of the future;

e) Industrialisation & Commercialisation

1. Develop a coordinated national system and plan to react to 4IR including definite intercessions to be done accomplishing worldwide competitiveness of the key economic segments (farming, finance, mining, manufacturing, ICT, and STI);
2. Make recommendations on interventions to enable innovation and entrepreneurship, and for SMMEs to take advantage of the 4IR;

f) Policy and Legal

1. Recommend an institutional framework and mechanism to coordinate 4IR programs;
2. Recommend approaches to address inclusivity and digital divide;

g) Capital Markets and Financing

1. Advise on strategies to mobilise resources to support the 4IR interventions;

h) Integration, Programme Management, and Communications

1. Develop a coordinated national system and plan to react to 4IR including definite intercessions to be done accomplishing worldwide competitiveness of the key economic segments (farming, finance, mining, manufacturing, ICT, and STI);
2. Recommend an institutional framework and mechanism to coordinate 4IR programs.

CHAPTER 7: Introduction of the pillars

Given the Fourth Industrial Revolution and the opportunity it presents, if harnessed by South Africa to make progress towards the country's economic and social goals, we need to clearly identify the main drivers of a South African 4IR Strategy and plan. These drivers would result in key scenarios for the country being developed, which can be tested and projected to understand their likely impact on the country, assessed for likelihood, and for the development of implementation plans. Given the assessment of South Africa's reality and preparedness for the 4IR, as discussed earlier, there are some key insights as to what should be focused on in developing a South African 4IR strategy:

7.1 TECHNOLOGY, INVENTION AND INNOVATION

There is a need to embrace the convergence of the Physical, Cyber, and Biological and more deeply understand and leverage smart converged systems, models, and solutions. As a country we need to determine our ability to lead in, compete in or leverage the race of supercomputing, open-source technology as well as the realities presented by Artificial Intelligence, the Internet of Things and smart systems in our social systems, governance, business. We also need to look at where the 4IR presents opportunities for us to grow, improve or save existing sectors in our economy or innovate in new sectors.

7.2 PEOPLE AND SKILLS

South Africa has a young population and high unemployment and as such requires a 4IR strategy that will look at how we develop people and the skills in the country that addresses those who are neither in employment nor in education (NEETs) as well. The 4IR requires a skilled, capable and technologically advanced workforce which is continuously learning and keeping pace with the rate of development and change that the 4IR makes the norm. A smart and connected society is also fast becoming the norm and South Africa has key issues to solve for in attaining this goal.

7.3 INFRASTRUCTURE, RESOURCES, AND NATURAL ENVIRONMENT

There is fundamental infrastructure required as the foundation of 4IR participation for citizens and indeed a country. In the road to a smart world and environment, South Africa needs to look into connected smart cities, towns, and communities. Transportation of goods and people can be made more efficient. Importantly sustainability needs to be a focus by leveraging clean renewable self-sustainable energy more while advancing environment management and control mechanisms.

7.4 ECONOMIC GROWTH AND INCLUSIVITY

The 4IR requires and makes the norm, smart business models and smart money. South Africa needs to understand its structural economic make-up and align with growth opportunities presented by the revolution. Economies of the 4IR are built on intellectual property and are driven predominantly by entrepreneurs. Smart businesses built for this revolution are run by deploying smart business models, new ways of production, distribution and cashless seamless payments. New economic sectors and opportunities are created through innovation and country are more and more finding themselves competing globally where geographical boundaries no longer limit business. South Africa needs to use this opportunity to drive growth in its economy and ensure that is proactively growing and supporting industries that are aligned to the 4IR, while enabling all industries with 4IR capabilities.

7.5 STAKEHOLDER RELATIONS AND GOVERNANCE

4IR breaks down the segregation of many aspects and requires more of a convergence in things that previously remained separate (e.g.: Cyber and Physical worlds). This reality requires a higher prevalence of interdisciplinary approaches and stakeholder collaborations. In this regard, Smart Government as well as Smart Partners, as well as Smart Partners, becomes paramount. In order to support this, there is a need for governance to become increasingly electronic as well as enabling. Smart laws that allow for technological

advancement; sound Governance and an accountable Government that is efficient and more and more real-time; Smart collaboration both continentally and Globally on common goals aimed at improving life; all become more and more of the norm.

These five pillars map closely to the NDP Approach To Change (figure below), which speaks to a focus the looks at Conditions, Opportunities, Capabilities working in a virtuous cycle with Employment, Growth, Poverty Reduction, and Rising Living Standards (Figure 27).

Figure 27: South Africa NDP Cycle of Development

The National Development Plan, 2013

CHAPTER EIGHT: In-depth treatment of the Pillars

8.1 TECHNOLOGY, INVENTION AND INNOVATION

Trends in technology and innovation have led to impacting various sectors of economies globally. One such sector is the manufacturing sector. Advancements in 3D printing and mass customization have added new dimensions to this sector. However, manufacturing is not the only sector to impacted by innovation and technology. All sectors are impacted by advances in processing capabilities of data. This processing power innovation has led to bringing together various sectors of the economy such as agriculture, power generation, manufacturing including various natural resources. The table below (Table 1) provides insight into the technologies and innovation from a global perspective.

Technology	Description
Artificial Intelligence and Robotics	Development of machines that can substitute for humans, increasingly in tasks
Ubiquitous linked sensors	Also known as the "Internet of Things". The use of networked sensors to remotely connect, track and manage products, systems and grids.
Virtual and augmented realities	Next-step interfaces between humans and computers involving immersive environments, holographic readouts, and digitally produced overlays for mixed-reality experiences.
Additive manufacturing	Advances in additive manufacturing, using a widening range of materials and methods. Innovations include 3D bioprinting of organic tissues.
Blockchain and distributed ledger technology	Distributed ledger technology based on cryptographic systems that manage, verify and publicly record transaction data; the basis of "cryptocurrencies" such as bitcoin.
Advanced materials and nanomaterials	Creation of new materials and nanostructures for the development of beneficial material properties, such as thermoelectric efficiency, shape retention and new functionality.
Energy capture, storage and transmission	Breakthroughs in battery and fuel cell efficiency; renewable energy through solar, wind, and tidal technologies, energy distribution through smart grid systems; wireless energy transfer, and more.
New computing technologies	New architectures for computing hardware, such as quantum computing, biological computing or neural network processing, as well as innovative expansion of current computing technologies.
Biotechnologies	Innovations in genetic engineering, sequencing and therapeutics, as well as biological computational interfaces and synthetic biology.
Geoengineering	Technological intervention in planetary systems, typically to mitigate effects of climate change by removing carbon dioxide or managing solar radiation.
Neurotechnology	Innovations such as smart drugs, neuroimaging and bioelectronic interfaces that allow for reading, communicating and influencing human brain activity.
Space technologies	Development allowing for greater access to and exploration of space, including microsatellites, advanced telescopes, reusable rockets and integrated rocket-jet engines.

Table 1: Important Technologies

Source: Trade & industrial policy strategies, department of trade and industry

8.1.1 South Africa Diagnostic

8.1.1.1 South African NSI Landscape

STI role in rallying South Africa developmental goals is well documented in various government strategic documents. The 1996 White Paper on Science and Technology, 2014–2019 Medium-term Strategic Framework (MTSF), 2008 Ten-year Innovation Plan (TYIP)[52], 2002 National Research and Development Strategy (NRDS), The National Development Plan (NDP) also recognises the important role of Science, Technology and Innovation.

South Africa's White Paper on Science and Technology (1996) describes the National System of Innovation (NSI) as "a set of functioning institutions, organisations and policies which impact constructively in the pursuit of a common set of social and economic goals and objectives".[53] South Africa National System of Innovation is made up of different stakeholder such as government, industry, academia, and society, with the aim to decrease unemployment rates, drive economic growth, address triple bottom line challenges of poverty, unemployment, and inequality and improve the lives of South African citizens.

Participation of black people and women in the research and development workforce has increased considerably, and doctoral graduation rates have risen, while the Science Technology and Innovation institutional landscape has expanded, and the number of publications has grown.[54] Through NSI South Africa economy can be transformed from resource-based to a knowledge-based economy while addressing several weaknesses that would hamper progress. To this end, the DST developed the "Ten Year Innovation Plan" (TYIP)[55], for the period 2008 to 2018. The Plan outlines the path that SA intends to take towards building a knowledge economy.

The National Development Plan (NDP) has identified science, technology, and innovation as main drivers for economic growth, job creation, and socio-economic especially in the era of the 4thIndustrial revolution. South Africa's National System of Innovation (NSI) will contribute to and helping citizens thrive in a world where increased national competitiveness it's a necessity, including rapid changes in creating opportunities for improved quality of life. South African NSI and global participation, EU, National-, and Regional Innovation strategy and projects are progressively being considered as an engaging structure to investigate open doors for joint effort, new associations, and instruments for coordination. This is especially significant considering the present situation of financial emergency where rare assets and fracture of activities presents genuine difficulties.[56]

The Fourth Industrial Revolution, with its specialist dangers and openings, is additionally upon us. South Africa, along these lines, needs refreshed policy reactions to extend the task that can be performed by STI, can play in, for example, re-industrialisation, administration conveyance, modernizing the agrarian area, and alleviating ecological debasement.

The Draft 2018 White Paper on STI57 underlines the central subjects of inclusivity, change, and collaborations. Activities should be made to address and actualize policy soundness, human capital improvement, information extension, progressive execution, and expanded venture, with the point being to expand on South Africa victories and embrace new methodologies where required, in order to cultivate an NSI in which innovativeness, learning and enterprise can prosper.

According to the South African STI indicators booklet 2017 (south-african-sti-indicators-booklet-2017), "R&D investment as a percentage of gross domestic product, increased to 0.8 in 2015/16, slightly up from the

52 http://www.naci.org.za/wp-content/uploads/2018/07/South_African_Science_Technology_And_Innovation_Indicators_Report_2017.pdf
53 http://www.naci.org.za/wp-content/uploads/2010/01/Review-of-the-White-Paper-on-Science-and-Technology.pdf
54 https://www.saasta.ac.za/saasta_wp/wp-content/uploads/2019/03/FINAL-White-Paper-to-Cabinet_11-March-2019.pd
55 https://www.saasta.ac.za/Media-Portal/download/bio_fs16.pdf
56 https://www.sarima.co.za/wp-content/uploads/2019/02/SA-Innovation-Landcape-and-Framework.pdf
57 https://www.gov.za/sites/default/files/gcis_document/201809/41909gon954.pdf

0.77% recorded in 2014/15."[58] Even though it has increased, South Africa is still far from the target of 1.5% expected in 2019. According to the World Economic Forum (WEF)/Accenture report (2017)59, "the use of a combination of technologies such as cloud, mobile, data analytics, artificial intelligence, and drones has the potential to fundamentally increase their impact and alter the way we live, work and interact."

Usage of such technologies enabled by telecom technology is anticipated to increase the flow of information and money flowing through the global economy from $26 trillion in 2012 to more than $80 trillion in 2025. This will be realized as more companies start to integrate cloud, mobile, and global digital services to their service and business models. The number of connected devices that enable and drive internet of things (IoT) could reach 30 billion by 2020. The global transition away from fossil fuel-based energy sources is driven by three key factors

- Upward price pressure as a result of the finite availability of resources for energy end-use
- Downward price pressure due to more renewable sources of energy being deployed
- Regulatory/policy pressure as a result of global implications and realities of climate change

The development of 4IR type technologies that can be applied in the energy sector has been driven by the realities around planetary limits, connectivity, and the convergence of a range of already existing and improving technologies.

8.1.1.2 Framework

The adoption of the South African Innovation Scorecard Framework by the National Advisory Council on Innovation (NACI) in 2016/17 provides a framework for the analysis of the state of science, technology, and innovation (STI) in South Africa. This framework classifies STI exercises into three parts: the open division's empowering exercises, firm-level advancement exercises, and the financial and social yields of development.

8.1.1.3 Skills

There is a low supply of doctoral qualifications for females in disciplines such as engineering, mathematics and statistics, and computer and information sciences. Only 18% of doctoral degrees in engineering were awarded to female graduates in 2015. In terms of race, there is a limited supply of black doctoral graduates in disciplines such as life sciences and engineering[60]. It is evident that we need to strengthen research capacity at historically disadvantaged institutions (HDIs) partly addresses this high-end skill supply challenge.

The firm-level innovation activities are investments, linkages, and entrepreneurship, as well as recent developments in the South African intellectual property right (IPRs) regime. Government's contribution to business expenditure on research and development (BERD) is shown to be low and lacking an appropriate coordination mechanism for a coherent response to the prioritisation and funding of research, development, and innovation (RDI) by various government entities. However, government is shown to contribute significantly to the South African venture capital industry, which is good news for innovation and technology commercialisation in small and medium enterprises (SMEs). Moreover, funds and resources need to be more accessible for entrepreneurs in the STI sector.

New skills will be required and should be prioritised at primary, secondary and tertiary education levels e.g. STEM, programming, robotics, AI, data analytics, IoT, ML/AI. Further investigations into mechanisms to enable this will be required (if not already in place or underway).

58 http://www.naci.org.za/index.php/south-african-sti-indicators-booklet-2017/
59 https://www.accenture.com/_acnmedia/pdf-64/accenture-fiscal-2017-annual-report.pdf
60 http://www.naci.org.za/wp-content/uploads/2018/07/South_African_Science_Technology_And_Innovation_Indicators_Report_2017.pdf

8.1.1.4 Policy

The industrial policy relies heavily on STI capabilities to transform the country into a knowledge-driven economy, a recommendation is made to strengthen the linkages between industrial policy and STI policy, as well as opening up the market for new players especially SMMEs. The high-technology exports remain low, with the country relying heavily on imported high-technology products. The high-technology industries in which the country is seriously underperforming are those of artificial intelligence, Blockchain, virtual/augmented reality simulation environments, automatic data-processing machines, electrical and electronic goods, biotechnologies, storage/transmission, advanced materials, advanced sensor platforms as well as medicinal products and pharmaceuticals.

South Africa still have key issues in STI policy, such as the implications of the Fourth Industrial Revolution (Industry 4.0) for South Africa, entrepreneur development and support, public-sector innovation, and local or regional systems of innovation. The analysis of the global competitiveness of South Africa, especially in respect of entrepreneurship, shows that there is a need for government to be agile and innovative in easing the burden of doing business in South Africa; hence the incorporation of a recommendation for improving public-sector innovation in support of starting a business, handling insolvencies and saving on tax administration. Information and communication technologies (ICTs) provide an opportunity to enhance public-sector innovation. As the country is planning to embrace Industry 4.0, its recommended that , South Africa should respond to this wave from the perspective of developing countries.

8.1.1.5 SA 4IR Opportunities, Centres of Excellence

The vision for SA's development in this era of industrial and social development should address the following key issues:

Prosperity and Wealth Creation – create a prosperous South Africa. All South African citizens share in the development of the country.

Prosperity means every community has access to infrastructure and facilities (paved roads, schools, clinics, libraries, electricity, clean drinking water, etc.). Prosperity restores our human dignity. Wealth creation happens where people live. Reverse the centralisation of wealth in major economic hubs. This realises that every part of South Africa has a competitive advantage that can be utilised to create local economic development opportunities.

Inclusiveness – We have a chance to address the shortcomings of the 1st, 2nd and 3rd industrial revolutions. Research shows that a significant portion of the global population has not benefitted from the advancements brought about the industrial revolutions of the past. This wave of technological, industrial, and social advancements must help the most vulnerable members of our society. People led rather than technology determined. Empowers human wellbeing, gives them more choices, opportunities, freedom, and control over their lives, the benefits are distributed fairly and evenly across the broader society especially the marginalized who were disadvantaged in the previous eras

Connected, digitally advanced and smart - Fourth Industrial Revolution, Industry 4.0 or Society 5.0 is brought about by advances in the convergence of and collaboration between a number of technologies. For SA enterprises to remain globally competitive, they will have to embrace technologies that improve efficiency of operations, allow for better internal and external integration, give their customers a unique customer experience, environmentally and financially sustainable, and break the boundaries of location and time. Similarly, governments of the future are efficient, effective, responsive and deliver high quality services to all its citizens. Society, government, enterprise, academia and small, medium, and micro enterprise (SMMEs) – These advances must benefit all of South Africa.

8.1.2 Energy sector

It is important to note that energy has been central to every previous industrial revolution and the 4IR is likely to be quite similar. Similarly, global energy systems are undergoing a transition enabled by some 4IR technologies but mostly driven by other factors. The 4IR can and should play a fundamental role for South Africa to realise the National Development Plan (NDP) Vision 2030 in energy.[61] Some key linkages between energy and 4IR technologies for South Africa are listed below in Table 2.

Energy	4IR
Sustainable low-carbon high-quality of supply of energy to enable 4IR technologies and vice versa	Energy storage/transmission, 3D printing, drones/ autonomous vehicles, biotechnologies
Improved connectivity and enabling 4IR technologies to operate, protect and plan future energy systems	Advanced materials, advanced sensor platforms (PMUs), AI, computing, IoT, virtual/augmented reality
Enabling platforms for distributed future energy systems e.g. demand-side response, aggregation platforms (VPPs)	Advanced sensor platforms, new computing technologies (big data, analytics), IoT
Energy storage as a 4IR technology in itself is directly linked to energy	Energy storage
Virtual Power Plants	Remote sensing, platforms, Blockchain
Increased demand-side participation (towards presumption)	Energy storage
3-D printing of energy infrastructure equipment components	3-D printing

Table 2: Linkages between energy and the 4IR in South Africa

In transitioning to a more diversified, distributed, cleaner and more sustainable energy system, sectors will become increasingly coupled, likely electrified as well as powered by renewable energy (as shown graphically in Figure 28 and 29). 4IR technologies like drones/ autonomous vehicles, advanced materials, biotechnologies, storage/transmission, advanced materials and advanced sensor platforms would be most important in this respect.

A listing of some of the linkages between 4IR and energy is provided below:

- Virtual/augmented reality simulation environments (for training and emergency response)
- Drones (for network maintenance and security)
- New computing platforms (predictive analytics, big data) for reduced maintenance outages (increased plant availability), improve maintenance planning and reduction of maintenance costs
- Utilisation of advanced remote, advanced sensor platforms (improved operations & control)
- Use of AI/ML (for improving operational planning in energy systems)
- Use of Blockchain, AI and new computing technologies for better communications and trading between market participants (Eskom, distributors (municipalities), individual/aggregated suppliers & customers in local communities and businesses) to fully leverage distributed resources e.g. enabling transactive energy, virtual power plants (VPPs) and energy co-operatives.

Figure 28: Possible future energy balance for South Africa

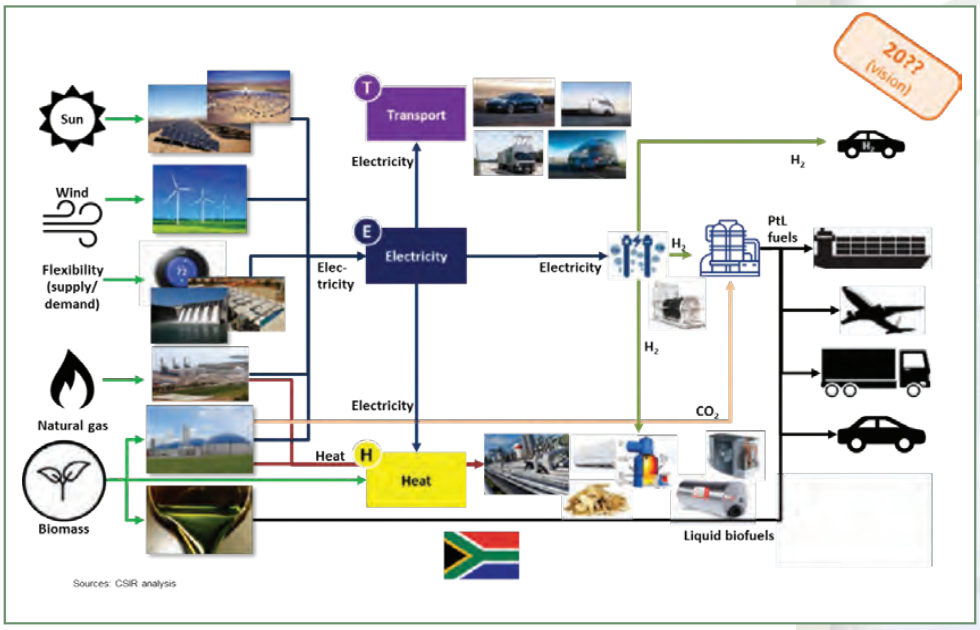
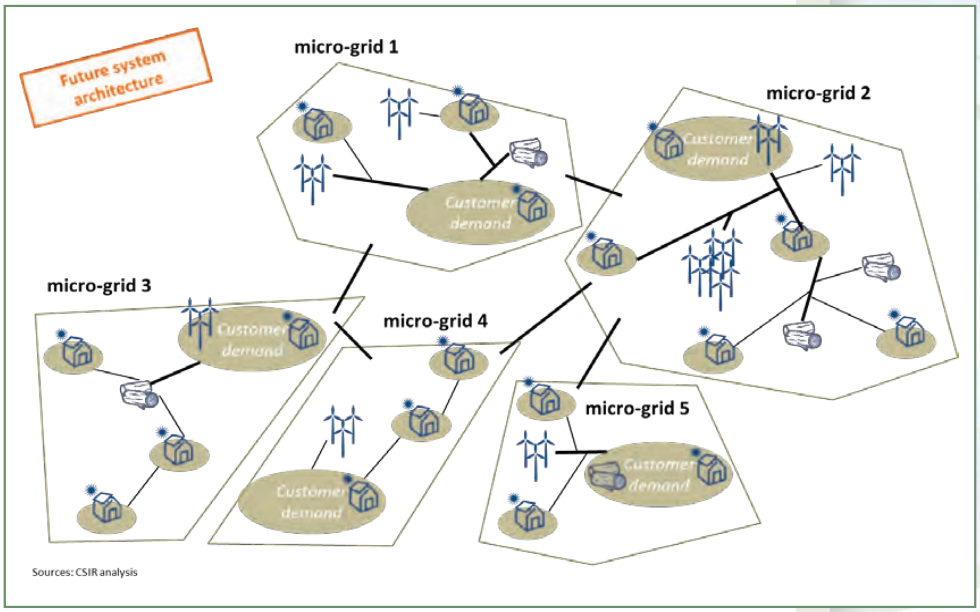


Figure 29: Enabling universal and affordable electricity access (leapfrogging historically large, centralised electricity to distributed interconnected mini-grids enabled by 4IR technologies)



61 National Planning Commission (NPC), National Development Plan 2030 - Our Future-make it work. 2012.

- Using advanced sensor platforms, AI to allow for improved homegrown, variable resource forecasting tools (wind/solar) to improve system integration of variable renewable energy technologies
- Intelligent automatic power system fault restoration
- Focussed RDI in emerging technologies and required business models for domestic consumption and exports, e.g. hydrogen (H2) production and storage, electrochemical storage, renewable energy, Power-to-Liquids (PtL), carbon capture utilisation and storage (CCUS).
- Minerals and materials needed and our unique advantage e.g., platinum group metals (PGMs), Manganese, Titanium, Vanadium, CO2, RE-based H2
- Second-life battery storage from electric mobility into stationary applications e.g., buildings, micro-grids, transmission and distribution substations.

The opportunity to export commodities and technologies exists in the intersection between 4IR and energy. A few of these are listed below:

- Domestic production, export, and end-use of renewables-based hydrogen (for energy end-use as hydrogen or synthetic fuels, high value chemicals) including commodities and technologies
- 'Green' hydrogen for mobility (especially in urban environments and public transportation)
- Mini-grid solutions to enable universal, affordable energy access in Africa
- Autonomous electric mobility (significant existing automotive manufacturing supply-chain)
- Energy storage systems (electrochemical, thermochemical, hydrogen)
- Improved efficiencies and productivity of business in South Africa resulting in increased international competitiveness for exports in particular sectors

A national strategic proactive approach across stakeholders is needed to take advantage of these opportunities to position South Africa as a leader in exporting our competitive and comparative advantage in resources, technologies, and commodities.

8.1.3 Agriculture

Precision agriculture enabled by information technology is revolutionising the agricultural sector in many countries, optimising the use of water and ensuring that fertilizer and pesticides are applied only when needed. The research conducted by Accenture proposes that the combined use of biotechnology (improved seeds), autonomous vehicles, drones, and sensors promotes precision agriculture, will enhance the use of resources and increase agricultural yields. Given that there is a need to focus on communal land, KwaZulu-Natal, the Eastern Cape, North West

Reskilling of agricultural labour force it's a necessity to align it with the technological advancement of 4.0, increasing investment, adopt to changing market needs and financial support to developing farmers, are key to improving the prospects of the sector.

The agricultural sector is not branded as a prime career destination for most of the students in tertiary institutions hence a new approach to attract young talent to the sector is required. Tertiary education foundations occupied with rural agricultural education ought to reinforce their educational plans by including hypothesis, aptitudes and innovations identified with the 4IR, such as usage of Sensors, smart farmers, etc.

National government and provinces, in conjunction with tertiary organizations and industry affiliations should cooperate in executing agri-accelerator advancement projects to fast-track learning through abilities trade programs with the main point being farming innovation development. This activity can likewise incorporate eAgroTourism CoLabs (North West University – Mahikeng Campus) focusing on smart farming, precision farming, farming best practices and agricultural technologies with the focus being 4IR.

It's essential to guard against digital divide outcome in South African agricultural sector, wherein only certain role players benefit from 4IR opportunities. The primary necessity will be to guarantee smallholder farmers/ makers are profitable in a business sense, and delivering for a market where their items will be traded through the reception of 4IR Technologies, for example, Big Data, Blockchain, Machine Learning and AI to give beneficial bits of knowledge into cultivating tasks, drives constant operational choices and can be utilised to update forms for game changing plans of action. Mechanical technology, UAVs, and transport advances ought to be acquainted with help with making planting, collecting, handling, and bundling increasingly effective, and is anticipated to have a critical positive effect on ranch generation.

8.1.4. Mining

Mining industry is at an inflection point, whereby digital technologies have the potential to unlock new ways of managing variability and enhancing productivity. For the country to reach Climate-smart Mining emphasis should be on renewable sources of energy, robots, and electric vehicles. This shift will require vast volumes of copper, lithium, cobalt, platinum, chrome, and manganese.

South Africa mines some of the minerals and metals required to develop e.g. drones, batteries, wind turbines, smart phones, and electric vehicles –which are the products of the fourth industrial revolution. The country mines at least five of the 16 minerals or metals (iron ore, lead, phosphate rock, silica and titanium oxide) used to produce solar panels. This creates extensive value chain opportunities for South Africa to use its mineral and metal endowments to structurally transform the economy.

Mining is not commonly connected with dreams of a round economy (CE), where waste is changed into contributions for environmentally safe yields. The advancement of CE model for the mining business can possibly settle the moves identified with the deficiency of mineral assets, misuse of assets, and ecological contamination with ensuing financial benefits.

4IR technologies will manage the cost of effectiveness gains in the mining business. Remote sensors on independent elevated vehicles: can identify geothermal action on the investigation front, guiding and inspecting to those regions where there is a solid sign of an extractable asset. Underway: robots, as opposed to individuals, can work in perilous situations. Computerized reasoning and AI imply that rock would now be able to be cut rather than impacted, prompting ceaseless mining. Computerized rock-face mapping can be incorporated with cutting apparatus, alongside material characterisation and fracture investigation. Some of the mining industry's latest technological innovations South Africa needs to adopt are:

8.1.4.1 Spatial data visualisation

Mining is facing an thrilling shift, because of the spatial (or geospatial) data, which is becoming more robust than ever:[62]

- Three-dimensional (3D) Modelling makes a visible, life-like impression with profundity recognition that enables the human cerebrum to comprehend and identify with complex interrelated issues. 3D modelling backs firms by reconsidering the mine all the more effectively.
- Virtual Reality (VR) is a falsely made programming environment that makes use of genuine information. The virtual environment inundates individuals into a client made 3-D environment. VR presents an improved impression to enable excavators to encounter what it resembles working in a mine.

62 https://www.angloamerican.com/futuresmart/our-industry/technology/trends-in-modern-mining-technology

- Augmented Reality (AR) transcends into the real-world through sounds graphics and videos that enhance the user's visual space. Thus Augmented Reality (AR) can be used, within the mining environment, to reduce various costs through training of virtual simulators.

By using novel technology such as spatial data effectively, the mining industry gains insights into "mine systems at a reduced cost and impact on the environment." [63] The mining industry is steadily moving in a futuristic direction where it is possible to virtually construct and breakdown buildings, plants, mines, and all associated infrastructure before even breaking ground to create a truly intelligent mine.

8.1.4.2 Geographic information systems

With the assistance of GIS, excavators can comprehend genuine issues where location and accessibility are critical.Geospatial information provides pertinent infromation about an object. Through this pertinent information, miners can obtain invaluable information about the mine and the surrounding environment. GIS can provide insight to the following:

- "Mineral exploration, Geochemical and hydrology data, Report generation, Facility and tailings management, Sustainability and regulatory compliance".[64]
- When mining today, geospatial information programs enable us to educate mine managers and representatives in new manners and improve long-term comprehension of mining with virtual understandings of genuine environments.

8.1.5 Telecommunication

The telecommunications (telecoms) industry is playing a critical role in enabling digital transformation across the globe. The telecommunications ecosystem has provided the fundamental building blocks such as access, interconnectivity and applications that act as key enablers of the digital revolution. Advancements in digital transformation and changes in consumer behaviour require all players in the telecommunications industry to become innovative in order to remain competitive in the market.

South Africa's technological skills gap is hampering the ability of the country to improve competitiveness and performance of all relevant sectors including the ICT sector (Schofield, 2016). This gap in skills is posing a constraint on the need to drive heightened innovation to sustainably address the unacceptable burdens of poverty and unemployment (DPS, 2016). The 4IR driven by the increasingly knowledge-based economy has expanded the interest for particular ICT abilities to make, actualize and continue rising innovations. These numbers demonstrate that the South African ICT aptitudes deficiency and related environment need critical, engaged and increased consideration if any yearnings of turning into a worldwide contender are to be entertained.

Data Centre and Cloud Computing

Building up data centres and the fundamental interchange foundations to get to them is the most significant contribution to this value chain. There is breadth for SMME inclusion in setting up data centres and cloud computing facilities. Despite the fact that these facilities are mind boggling, capital intensive, SMMEs could cooperate with bigger players in the area, for example SITA. When the foundation has been set-up, there are a wide range of services and items accessible over the central framework. SMMEs have gigantic chances to use cloud frameworks to give a scope of particular and specialty contributions to both big and little clients. This is another and rising region of business, and SMMEs should create imaginative arrangements and plans of action (DTPS, 2017).

63 https://www.angloamerican.com/futuresmart/our-industry/technology/trends-in-modern-mining-technology
64 https://www.angloamerican.com/futuresmart/our-industry/technology/trends-in-modern-mining-technology

Digital Content

Digital content shows a great deal of chances for SMMEs, thinking about the expansion of online presence. Most of online substance consumed by South Africans starts abroad. It at that point becomes very important for government to give business visionaries the vital apparatuses and frameworks to empower them to create local substance and total it for dispersion purposes, for example Computerized Content Development Incubation Centres. The African locale likewise introduces an open door for circulation of content (DTPS, 2017).

Games and Apps

There is tremendous scope for local SMMEs to end up associated with creating Apps and Games that address neighborhood issues and bid toward the South African and African markets. South Africa has world-class programming improvement capacities and SMMEs should expand on this custom and notoriety regarding App and Games advancement. The most mainstream "Application Stores" are claimed by Google, Apple and Microsoft. This control restrains local interest in this very important circulation channel. Nearby "Application Stores" are important to guarantee that clients can find and download local Apps and Games. This would encourage circulation of nearby SMME-created content.

Cybersecurity

Given the growing complexity of connected environments, there is strong need for and diffusion of software and tools to strengthen cybersecurity. The security or trust dimension is an important element required to build citizen confidence when using digital technologies. It is important to note that ICT security is not limited to authentication and encryption only.

Networks of the Future

South Africa has an overall internet penetration rate of 54%, representing just over 31 million people that are online in the country. According to research conducted by Accenture, improving internet access could result in an additional 4.3 million jobs and a cumulative increase in productivity and earnings of R26.7 billion. In addition, society will also benefit from increased access to digital content and augmented reality (AR)/ virtual reality (VR) digital services. Consumers will benefit from potential time and cost savings due to integration of processes such as mobile payments, digital services in health care, video media, application of IoT in automotive, connected homes and entertainment offerings.

The key initiatives that will shape the network of the future include:

- Alternative connectivity- There has been increasing demand for alternative connectivity to expand internet access to new markets and regions. South African has made significant investment in fibre roll-out.
- Software defined networks – Virtualisation of the physical hardware infrastructure using technologies such as Software Defined Networking (SDN) and Network Function Virtualisation (NFV) will drive down the costs of the telecoms services and increase coverage. These technologies will also shape the build of the mobile fifth generation (5G) wireless network architecture.
- Zero touch networks and Cyber Resilience – IoT and machine to machine (M2M) communication "is becoming more prevalent as more devices are connected to the network."[65] The number of connected devices in South Africa is expected to reach 168.4 million in 2021, increasing from 119.2 million in 2016. This will require more capital investment in technologies like SDN and NFV to create autonomous and zero touch networks that are self-optimising and provide more protection against cyber-attacks.

65 https://semiengineering.com/are-devices-getting-more-secure/

8.1.6 Water and Sanitation

South Africa is confronting a few noteworthy difficulties in connection to water, both at the level of the asset just as in the genuine arrangement of water benefits by districts. Ongoing examinations have evaluated interest for water in South Africa will surpass supply by 2025 if nothing is done to enhance water assets. The maintainability of the area is likewise in danger because of the inadequately kept up and regularly sick-prepared framework, general under-evaluating of water over the value chain and the falling apart nature of sanitation administrations in several municipalities.

Opportunities: Good relationship with water sector partners, Well-resourced water entities, the labour force produces a good supply of graduate trainees, Mobilization of skills training for the water sector, Training of Engineers and Technicians and Utilization of Learning Academy

Opportunities for Innovation

The effective use of research and application of new technologies could hugely transform this sector. Partnerships need to be established between technology providers, communities and decision makers in order to deliver solutions that are sustainable, affordable, safe and cater for current and future needs.

IoT enables numerous devices connected to each other to collect real-time information and send this data via wireless communications to centralise systems. These in turn can change and improve a wide range of operations. AI allows large datasets to be analysed computationally to reveal patterns which can be used to inform and enhance municipal decision making.

The creation of 5G (fifth era mobile technologies) can possibly associate gadgets to the Internet and different gadgets, transport information much rapidly and process high volumes with least deferral. While nations and regions are driving ventures and undertakings to reasonably oversee water assets, it cannot be exaggerated the significance constraining, recycling and reusing water utilization at the individual level

With new advancements in technology like smart water meters and applications to screen home use, computerized advances are empowering people to all the more likely deal with their own water use. As water is an undeniably rare asset, endeavours to restrict, reuse and treat wastewater are critical to maintainable advancement. In spite of ebb and flow endeavours for water reusing or treatment, it is evaluated that over 80% of the wastewater created by society streams once more into the environment without being dealt with or reused . Computerized advances could prove to be successful in the treatment and reusing of wastewater and key to handling the world's water shortage catastrophe (ITU, 2018).[66]

8.1.7 Smart Cities

South Africa like any other country understands that a lot needs to change in the way in which our people live, and access services be it from the public sector (government) or from the private sector (business). The sphere of government which has a direct impact to the people is local government. In order for this sphere to be able to serve the people there is no doubt that it needs to do this in a smart way.

Cities would be required to make use of emerging smart technologies enable for efficient and intelligent ways of engaging be it with government, business and citizens. The 4IR Technology drivers affecting Smart Cities initiatives will mostly include artificial intelligence (AI), the internet of things (IoT), blockchain and mixed reality (AR and VR).

5G becomes the glue to everything smart, it creates the super-fast highway in which all the other applications of a connectedness required in a smart city implementation is enabled. Municipalities, COGTA, SALGA, Premier Offices, Industry, and Universities needs to start collaborating in building Smart city Concept, informed by SALGA Smart City Framework. The implementation of Smart cities should also include Smart Villages and Smart Townships.

66 https://telecomworld.itu.int/2018-event/

8.1.8 Financial Services Sector

A strong, established sector that contributes significantly to South Africa's GDP, financial services has remained robust amidst economic and policy uncertainty, global headwinds and a sustained period of poor economic growth. As South Africa strives to boost economic growth, the opportunity for financial services to act as a catalyst for growth and a force for good is significant.

The new technology dilemma: value, speed and safety

Emerging technologies of the 4th Industrial Revolution, such as artificial intelligence (AI), virtual reality (VR), and blockchain, will be embedded in the financial services industry and become mainstream.

Financial institutions are also re-thinking their IT architectures to leverage the benefits of emerging technologies and to address the issues associated with their legacy systems. Facing capacity and skills constraints, many are attempting to run their IT transformation agenda at multiple speeds—embracing agility by using new technology decoupled from legacy systems while methodically unravelling legacy complexities.

With the increased ubiquity of digital technologies and services has come an increase in cybercrime.

Crime is shifting from the physical to the online world. We expect this trend to continue as cyber criminals find new and innovative ways to penetrate system vulnerabilities. Governments and financial institutions have an obligation to stay ahead of the curve, assigning dedicated resources to prevent cybercrime and information theft. To date, the growing importance of data coupled with underestimation of the cybercrime threat, has contributed to the vulnerability of South African businesses. It is important to understand how to combat cyber security from a legislative perspective as well as from a consumer perspective.

Peer-to-Peer

One specific platform type that has emerged, but has failed to reach scale as yet, is the crowd-driven or peer-to-peer (P2P) platform model.

These models provide alternatives to connect willing investors with investment seekers and willing lenders with those seeking finance. The benefits include sharing the risk of protecting assets and wealth, all while lowering the cost. As these services continue to mature across the value-chain, we expect participation from end users, traditional financial institutions and fintechs, as well as insuretechs, to grow exponentially.

Accenture's research indicates that P2P Banking can generate R84 billion in value for industry and society by 2026. P2P Insurance can generate R122 billion in value.

Embracing "-as-a-Service"

Nor is it feasible to build and own every conceivable digital technology or capability required for success in the future—e.g., data and analytics; artificial intelligence and machine learning; Internet of Things (IoT) and smart machines; quantum computing, etc. Financial institutions must look more and more to "-as-a-service" and cloud providers to enable the agility and scale required to remain relevant. They will also need to make difficult decisions with respect to technology and infrastructure investment and ownership.

Journey to cloud

The benefits of cloud are plain—they include agility, speed to innovation and lower IT costs. Companies are now focused on when and how to move to the cloud and not if they should move to the cloud. Accenture research indicates that a colossal 91 percent of companies say they will be in public cloud by 2019. The majority of financial institutions have embarked on the journey to cloud, such as CITI and CapitalOne, with public cloud and multi-cloud strategies being the next wave.

Of the **New Technologies**, we believe that blockchain offers the highest potential as a game changer for the industry. Financial institutions deal with information and ledgers as a key part of their role and recognise the tremendous potential blockchain provides as a distributed, decentralised public ledger in revolutionising how information is stored, accessed, modified and validated. So far, there has been a lot of experimentation with blockchain, but very little practical application at scale that adds value for financial institutions and their customers.

8.1.9 Health Sector

Even as digital advances begin to take life sciences to the brink of radical reinvention, healthcare continues to face the triple endemic challenges of lack of access, high costs and poor outcomes. Informed, tech savvy consumers are demanding better health services. South Africa, a country where 80 percent of the populace relies on failing public health services, digital technologies can make significant difference.

Technologies such as artificial intelligence (AI), analytics, Internet of Things (IoT), blockchain and cloud are helping to address fundamental issues, improving access, supply chain efficiencies and patient data management. They are also driving a revolution in healthcare and in life sciences, enabling precision and personalised medicine, and prompting the emergence of a new mindset around healthcare.

These are: digitising the supply chain; telemedicine; and 'accessible intelligence', the ability to access and intelligently use data generated across the chain of care.

The technologies that will fuel these three key initiatives? They include AI, IoT and connected devices, and big data and analytics, which includes: -

- **Telemedicine** uses audio and visual technology to connect patients and healthcare providers, provide remote diagnosis and implement preventative care.
- **Accessible intelligence** can save lives. It can add **R101 billion** in value. In South Africa, there are over 42 different health information systems across the nine provinces of South Africa. Each province manages its affairs independently leading to lack of coordination between provinces and resulting in heavy expenditure on decentralised software systems with no interoperability.
- **A digital supply chain** canadd**R37 billion** in value, primarily to society. It uses predictive analytics on data generated from healthcare supply chain information systems to facilitate demand planning and logistics management. Value is created through reduced administrative and overhead costs, improved forecasting and efficiency of ordering of drugs, and reduced out of pocket spend on tuberculosis (TB) and antiretroviral (ARV) drugs by citizens.

8.1.10 Manufacturing

The manufacturing sector in South Africa is in decline. Low demand, a lack of competitiveness, negligible economic growth and slow recovery from economic and political volatility compound to present little prospect of improved performance. At the same time, manufacturing across the globe is being shaken to its roots by the entry of disruptive digital technologies such as predictive analytics, additive manufacturing, machine learning and artificial intelligence (AI), and the Industrial Internet of Things (IIoT). These technologies can usher in new efficiencies, driving productivity and competitiveness.

Seven initiatives will address the identified challenges

The following digital initiatives will address the key challenges along the South African manufacturing value chain identified by our research:

- Digitally enabled manufacturing can leverage a combination of technologies—robotics, autonomous equipment, sensors and control towers—to automate tasks and increase efficiencies and productivity.

- Advanced analytics leverages data from sensors, smart and connected devices to capture insights, improve planning and decision-making, and optimise operations. In combination with other digital initiatives, particularly smart sensors, analytics can provide more accurate surveillance of equipment and assets, improving productivity and reducing risk.
- Workforce reimagined is about building a workforce for digital. Technologies like remote assistance, machine learning, wearables and augmented reality support upskilling, reduce training time and improve productivity.
- Digitising the supply chain through the use of RFID, sensors, supply chain control towers provides visibility to all stakeholders, enabling real-time monitoring of movement along the supply chain to eliminate bottlenecks; increase production throughput; better manage demand; and reduce inventory, warranty and delivery costs.
- 3D printing makes use of custom manufacturing and in-field part printing technologies to design and print products and parts onsite for maintenance, repair and operations.
- An integrated platform for collaboration and exchange of data within and across multiple value chain stakeholders can reduce transaction costs and time and reduce the cost of operations.
- Digital sales use machine learning, artificial intelligence, chatbots to automate customer interaction, and analytics to target and customise offerings.

Digitally-enabled manufacturing

With increased competition to South African manufacturers from imports and constrained local demand, increasing local productivity becomes essential. Digitally-led manufacturing can drive production cost optimisation, faster time-to-market and mass production of individually configured products.

An optimised combination of technologies like robotics, sensors, and autonomous machines can transform conventional manufacturing processes, automating repetitive tasks and creating a smart factory. Connected manufacturing and assembly can deliver significant benefits:

Robotics and automation augment manual tasks, increasing throughput and delivering a 10-30 percent saving in workers' time. Autonomous machines can offer a 2-20% reduction in input cost. With control towers monitoring processes in the plant and sensor-enabled machine-to-machine communication, plant efficiency is improved. Advanced Analytics

Digital Supply Chain

With global and complex supply chains emerging within advanced businesses, data—such as manufacturing lead times, end-to-end cost visibility, product availability data for suppliers, shipping and logistics estimates, and demand forecasts from end-customers—brings immediate value to a business and its partner network. Intelligent and digital supply chains can increase visibility across the ecosystem, allowing value chain participants to interact seamlessly, identify supply chain constraints and fix the major pain points, improve planning and, ultimately, reduce manufacturing cost and time and increase productivity.

3D Printing

Unplanned downtime costs the manufacturing industry approximately 5 percent of its revenues. By printing parts onsite, 3D printing can mitigate risks associated with expensive downtime in manufacturing plants by lowering the lead time (for inputs and parts) from a few days to a few hours.

8.2 PEOPLE AND SKILLS

"I am convinced of one thing—that in the future, talent, more than capital, will represent the critical factor of production." - Klaus Schwab, Founder: World Economic Forum

The architecture of the 4IR era has significant impact on the human capacity development ecosystems and institutions of work and an understanding of this shift should underpin our design of solutions for human capital innovation.

The issue of human capital and the future of work is currently on the global agenda for companies to consider the effects not just on their workforces and their recruitment and training strategies, plans and policies, but also on their business models – many of which stand to be completely disrupted by technological change such as automation and artificial intelligence.

According to the WEF, technological breakthroughs are quickly changing the work tasks that were performed by workers and giving over to machines more tasks – "algorithms, global markets are undergoing major transformations. These transformations if managed wisely could lead to a new age of good work and good jobs and improved quality of life for all, but if managed poorly pose the risk of widening skills gaps, greater inequality and broader polarization."[67]

Companies which are advanced in 4IR technologies are seeking to maximise returns through the use of emerging technologies – thereby improving efficiencies and better production patterns and thus expanding into new markets. A 2018 WEF report on the Future of Jobs found that as these enormous shifts increase in the workforce, the window of opportunity for proactive management of the "change is closing fast and business, government and workers must proactively plan and implement a new vision for the global labour market."[68]

According to Guy Ryder, Director General of the International Labour Organisation, "the world is facing a number of fundamental challenges, such as demographic change, low economic growth, migration, conflicts and environmental problems. Employment patterns are evolving fast, with new forms of employment on the rise, with limited job and income security, and without adequate social protection growing income insecurity, including among the middle-class, as well as decent work deficits have weighed heavily on perceptions of social justice and challenged the implicit social contract in many societies."

While the net outlook for jobs is predicted to be positive, the reality is that there will be an initial displacement of jobs and a transition period in which governments, business and labour need to urgently prioritise re-skilling the current labour force for the future of work, consider relevant policy and social protection interventions and identify the levers which could provide opportunities to accelerate growth.

It is noted in the report of the Global Commission on the Future of work that it is those workers who are least educated and perform work that is simple who are most unable to seize the new opportunities that may come with automation. It is those who are made vulnerable by a lack of education and financial means who would likely be most badly affected by the transition to the digital economy.

- 47% of workers in the United State are at risk of being replaced by automation
- In the ASEAN region 56% of jobs over the next 20 years will be lost to automation
- 9% of jobs in the OECD are at risk of being gobbled up by automation.

67 WEF 2018 Report on the Future of Jobs
68 https://www.uwc.ac.za/News/Pages/The-role-of-of-Universities-in-the-Digital-Era.aspx

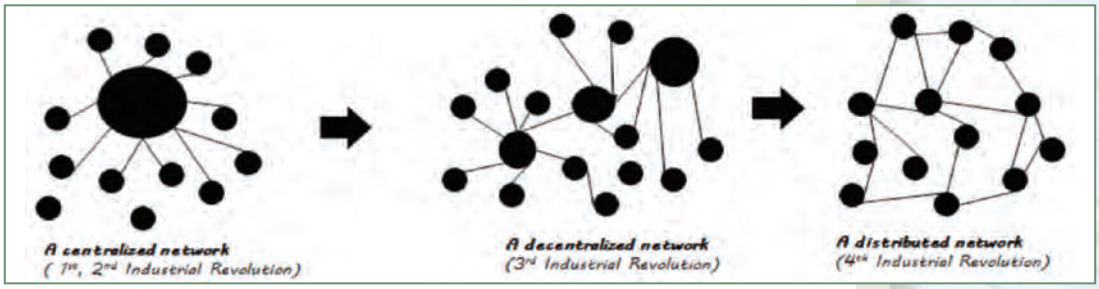
The McKinsey document prepared for the Fortune Vatican forum in 2016 and updated in 2017 paints the following picture:

"The world of work is in a state of flux. There is growing polarization of the labour-market opportunities between high and low-skill jobs. Unemployment and underemployment, especially among young people, and stagnating incomes for a large proportion of households are increasingly notable. Migration and its effects on jobs has become a sensitive political issue in many advanced economies. The development of automation enabled by technologies including robotics and artificial intelligence brings the promise of higher productivity; increased efficiencies, safety and convenience, but these technologies also raise difficult questions about the broader impact of automation on jobs, skills, wages, and the nature of work itself."[69]

8.2.1 The Changing World of Work

Industrial revolutions have resulted in a move from a centralised, narrow and limiting architecture of human capital and work, to a more distributed and augmented architecture today. As indicated in the figure below (Figure 30), the fourth industrial revolution is represented by a distributed network where all connections have equal power and market size grows. This leads to a multi-product society that is personalised. The new era of 4IR differs from the previous era of 3IR which is represented by the dispersal of powerful centralised hubs.

Figure 30: Industrial Revolutions and Network Relationships[70]



The silo thinking typical of the third industrial revolution with its powerful centralised hub-based economic structures will not be relevant in the fourth industrial revolution. As the fourth industrial revolution is characterised by the blurring of lines between cyber-physical systems, so the emerging economic architecture of the new era will start to reflect this reality in its structure.

Terms such as the social economy, rural economy, green economy, creative and knowledge economy are being used to describe emerging sectors for the fourth industrial revolution which will manifest in future areas of work. These "economies" span multiple sectors, for example, the creative economy refers to an economic system which focuses on creative qualities rather than the typical sources of land and capital and includes the creative industries, innovations and design from the IT, agriculture, mining and many other sectors etc. Increased collaboration and cross sector cooperation will be the hallmark of the fourth industrial revolution.

The Journal of Open Innovation in an article on how to respond to the fourth industrial revolution refers to the "Entrepreneurial state" which "intensively and directly invests in fields whose social value is high but not immediately shown, such as renewable energy, social innovation, senior citizen welfare, environmental risks, and the resolution of disparities among ages, regions, and classes."[71].

69 Mckinsey Global Institute: Technology, Jobs and the Future of Work (Briefing note prepared for the Fortune Vatican Forum), Dec 2016, updated Feb 2017

70 Source: Journal of Open Innovation: Technology, Market & Complexity. How to respond to the fourth industrial revolution, or the second information technology revolution? Dynamic new combinations between technology, market and society through open innovation.

71 Journal of Open Innovation: Technology, Market & Complexity. How to respond to the fourth industrial revolution, or the second information technology revolution? Dynamic new combinations between technology, market and society through open

Some of the emerging changes to the world of work include the evolving nature of paid work, the dependence of knowledge work on the internet, the reduction in commuting time that has been enabled by the advancements in technology and the gains in higher productivity as technology increases the velocity of transactions possible within a given time frame. This has also led to a world characterised by work intensification. Issues of reduced commuting time for workers and work-life balance come into sharp focus and so do the issues of greater work autonomy and flexibility. Health and safety issues also are evolving and a few challenges in respect of these lie in the wake.

Most reports indicate that the untapped and underutilised labour reservoirs around the world are women, youth, the disabled, and aged. These pools of untapped labour can be brought into productive use by tapping into the potential and opportunities brought about by technological development as these do not require employees to work from the premises of the employer and many can use information technology tools and equipment to provide services efficiently to a variety of employers in shorter time and in more productive forms as technology trends indicate the speed productivity and velocity of work are enhanced by technology.

As current work skills are quickly becoming redundant , the gig economy, freelancing and growing skills instability are marks of the new world of work.

In BRICS countries the response to the debates and the establishment of responses has been mixed. It is reported in the literature under review that in Brazil and India public interest in the issues raised by the proliferation of technology and the policy responses of government has been slow to pique public interest. It is reported that thus far in both Brazil and India national debate about various responses and the merits thereof has been muted even though various civil society and state actors are increasingly organising conferences and cohering papers and panels to discuss growing concern about air pollution and traffic congestion in the major urban areas of BRICS countries from India to Brazil – and in the context of discussions of solutions thereto, the issue of the evolving location of work and the impact of ICT on population working habits is increasingly rising and being discussed for the potential solutions that lie in promoting these through legislation and policy instruments of various kinds.

In the BRICS countries the studies that do exist indicate generally positive effects on individual performance, as reported in the national studies from Argentina, Brazil, India and even Japan and the United States. These studies support the conclusion that technology generally has a positive effect on individual work performance. More studies on the impact on family life, work-life balance and society in general are recommended for investigation.

WEF in a position paper on the subject of a Reskilling revolution writes that "Education is and will remain critical for promoting inclusive economic growth and providing a future of opportunity for all. But as the technologies of the Fourth Industrial Revolution create new pressures on labour markets, education reform, lifelong learning and reskilling initiatives will be key to ensuring both that individuals have access to economic opportunity by remaining competitive in the new world of work, and that businesses have access to the talent they need for the jobs of the future. The Fourth Industrial Revolution is causing a large-scale decline in some roles as they become redundant or automated."[72]

Researchers indicate that many of the existing education systems even in the developed world have not kept pace with the needs of the economy and the technical skills revolution for the new economies. The ILO states that, "the current education systems need to be examined given the arrival of the Artificial Intelligence-based wave of technological change. Its current set up as a young-age, once for all type of system of skills provision is no longer sufficient when it comes to retaining workers who expect to have increasingly lengthy

innovation

72 WEF White paper: Accelerating Workforce Reskilling for the Fourth Industrial Revolution. An agenda for leaders to shape the future of education, gender and work, July 2017

work careers."[73] Thus, it can be reasonably predicted that a mass revolution in education as we know it will occur over the next few decades as human beings respond to the skills needs of the 4th Industrial Revolution. Throughout the increasing proliferation of research and literature on skills and the 4IR the emphasis on the importance of lifelong learning is made throughout.

According to McKinsey, "Educational stems have not kept pace with the changing nature of work, resulting in many employers saying they cannot find enough workers with the skills they need. In a McKinsey survey of young people and employers in nine countries, 40 percent of employers said lack of skills was the main reason for entry –level job vacancies. Sixty per cent said that new graduates were not adequately prepared for the world of work. There were gaps in the "technical skills such as Stem subject degrees, but also soft skills such as communication, team work, and punctuality."[74] Conversely, even those in work may not be realizing their potential. In a recent global survey of job seekers conducted by LinkedIn, 37 per cent "of respondents said their current job does not fully utilize their skills or provide enough challenge." [75] Indeed, it seems that technological skills will be called for when digital products and services are required. It is predicted by the ILO that for a while these new type skills sets will remain scarce or in short supply for decades – as policy and societies catch up.

Over and above technical and digital skills the following "soft" skills are critical: Complex problem-solving skills, Critical thinking skills, Integrative ability, People Management, Communication skills, Coordinating with others, Creativity, Empathy/caring, Judgement and decision-Making, Cognitive flexibility, Emotional Intelligence, Negotiation. It is these core competency skills that will allow workers to add value that machines cannot and fulfil functions and tasks that only human beings are capable of.

One of these skills is creativity, which will be a competitive advantage in the age of the robot worker. This competency is up from tenth place on the WEF's list of critical skills in 2015 and now third in "2020, behind only critical thinking and complex problem-solving skills. Workers will need to become more creative to get the most out of new technologies, and to ensure their skills remain relevant in an increasingly competitive, shrinking global labour market."[76]

While new technologies and computerization may dispose of the requirement for specific types of labour and work, they will likewise open up already unheard of opportunities in enterprises that blossom with imagination and development. What sets humans apart from machines is creativity. Proof that mental and physical prosperity is foremost to imaginative reasoning will turn the memorable trade of human well-being for monetary development on its head.

8.2.2 Jobs of The Future

The WEF Report of the Future of Jobs has stated that the coming years will see new work roles emerging, some work roles remaining stable and many becoming redundant. Existing roles expected in increase in demand up to 2022 include E-commerce & social media specialists, data analysts, data scientists, software developers, application developers i.e. tech-based jobs. Other jobs that will grow include those requiring people skills such as organisational development specialists, sales and marketing professionals, learning specialists, customer service workers, and people and culture specialists. Artificial Intelligence and machine learning, big data, information security analysts, blockchain specialists, robotics engineers, and human-machine interaction designers are among some of the new specialist roles required.

73 Work for a Brighter future; Global Commission on the Future of Work; International Labour Organisation (2019) Paper Series ILO
74 McKinsey Global Institute: Skills Shift. Automation and the Future of the Workforce, May 2018
75 McKinsey Global Institute: Skills Shift. Automation and the Future of the Workforce, May 2018
76 https://www.creativenz.govt.nz/blog/creativity-will-boost-career-prospects-in-the-fourth-industrial-revolution

8.2.3 South Africa Diagnostic

Aspects of the South African People and Skills diagnostic include the people (their skills, employability, quality of life), institutions of work, learning and development (the skills ecosystem and the future of work (emerging sectors)) as well as an enabling environment required to facilitate human capacity development (legislation, governance) (Figure 31).

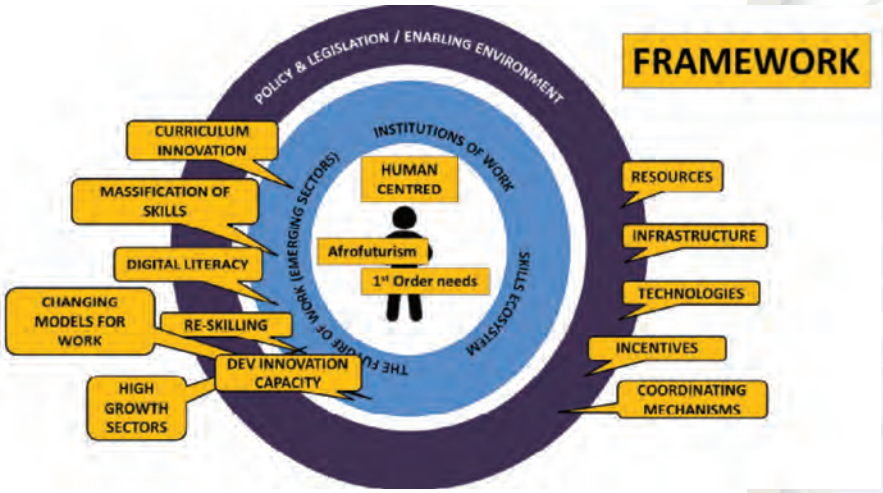


Figure 31: Human Capital and Future of Work Framework

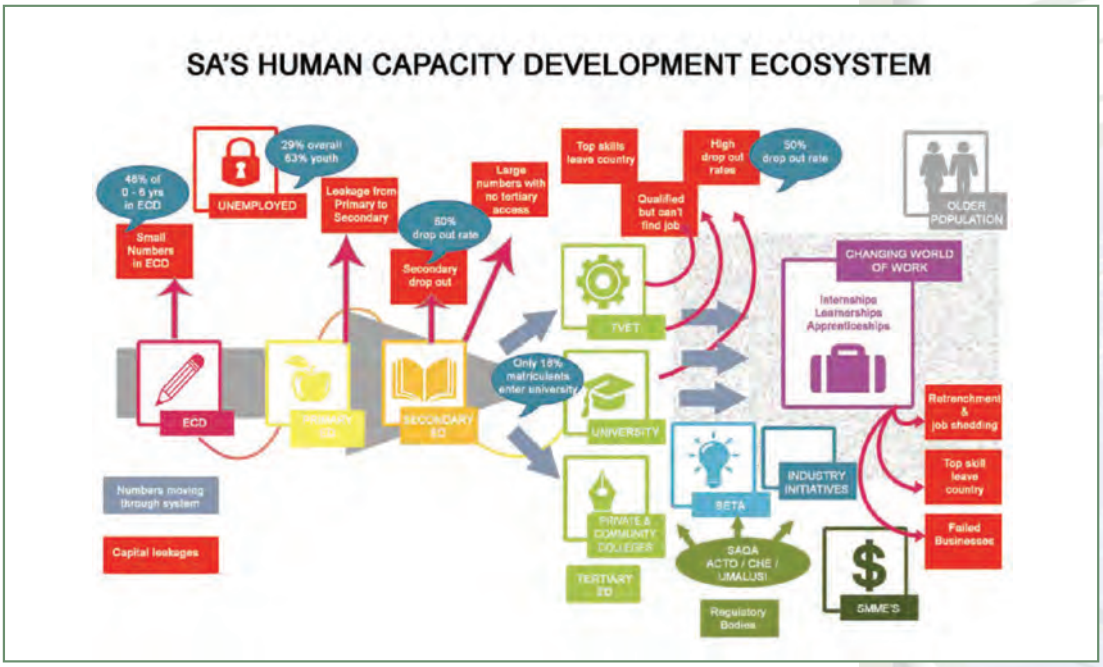
South Africa has 58,78 million people[77]. This figure is projected to grow to 64,4 million by 2030[78]. Two thirds of the South African population are below the age of 35 years[79]. This is often presented as an opportunity because more people are available for productive work. The current fact is that too many of these young people are without work. Moreover, a lot of South Africa's young people are not yet equipped to produce productive work in the context of the 4IR.

According to a study by the World Bank, only a quarter of South African secondary school learning are work ready. This is compared to 96% in Singapore[80].

A factor critical to agile response to 4IR is the levels of digital literacy in the country. The percentage of the adult population that uses a smartphone in South Africa is at 60%, and one assumes general proficiency in the use of these devices. The number of internet users from the total population is 54%.[81] Basic digital literacy skill levels are low. The patterns of proficiency show higher digital literacy in urban areas and lower levels in rural areas. Unequal access to connectivity and high data costs significantly impact the access of the majority of the South African population to maximise the enabling effects of technology in their learning, homes and work environments. Figure 32 gives a high-level view of the human capacity ecosystem in South Africa.

77 StatsSA
78 worldpopulationreview.com
79 Department of Higher Education and Training 2019
80 World Bank 2019
81 Nedlac: Futures of Work in South Africa, March 2016. Institute for Futures Research

Figure 32: SA's Human Capacity Development Ecosystem



While the environment is more complex than is possible to illustrate, the diagram is intended to show the public skills ecosystem for human capacity development, as is it the public education system that serves the majority of South Africans, and our logic is that it is in this context that interventions to leverage 4IR will have the most social and economic impact. The diagram also shows the leakages of human capacity from our system.

8.2.3.1 Challenges in the South African Education System

South Africa's public education system is severely underperforming in equipping learners with the necessary skills to become productive labour participants. The mushrooming of private schools is a consequence of this under-performance. Unfortunately, too few can afford a private education option.

ECD

Almost half of South African children do not have access to early childhood development opportunities. This puts many young South Africans at a learning disadvantage even before they enter the formal education system. The StatsSA 2016 Report on Early Childhood Development estimates that 46,9% of children (age 0 – 6) are not attending an education institution. Recent pronouncements by government to prioritise this sector will assist to address this issue. Critical competency skills such as creative thinking, critical thinking and problem solving are hugely impacted by the cognitive development which takes place in the foundation phase of a child's education (up to 7 years) and the optimal time for developing this ability in the pre-school and foundation phase years.

Basic Education

Our primary education system is the place where the highest numbers of people are present in the system. It is in the ECD and foundation phases that we have the maximum opportunities to impact our human capital development in terms of competency skills. There is a small leakage of human capital from the system between primary and secondary school, and another significant leakage during secondary school. It is

estimated that 60% of learners who started grade one drop out before grade twelve. Most of the dropout happens in grades eleven and twelve. The human capacity leakage here goes into the youth unemployment pool or into low end jobs requiring unskilled labour. The weight of joblessness is concentrated among the young (aged 15–34 years) as they represent 63,4% of the absolute number of jobless people. Just about 4 in each 10 youngsters in the work force do not have an occupation, with the joblessness rate inside this group at 39,6% in the first quarter of 2019.[82]

Despite the numerous challenges and hard realities facing our formal education system, there are some encouraging moves afoot to align the current Basic Education System with the needs of the 4th Industrial revolution. The Department of Basic Education began a process in 2015 of preparing for 4IR, which included having the current curriculum assessed for relevance. This was done in conjunction with the Brookings Institute. The findings were that our curriculum adequately covers the four competencies used as a benchmark for 21 century-ready curricula i.e. critical thinking and problem solving, creativity and innovation, collaboration and working as a team, communication and digital literacy. It may be said that although these competencies are embedded in our curriculum, as a country we are not seeing the results. This points to the problem potentially lying with the delivery and teaching of the curriculum as the point of breakdown.

In addition to assessing the curriculum, the Department of Basic Education (DBE) has also developed a coding and robotics curriculum for grades R – 3. DBR reported that most countries start this type of curriculum later in the schooling journey and South Africa is being lauded for starting this intervention at an earlier stage. In 2020 the coding and robotics curriculum for grades 4 – 9 will be developed.

A new streaming model for secondary education is being developed in an attempt to create pathways for learners to pursue a variety of academic, vocational and occupational directions at school level. In some ways this strategy makes the current role of the TVET colleges redundant, or at least requires the TVET system to operate at a higher qualification level to promote continuity from secondary to tertiary to the job market. There is also a danger in the implementation of the streaming option that the current inequalities in terms of the spread of skills will persist and in fact be exacerbated.

Challenges, as expressed by the DBE, in implementing these changes include a lack of resources (human capital expertise, strategic capacity, financial resources), teacher re-orientation and training and direct linkages to industry to facilitate job market uptake for school leavers.

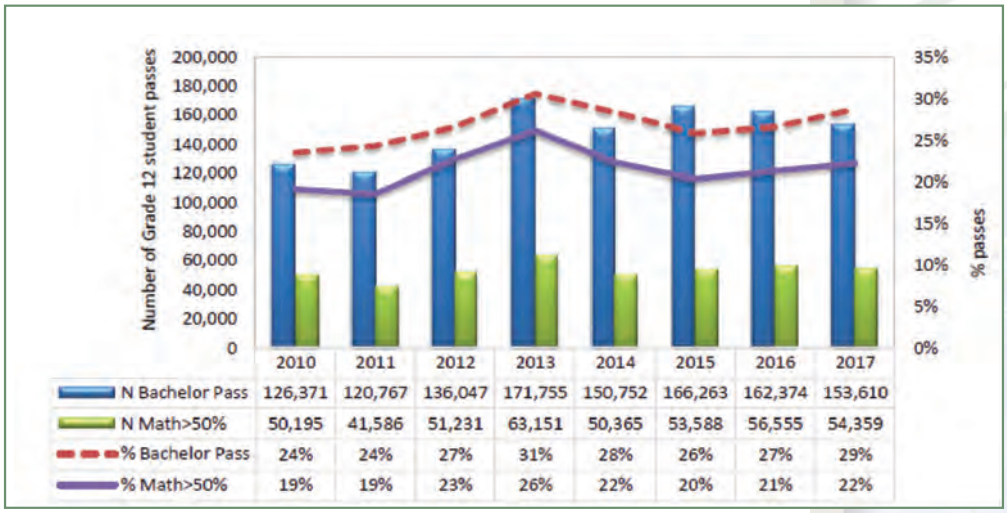
The public schooling system does not have an overt focus on creating learner competency in creativity, critical thinking and problem solving. In order to have creative thinking, whole brain thinking is required. The exclusion of the arts as a priority learning area, taught by qualified practitioners is a factor in limiting the creative thinking and problem-solving ability of youth. The inclusion of STEAMIE (Science, Technology, Engineering, Arts, Mathematics, Innovation & Entrepreneurship) subjects is becoming a focus worldwide as preparation for 21st century skills, where the arts and humanities' role in facilitating whole brain development and creative thinking elevates learning of STEM subjects. In South Africa, where STEM is at the beginning stages of being introduced, we have the opportunity to implement STEAMIE approaches from the outset.

8.2.3.2 Higher Education and Training

The end of the secondary phase represents the next human capital leakage. According to the Department of Higher Education and Training (DHET 2019), between 2010 and 2017, the proportion of learners achieving matriculation with bachelor's pass increased by five percentage points from 24% in 2010 to 29% in 2017 (Figure 33).

82 StatsSA, www.statssa.gov.za

Figure 33: Number and percentage of learners achieving matriculation with bachelor's pass and Mathematics (DHET 2019)



	2010	2011	2012	2013	2014	2015	2016	2017
N Bachelor Pass	126,371	120,767	136,047	171,755	150,752	166,263	162,374	153,610
N Math>50%	50,195	41,586	51,231	63,151	50,365	53,588	56,555	54,359
% Bachelor Pass	24%	24%	27%	31%	28%	26%	27%	29%
% Math>50%	19%	19%	23%	26%	22%	20%	21%	22%

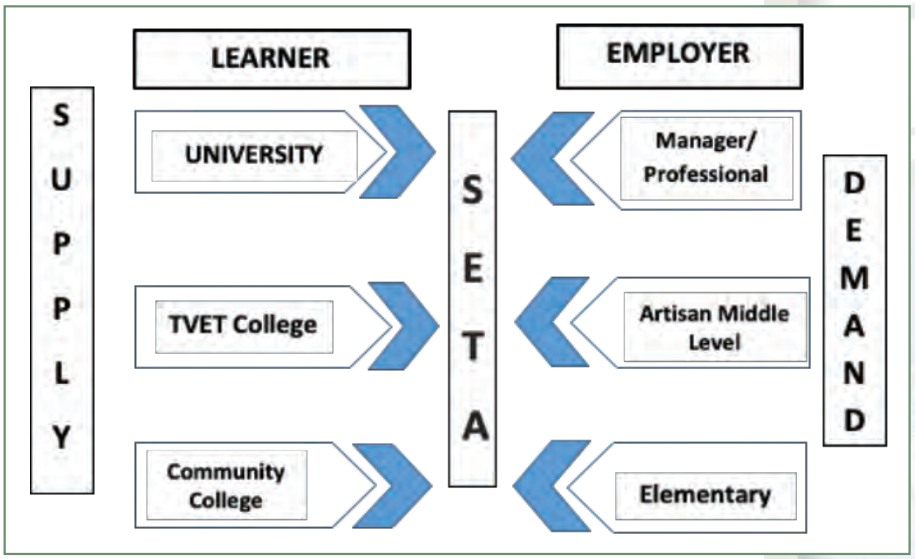
Mathematics and Science subjects remain elusive. This poor foundation impacts negatively on the types and quality of skills entering the labour market. In a report commissioned by the Centre for Development and Enterprise (CDE) on the quality of education in South Africa in 2013, it is concluded that South Africa's level of performance, measured in the maths and literacy categories, is substantially lower than the required curriculum levels, as well as being below most African and all of the middle-income countries participating in similar studies. Recent assessments of the South African education system showed that 78% of grade four learners in South Africa fell below the lowest levels on the Progress in International Reading Literacy Study (PIRLS) 2016 tests. This essentially means they cannot understand what they are reading. South Africa was ranked 50 out of 50 countries surveyed, coming in just behind Egypt and Morocco.[83]

The nature of matriculation (Grade 12) pass rates, especially the marker of the quantity of bachelor's passes, gives a sign of the potential pool accessible to enter post-school education and training establishments, particularly in specialized sectors. The majority of the ICT skills require mathematics as a prerequisite, which puts South Africa in a position where regardless of the high number of youth we have, not enough are eligible to be skilled in these critical fields to meet the 4IR ICT skills demand.

he current higher education/ tertiary skills ecosystem in South Africa, comprised of Universities, Technical and Vocational Education and Training Colleges (TVETs), Community Education and Training Colleges, SETAs, Employers (incl. SMMEs) and Collaborations (Multi-stakeholder provision) (Figure 34).

83 http://theconversation.com/south-africa-has-a-reading-crisis-why-and-what-can-be-done-about-it-88711

Figure 34: Higher Education Skills Ecosystem



The ecosystem is designed with the Seta's and TVETs at the centre of the model and is designed to fit the requirements of a third industrial revolution economy. It is also characterised by a "silo" mentality and the speed at which the entities are able to adapt and change curricula, understand the needs of the workplace and create accredited training solutions is questionable. The TVET system, although identified in WEF and other literature as becoming pivotal structures for 4IR skills and training, has not been effective in delivering its mandate in South Africa and a complete overhaul of this system would need to be engaged.

There is a challenge on the supply side with massive leakages from the secondary education system. On the positive side, South Africa invests substantial resources into education and training, both from a government and private sector point of view. The country also has an extensive education reach in terms of the entities above being spread throughout all nine provinces, and although there are infrastructure challenges, there is an extensive skills network in place which can be leveraged to leapfrog skills to mass recipients. The question is how to maximise the current infrastructure while identifying the pivot point in this ecosystem to shift it to be relevant, efficient and agile for skills delivery in the fourth industrial revolution.

Approximately 18% of matriculants go to universities, but half of these drop out. University enrolments in 2016 were at approximately 1.1 million, TVET colleges at 700 000 with approximately 160 000 are enrolled at Community Colleges and 90 000 at private institutions. TVET completion rates were approx. 60%, Community College completion rates were 36% and the completion rate at Seta supported programmes was 72%. [84] The majority of youth end up forming part of the pool of unemployed youth or unskilled labour. According to StatsSA approx. 3.3 million (32,4%) out of 10.3 million young people aged between 15-24 are not in employment, education or training.

Yet another leakage happens after accredited skilling through tertiary channels as according to StatsSA, the graduate unemployment rate is 33.5% for those aged 15-24 and 10% for those aged 25-34. These graduates are unable to find work and join the ranks of the unemployed. There is also a loss at this point as those who are able to leave the country with their skills to work overseas. Much has been written of late about the sharp rise in skilled South Africans leaving the country. It is difficult to quantify this leakage accurately as data on South Africa's brain drain is not current. It is however agreed that there is a significant loss of human capital to emigration.

84 Statistics on Post-School Education & Training in South Africa: 2016

At present, the South African youth are most affected by the relatively weak performance of the South African economy. By virtue of stagnated growth, coupled with a skills mismatch, youth are excluded from being absorbed into the workforce constituency. The current youth unemployment rate bears testimony to this occurrence. This places the future of South Africa in a vulnerable position, since the critical mass of labour force lies within the youth population.

Systemic Structural Issues in the Skills Ecosystem

Educator Ken Robinson (Figure 35) in his book, Creative Schools, states that "Our current education system is a construct of the third industrial revolution. It was developed in response to the demands of a 3IR economic system. The problems of the current education system are not accidental by-products of standardised education; they are a structural feature of these systems. They were designed to process people according to particular conceptions of talent and economic need and were bound to produce winners and losers in just those terms."[85]

We must guard against making changes in the existing system which are not portable and attempt to initiate changes which are catalytic to structural change, as it is inevitable that the education system will evolve structurally to reflect the architecture of the 4th industrial revolution over time. Thought must be given to flexibility, agility, speed of accreditation, integration of learning streams, mobility of learners, remote content delivery and cognitive flexibility and the use of technology to enable the efficiency of the skills delivery system.

3RD INDUSTRIAL REVOLUTION STRUCTURE	3IR EDUCATION SYSTEM STRUCTURE
Industrialism needed more manual workers than university graduates	Built like a pyramid with broad base of compulsory elementary education for all, smaller sector of secondary education and narrow apex of higher education
Purpose of industrial manufacturing is to produce identical versions of the same products. Items that don't conform are thrown away or re-purposed	Mass education systems designed to mould students to certain requirements. As a result, not everyone makes it through the system and some are rejected by it
Industrial processes demand compliance with specific rules and standards	Standards movement in education is based on compliance in curriculum teaching and standardised assessment
Industrial processes are linear. Raw materials are turned into products through sequential stages, each with some form of testing as a gateway to the next	Mass education is designed as a series of stages from primary to high school to higher education with students organised into separate year groups and progress through the system in batches defined by date of birth. Periodic tests determine who goes down which route and when
Industrial production is related to market demand. As it rises and falls manufacturers adjust production to meet it	Admittance to universities was tightly controlled as industrial economies need comparatively few administrative and professional workers. In more recent times the demand for intellectual labour has grown and the doors to universities have been flung open in increase the flow of graduates into the economy.

85 Creative Schools, Robinson K. & Aronica L, 2016

3RD INDUSTRIAL REVOLUTION STRUCTURE	3IR EDUCATION SYSTEM STRUCTURE
Time is organised around the division of labour (factories)	In high schools the day is usually segmented into regular chunks of time and everyone changes tasks and rooms when the bell rings. Teachers specialise in specific subjects and move from class to class in separate segments
Industrial processes commonly overlook the value of raw materials that are not relevant to what is being made	Preoccupation with particular subjects and types of ability means that students' other talents and interests are systematically marginalised
Most industrial processes generate huge amounts of waste ad value by-products	Education reflects this in the huge number of drop outs, disengagement, low self esteem and limited employment opportunities for those who don't succeed in the system
Industrial processes can create catastrophic problems in the environment. It's often left to other to clean up the mess (externalities)	Students who feel alienated by the current education system of standardisation and testing and exit the system become the responsibility of themselves and others (unemployment benefits, social programmes, etc.)

Figure 35: Third Industrial Revolution Education System

Source: Creative Schools, Ken Robinson and Lou Aronica

South Africa has a robust labour environment and ideological tensions exist in terms of the redistribution vs growth debates. There is currently a low growth rate, high unemployment and huge recent job losses in several sectors including banking and mining. The changing world of work and the weak state of our economy causes leakages at the work stage of the system due to retrenchments and job shedding, as well as highly skilled individuals taking better offers outside of South Africa. There is a need to re-skill workers whose jobs are being made redundant by technology and the changing business models brought about by the fourth industrial revolution. How do we re-skill and for which jobs? Who is responsible? It is critical that solutions for the unemployed, retrenched and workers whose jobs are under threat in the context of the fourth industrial revolution are sought in the short term while planning for medium and long term impact the changes the fourth industrial revolution is bringing to industries.

Many of the unemployed have ventured into starting small businesses and survivalist enterprises. While the South African government has put a strong focus on SMME sector support, this is still a struggling sector and, in many cases, has not yielded quality of life and decent work. There are inadequate social protection systems and incentives for entrepreneurs, high barriers to entry through bureaucracy and a lack of venture and risk capital pools to leverage growth.

Another pool of human capital that remains disconnected from the system is the aged population. Although South Africa's median age is currently low, research points to the portion of people aged 55 and older increasing significantly. In South Africa these are some of the most vulnerable people in our society with unsuitable skills, not economically active, in poor health and with limited social protection networks. With South Africans living longer the role of a system that supports and enables economic participation and the development by educational institutions of short courses and further training interventions focused on the development of entrepreneurial intelligence and other skills of people aged 40 and above is important. [86]

86 Using Futures Studies Methodologies to Explore the Economic Participation of the Older Cohorts of South Africa's Population Towards 2030: Andre Roux, Doris Vijoen, 2018.

To adequately link our entire human capital pool into productive, decent work and allow quality of life for all, a comprehensive view of the entire human capital system must be developed, and the leverage points identified which can be accelerated by 4IR. The approach must be inclusive and 4IR technologies also provide an opportunity to address issues of disability and access.

It must also be acknowledged that while skills are foundational for human capacity development, the underpinning areas of health and wellness, nutrition and prenatal care, access facilitated by transport systems and infrastructure, digital connectivity and affordable data, as well as crime, gender-based violence, safety and security, are all enabling factors for productive learning and work.

8.2.4 Changing world of work in SA

South African exists in the global context which impacts on the future of work. At the same time the country has a local context of unemployment, inequality, ideological tension with regards to economic approaches and slow economic growth.South Africa is one of the countries that are most vulnerable to 4IR disruptions. If one considers the latest Human Capital Index (HCI) figures from a World Bank study, it shows that South Africa's HCI is just over 0.4, similar to that of Benin and Malawi. The significant difference is that South Africa has a larger GDP per capita. This means that South African still has economic opportunity, but the majority of its citizens are not equipped to take full advantage of this opportunity. South Africa ranks poorly with life expectancy and inequality and ranks average on wellbeing and ecological footprint.

As the world takes note and stock of the effects, patterns, innovations and changes that have been brought about by the digital revolution of the 21st Century, South Africa stands poised to learn from international best practice and world-class thought on how to harness the beneficial effects of digital and ICT changes as well as a trend towards automation and the use of artificial intelligence to, at once resolve its perennial problems of high unemployment, decent jobs, inequality and poverty. At the same time, the country has a unique opportunity to take stock of our vast potential in the form of our human capacity, identify opportunities consistent with promoting a human centred, Afro-centric strategy for the future and look at ways to coordinate the substantial existing work and platforms established for this purpose in the country already.

The advent of the 4th Industrial Revolution (4IR) in South Africa brings with it many exciting opportunities, while at the same time, creates a degree of anxiety. Given the current unemployment rate, those who are still employed feel uneasy about the fate of their employment status when considering the effects that automation will have on the economy. This has a detrimental effect on the psyche of an individual due to the satisfiers of their first order needs being jeopardised.

In general, the South African workforce could be classified into two categories viz. knowledge workers and manual workers. The former refers to individuals who use theoretical and analytical skill sets, acquired through formal training, to develop products and services. The latter refers to individuals who use their "hands" to perform their work.

Work that has a high potential to be automated includes physical manual labour, machine operations and manoeuvring, technical equipment maintenance, processes and analytics. As it is observed workers in the lower to middle levels will be more likely to be the first affected. About 60% of the labour force in South Africa occupies roles consisting largely of automatable tasks. The majority of employers in South Africa say that less than 25% of their employees are ready to work with new technologies and machines.

In order to develop an all-encompassing and sustainable roadmap for the future of work in the South African context, both of the above-mentioned work force classifications must be considered. The execution of the roadmap ought to be planned in a phased approach which deals with the current status of the South African workforce as well as the development of unemployed youth towards being absorbed into the industries of the future.

The WEF Africa Skills Initiative states that "The key challenge for the region entails reshaping countries' skills development agendas in line with their exposure to the jobs landscape of the future. While a large cluster of African countries currently have a comparatively low capacity to adapt to the requirements of future jobs, their relative exposure to these trends, at least for now, is also still somewhat limited. These economies have a window of opportunity for engaging in long-delayed reforms and their efforts should particularly focus on strengthening basic education as well as building a strong TVET system to lay a good foundation for the future."[87]

It further states, "a second group of countries—including Kenya and South Africa—have a somewhat higher capacity to adapt but are also more immediately exposed to the job disruptions of the Fourth Industrial Revolution. In these countries, urgent reskilling and upskilling efforts are needed, focusing in particular on strengthening higher education and adult learning."

South Africa has a highly structured skilling ecosystem but there is a question as to whether it is flexible and agile enough to be responsive to the current skills development needs. The current skilling approach in South Africa focuses more on those entering the workforce for the first time and those who are unemployed. The current skills programmes emphasize more on the specific-occupation technical skills vs the critical cross-cutting skills. The current skills development model acknowledges clear boundaries between learning centres and workplace. The cross-cutting soft skills are skills that cannot necessarily be developed through a school curriculum. Most of them can be developed by immersing a learner in real life environment. This then calls for an approach where there is blurring of the lines between learning centres and workplace. There is therefore a need to revise the current skills development model.

There are numerous industry programmes for skills development developed within companies as they grapple with the changing skills landscape. Professional development plans need to prioritise competency skills/soft skills in order to prepare professionals for the changing world of work. Education and industry partnerships have also been established. The Department of Higher Education is partnering with the DTIC and the manufacturing industry, for example, to establish skills centres for skilling and reskilling. Centres of specialisation have been established for skills transfer. The DTIC is also partnering with the CSIR and industry to establish "learning factories" in several provinces.

A national digital skills strategy has been developed by the Department of Communications, intended to provide a framework for the prioritisation of critical digital skills necessary for 4IR.

The Department of Higher Education and Training is currently reviewing the national Human Resource Development strategy via a task team established for this purpose. Part of the task team's mandate is to ensure this strategy is 4IR aligned.

If one takes into consideration the rapid changes and advancement in technology, there is a need to also focus on those workers who are about to lose their jobs due to automation.

Africa's CEOs refer to inadequate comprehension of the disruptive changes in progress as the single greatest obstruction to future workforce planning, trailed by asset limitations and deficient arrangement of firms' talent procedures with their more extensive innovation techniques. Joint effort among business and the education sector is likewise restricted. Moreover, there is generally little cooperation among the organizations that are trying to address aptitudes gaps in their very own workforces just as the communities around them, bringing about uncoordinated, possibly inefficient, endeavours.

South Africa has been participating in global and international forums that have been seized with these issues and has begun to contemplate serious policy options to optimize the country's response to the looming challenge. Many industry initiatives and government initiatives are underway, along with industry-government

87 World Economic Forum: The Future of Jobs and Skills in Africa. Preparing the region for the fourth industrial revolution. WEF (Executive Briefing), May 2017

partnerships to look at these issues. A concern is the silo approach and potential duplication of resources with these interventions being developed in isolation of a broader human capacity country strategy.

The issue of legislation and policy in the context of creating jobs in the digital era has been extensively written about. The report by the African Development Bank identified education and research development, public multi-disciplinary spaces, digital infrastructure, business registration, finance for innovation and entrepreneurship, access to local and pan-African markets, intellectual property rights and taxation as areas that need policy review in order to foster digital transformation and create job[88]. Furthermore, there are specific guidelines outlined by the International Labour Organisation on how the gig-economy should be promoted and integrated into mainstream work by creating and recognising specific categories of work into law[89]. This is likely to have an impact on other pieces of legislation such as taxation.

Global 4IR trends will impact different sectors and industries in different ways. The Nedlac Research reference Group commissioned research into emerging trends in 12 industries as part of their "Futures of Work in South Africa" report, this includes sectors such as healthcare, the informal sector, energy, mining, agri-processing, education, transport, public sector, services and financial sectors.[90]

8.2.5 SA 4IR Opportunities, Centres of Excellence

Ensuring that South Africa's greatest asset, its people, are adequately prepared for and receive maximum benefit from the 4th Industrial Revolution presents a challenging and complex task. The country has substantial inequality gaps, high unemployment levels (particularly among the youth) and other associated socio–economic problems. However, the 4th industrial Revolution also provides unprecedented opportunities for South Africa to leapfrog and mainstream historically marginalised citizens. The things that mattered in the past may not be the foundations upon which we build a sustainable 4IR strategy. And despite the commentary on technology, knowledge in Artificial intelligence and other related 4IR technologies may not be enough to propel South Africa into the imminent 4IR future.

The Commission is of the opinion that the initiatives to meet the 4th Industrial Revolution not be interpreted as adjusting humanity to the new landscape – but rather transitioning societies and people to better cope in the new digital economy and to ensure that a greater diversity of people and previously marginalised sectors increasingly participate in the world of work in the interests of economic growth and human progress. Thus, the improvement and development in the living standards and conditions of workers while safeguarding their human rights, is a great focus. Stepping up investment in institutions, policies and actions that will support people through the future of work transitions is a major principle contained and explained in the position papers of the Global Commission on the Future of Work.

Currently, the South African 4IR Human is ambitious and dreams of a better life. They are, however, excluded from the mainstream economic opportunities and the fact that they do not have the knowledge and skills to compete globally makes it harder to find a job, earn an income and make choices that better their lives. The 4IR context does not make things easier, it makes it even harder. This is why this paper call for a core focus on human capacity development. One of the most important objectives of South Africa's 4IR should be to re-integrate the South African 4IR Human into the thrust of the main economic engine.

This requires a human centred agenda for responding to the 4IR in a South African context in order to capitalises on our unique strengths and the vast demographic dividend we have in the form of our youth. We need to position South Africa's competitive advantage as one of human capacity, supported by technology. South Africa and the rest of Africa are positioned to provide the world with the human skills that are needed for the 4IR with technology as an enabler. This requires radical shifts in our current human capacity ecosystems

88 African Development Bank: Creating Decent Jobs – Strategies, Policies and Instruments, 2019
89 International Labour Organisation: The rise of the "just-in-time workforce": On-demand work, crowdwork and labour protection in the "gigeconomy", 2016
90 Nedlac: Futures of Work in South Africa, March 2016. Institute for Futures Research

(including re-thinking the architecture of the skills ecosystem to reflect the structure of the 4IR, accelerating upskilling and plugging upskilled youth directly into high growth market sectors and jobs of the future, re-skilling the existing workforce and facilitating changing models for work). The response needs to be Afrocentric while globally relevant and competitive, while meeting the first order needs of citizens.

South African business body BUSA put it this way in their presentation before the International Labour Organisation (ILO);" The principle of a human-centred approach is fully endorsed – this should be at the level of substantive outcomes, rather than modality. Put another way, the future of work should aim to deliver outcomes that are human-centred and that put the wellbeing of people and societies at their core. To achieve this outcome, the recommendations need to be viewed hand in glove with business requirements and emerging trends. A human-centred approach, when driven in isolation of business and country realities, will fail – it has to be firmly rooted in a human-centred approach that interconnects on going and emerging business and country needs."

This human centred agenda aligns with the framework developed by the Global Commission on the Future of Work. The below image (Figure 36) shows an adaptation of this framework, to make it more relevant to a South African context.

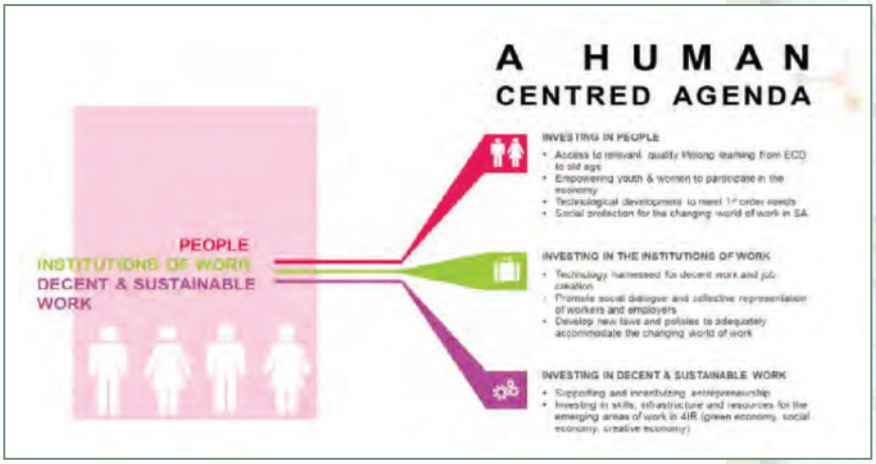


Figure 36: Proposed Agenda for Human Capital Development (adapted from Global Commission on the Future of Work's framework, with a specific focus on implementation in the SA context)

A recent report on the future of work by Accenture[91] encourages countries, like South Africa to begin to proactively take action to prevent the marginalisation of people who currently have a lower base of skills and would be rendered vulnerable and marginal by the digital economy. Their research found that the most vulnerable workers typically have a limited financial safety net and lower job security and lower proficiency in high demand skills, and they have unequal access to the kind of education that would assist them to transition to the digital economy. New skilling must therefore be developed for these vulnerable workers and further, research and investment is needed to better support workers to transition to the digital economy. These workers require proactive support and their training must emphasise future skills needs. According to Accenture, there is a need to help workers to first envision the future of work, and themselves within it. Next, it is necessary to help workers to expand their access to relevant formal and informal learning and training opportunities to grasp the new skills sets required. Further, workers ought to be assisted to simulate and experience the new forms of work and new roles once a certain level of proficiency in the new skills set had been attained and or acquired. Accenture argues that new skilling must be developed and taken seriously to prevent the social fallout that results from economic exclusion. Employers cannot quantify the impact AI

91 https://www.accenture.com/_acnmedia/pdf-90/accenture-inclusive-future-of-work-full-report.pdf

technology will have on the workforce. This creates uncertainty for workers, 57% of whom worry that their skills will become obsolete and 41% of who doubt their ability to manage increasingly complex digital tasks. In fact, only 34% of workers feel very confident in their skills and ability to work with intelligent technologies. In addition, market demand transparency compounds the problem further concerning opportunities.

Jobs, knowledge and manual, becoming obsolete ultimately results in retrenchment. In most instances, those who have been affected possess skills and expertise that are limited to the nature of work that they have been involved in. This leaves one with very few alternatives for re-employment. A viable solution for this problem lies in the establishment of alternative economies. In the global context, this alternative or emerging economies have been identified as the creative economy, circular economy and the social economy. By harnessing their already acquired skills, expertise and experience via re-skilling and upskilling interventions, employment opportunities may be created within these alternative economies. These could be in the form of formal employment or entrepreneurship. Through this process, products and services could then be developed, such that they resonate with the business requirements of incumbent industries, resulting in a supplier-buyer relationship between the old and new economies.

As presented in Figure 37, there are inter-relationships between each of the alternative economies wherein sustainable business ventures may reside. For example, consider the accessibility of rural areas to news, advertising and public announcements through digital mediums of communication. The establishment of a digital marketing company, that identifies rural communities as their target market, would find itself in both the creative economy as well as the social economy. Through leveraging existing 4IR technologies, such a digital marketing company could serve as a bi-directional bridge between mainstream economies and rural areas. There are numerous opportunities that exist in the South African context which are similar to those mentioned in the example above. As markets and economies grow, these entities have the potential of being absorbed into the value stream of the incumbents by means of acquisition, joint venture or the like.

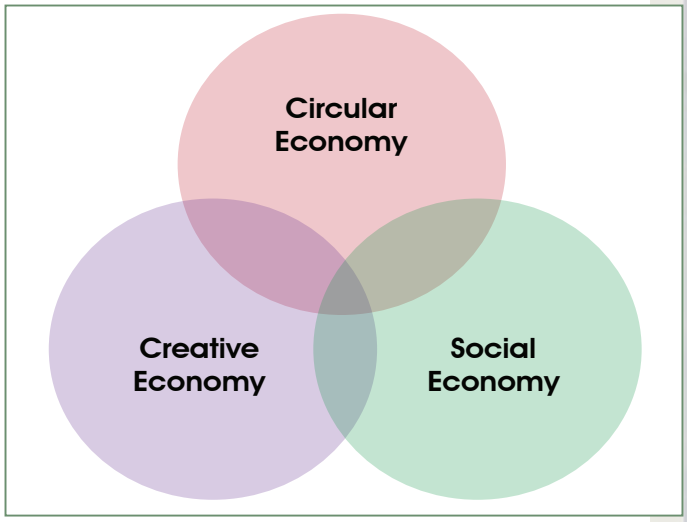


Figure 37: Future of work ecosystem

Our country, South Africa, not only has to innovate its curriculum design and adapt the way that it creates and prepares its young people for the new world of work, South Africa also has to consider the significant economic significance of what is happening in the context of low growth and major skills and social backlogs like abnormally high structural unemployment. South Africa has to examine and contend with creating the challenge of generating new skills for the new era while dealing with a massive skills backlog from the industrial era – and give meaning to the belief and mantra that no citizen should be left behind.

The critical South Africa mass labour force lies within the youth population however, this demographic is predominantly unemployed. To address this problem, competitive advantages that lie within the youth population need to be identified and exploited. For instance, survivalist ingenuity coupled with the know-how of social media may provide opportunities for youth in the digital marketing space; a sector that has been identified by big business as a considerable channel to reach potential customers. The booming content production, media industries and creative industries (animation, gaming, virtual reality, augmented reality, music production) in Africa also provide accessible "onramps" for unemployed youth. The platform economy and monetising digital content are familiar work environments for these "digital natives", and with targeted skills programme could yield direct uptake in the gig economy in the short term. The sheer numbers of youth and their availability to be skilled, creates an opportunity for South Africa to become a nett exporter of skills and lead in the digital economy, similar to countries such as Bangladesh and India.

The current transformations under way in the world of work in South Africa have flexibility yet no security, therefore demanding the reinforcing and rejuvenation of the foundations overseeing work, including the foundation of a Labour Guarantee, extending time power, reviving aggregate portrayal and harnessing innovation for better than average work. These means are important to shape a fate of work with social equity, manufacture pathways to formalization, lessen disparity and working neediness, upgrade security and ensure the poise of work.

Labour Guarantee

New ways must be found to manage the cost of satisfactory security to all specialists, regardless of whether they are in all day business, executing errands on the web, occupied with locally situated generation or dealing with a brief agreement. All specialists in all types of business ought to be ensured similar social and basic rights, including a "sufficient living compensation, most extreme cut-off points on working hours and assurance of well-being and safety at work." Collective agreements or laws and regulations should raise this protection floor.

The business relationship remains the focal point of work assurance. There is a need to survey and where important, explain duties and adjust the extent of laws and guidelines to guarantee successful security for labourers in a work relationship. Simultaneously, all specialists, paying little respect to their authoritative plan or business status, should similarly appreciate satisfactory work insurance to guarantee accommodating working conditions for everybody.

Expanding Time Sovereignty

Labourers need more noteworthy independence over their working time, while addressing business needs. Harnessing innovation to grow decisions and accomplish a harmony between work and individual life can assist them with understanding this objective and address the weights that accompany the obscuring of limits between work time and private time.

Blurring of boundaries can contribute to an extension of working hours. The creation of measures to implement maximum limits on working time including a right to digitally disconnect, along with measures to improve profitability, just as least hour guarantees, will empower genuine decisions for adaptability and command over work routines. These measures ought to make working time self-governance that addresses the issues of the both labourers and businesses.

Social dialogue serves as an important tool for shaping innovative working-time arrangements tailored to both workers' and employers' needs. The reception of fitting administrative measures that furnish labourers with an ensured and unsurprising least number of hours ought to be executed. Different measures ought to be acquainted with make up for variable hours through premium compensation for work that isn't ensured and waiting time pay for periods when hourly specialists are "on call".

Invigorate Collective Representation

The strengthening of social dialogue and social partnership will enable a platform for industry growth and provide the institutional capabilities needed to navigate future of work transitions. Public policies that promote collective representation and social dialogue should further be enhanced

Labourers' and bosses' associations must fortify their agent authenticity through creative sorting out procedures that arrive at the individuals who are occupied with the plat-structure economy, including using technology. They should likewise utilize their meeting capacity to carry various interests to the table.

Harnessing Technology for Decent Work

This means, commitment that AI and ML innovations will be putting the good of people and planet first, that labourers and supervisors arrange the structure of work. It is a "human-in-command" way to deal with man-made consciousness that guarantees that ultimate conclusions influencing work are taken by people. Advances in technology additionally request guideline of information use and algorithmic responsibility in the realm of work. A National administration framework for advanced work stages ought to be set up to require platforms (and their customers) to regard certain base rights and assurances.

Multi-Stakeholder Cooperation

Securing a just 4IR transition and developing meaningful country is a task that needs to be solved through a multi –stakeholder cooperation.

Institutional role-players with a stake in managing and contributing to the future of work in South Africa include business, labour, government and SMME's.

It must be noted that in the South African context, Government acts not only as an enabler of a conducive policy and legislative environment for growth but is also an economic actor for producing goods and services in the country. Government also enables the skills ecosystem (public) which underpins human capital development opportunities for the majority of people in our country. Given the critical role of government to catalyse and implement much of the work for change for 4IR, the human capacity development of public sector employees becomes a necessary priority focus. The findings in this regard to date indicate low levels of awareness regarding 4IR and its impact by the average public sector worker, and a lack of agility within government systems to respond quickly to the changes required

The SMME sector is a critical sector for inclusive growth and the 4IR environment should see a rise in entrepreneurial activity. South Africa still ranks relatively low in global systems measuring national entrepreneurial prowess and survival rates of SMME's are low. Social protection for entrepreneurs is non-existent and very few financial and other incentives to venture into entrepreneurship exist.

A South African strategy has to acknowledge that many of our sectors are still operating in the 3IR space. A human capital strategy needs to focus on the future areas of work, while strengthening current sectors for maximum job retention, job creation and a transition from the current to future ready scenarios.

An effective and sustainable transition into a 4IR-based paradigm requires significant reform in the systems of education & training, labour market policies and the manner in which businesses approach skills development. Knowledge workers have been identified as the key resource to drive the 4IR transition. However, the current skills development ecosystem only caters for 3rd Industrial Revolution industry requirements. For an effective transition, "knowledge workers" are required to become "learning workers". A learning worker is one who is able to apply multidisciplinary concepts to solve problems using knowledge that has been acquired, through self-learning initiatives, from what is freely available on the internet. The responsibility lies with the individual to develop critical, cognitive and independent thinking skills; skillsets which enable self-learning and the application of multidisciplinary concepts to solve problems.

Possibilities for the Skills Revolution

Figure 38 describes possible approaches and points of interventions to leverage change in the existing skills ecosystem for maximum empowerment and retention of South Africa's human capital.

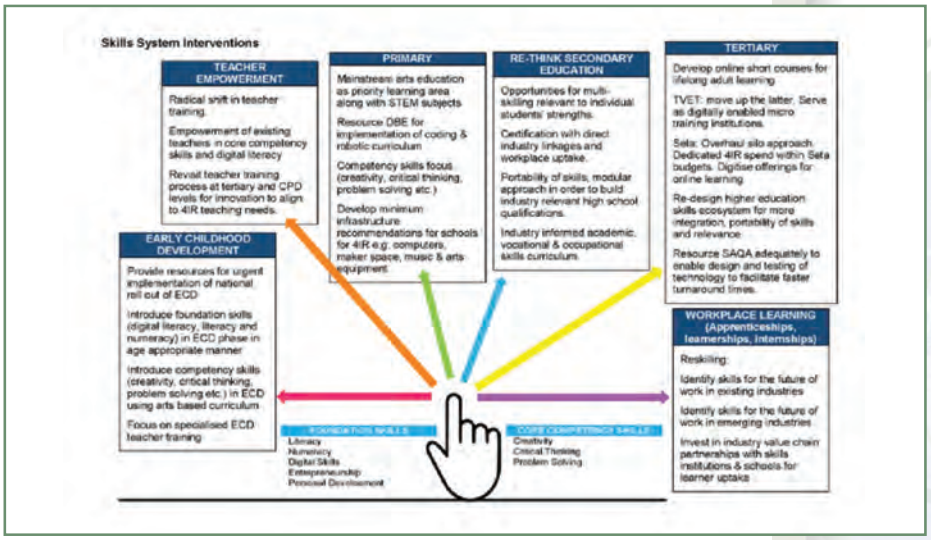


Figure 38: Possible approaches and points of intervention to leverage existing skills ecosystem.

In order to adequately equip South Africa's youth with 4IR relevant skills, attention must be paid to **foundation skills** (literacy, numeracy, digital literacy) and **competency skills** (creativity, critical thinking, problem solving, communication, collaboration, Integrative ability, People Management, Coordinating with others, Empathy/ caring, Judgement and decision-Making, Cognitive flexibility, Emotional Intelligence, Negotiations). These skills are taught to maximum effect between the ages of 0 – 7/8 years, meaning that interventions in this regard should preferably take place in the ECD and Foundation phase of learning. They do not have to stop after this phase, but maximum benefit is gained at this age.

An approach to be considered is to make use of the current Arts subject in the CAPS curriculum so as not to further burden the system with additional content. This subject needs to be re-worked to include practical music making and arts activities designed for cognitive development. Studies show that early exposure to music and art based techniques improve abstract thinking and problem solving ability, increase overall IQ and facilitate mathematics and literacy learning.[92] The Arts subject area must become a priority learning area on the same level as maths and literacy and teachers exposed to specific subject training programmes in this regard. If successfully implemented, a new crop of learners who are able to think creatively and problem solve will emerge within a short and measurable period of time. This will have a knock-on positive effect on other foundation subjects. In Finland, widely hailed as one of the world's most successful education systems, teachers utilise the arts from the earliest grades to help support other subject areas and to develop basic motor skills. Arts and content integration are drivers for developing creative thinking ability. Digital skills are already planned for implementation at Foundation phase level by the DBE. A further area of focus is the assessment systems which can no longer only test knowledge retention and memory but need to be able to assess application and interpretation of knowledge, as well as emotional intelligence and core competency skills ("soft" skills).

92 Hallam, S. (2010). The power of music: Its impact on the intellectual, social and personal development of children and young people. International Journal of Music Education

An integrated approach to include entrepreneurship within the current subject areas is possible and should also be engaged at the ECD and Foundation phase.

The Department of Education is at the early stages of deploying a three-stream curriculum to create multiple pathways for secondary learners. This can be interrogated in more detail with a 4IR grid promoting future of work considerations. The deployment of technology to enable the functioning and efficiency of the education system is paramount. At the same time the use of technology by learners and digitisation of content delivery, assessments and various other processes can be accelerated.

Another key aspect of the capacity development relates to educational and curriculum reform. Some innovative approaches to consider include:

- Japan's shift away from "pass or fail in a grade" to subject specific progression. This means that students can progress in some subjects while remaining "behind" in others in order to improve and get to the required level of subject proficiency.
- Removing subject and discipline boundaries - inter-disciplinarity to encourage complex-thinking

The role and function of tertiary bodies within the skills ecosystem needs to be re-worked in order to produce agile, accelerated learning in high priority skill areas for the future of work, as well as to create online learning and short courses for lifelong learning for adults from all walks of life. Central to this is a review of the accreditation processes and bodies which currently take long periods of time to certify new curricula. The South African Qualifications Authority should be urgently resourced to allow the institution to deploy relevant technologies to improve system agility for faster accreditation processing response times.

As we recommend that the skills development ecosystem needs to be reviewed, at the centre of it is our definition of the Unit standards that may need to be looked at. There is a need to broaden the definition of Unit standards to allow for flexible skills pathways. This will allow for the collapse of boundaries between the learning centres and workplace. Learners must be able to easily get recognition for the learning that has taken place outside the traditional learning centres. Recognition of Prior Learning as it is always touted as a solution has not worked precisely because of the narrow definition of the unit standards.

It is imperative that South Africa does a skills demand and supply analysis for current and future realities to identify the gaps and understand how many people we need to train in which skills, before allocating numbers and budget. The specificity of skills must also be defined. Deciding on specialisation within skills areas will assist to define our competitive advantage with regard to digital and future skills and allow us to recommend specific skills for learning in both school and post-school environments.

The National Digital Skills Strategy has been developed by the Department of Communications and Digital Technologies (DCDT), the lead department within government tasked with driving 4IR readiness for the country. The strategy is intended to provide a framework for the prioritisation of critical digital skills necessary for 4IR and the coordination and integration across government of the related implementation of this. It is recommended that this strategy, inclusive of the full spectrum of appropriate skills for future of work i.e. digital skills, technical skills, and competency skills, provide an overarching framework and coordination point for the 4IR skills drive for South Africa.

The Institutions of work require a renewed engagement for a social contract and the accompanying social protection systems in the context of 4IR and the changing world of work. Entirely new areas of labour and tax laws need to be engaged to regulate for example the gig economy, work done electronically across geographical borders. Workplace skills development and re-skilling of the current workforce falls to companies to navigate in partnership with the Seta's, and the relevance and agility of these processes must be investigated.

Human capacity in our informal economy and SMME's requires investment in social protection systems as well as financial mechanisms to boost start up and early stage ventures. Enabling SMME's access to appropriate technology will enhance their growth and ability to scale.

South Africa has several funding structures for skills development and a review of these is needed in order to ensure a more coordinated and effective approach to funding skills for the 4IR. Current duplication and a lack of overall direction is resulting in the inefficient use of these funds in moving South Africa forward.

Potential additional funding for skills development include:

- The Universal Service and Access Fund (USAF) houses substantial funds earmarked for ensuring universal access and service to electronic communications services, primarily focused on infrastructure initiatives. The effectiveness of this fund needs to be reviewed and linked to an integrated approach to digital infrastructure development aligned with critical digital and future skills development.
- The national Digital Skills Strategy proposes the establishment of a Digital Development Fund which will be created with the aim of general digital development including priority digital and future skills development projects and digital literacy.
- The Labour Activation Programme managed by the Unemployment Insurance Fund (UIF) is a possible funding source for the re-skilling of workers who have lost their jobs due to disruptive technologies.
- Prioritisation and incentivising of Enterprise Development, Skills Development and Social and Economic Development funds from companies with regards to the BBBEE codes to support digital and future skills development for a 4IR economy can also contribute to skills development.

There is a general and urgent need for education and awareness of what the 4IR means at multiple levels in our society. This includes education and awareness of the types of skills required for a new economy and how the world of work is changing. Campaigns should be focused on young people, industry and sector discussions should be encouraged, and the public service should be targeted with an awareness and upskilling campaign. A national online platform to educate, inform, update on training and other opportunities in the 4IR context should be established, while also showcasing current 4IR centres of excellence.

These initial thoughts in this first draft of our report form a basis from which public engagements with sector experts will be held with a view to developing a specific strategy for human capacity development which is human centred as per the pillars and focus areas outlined below.

SUMMARY OF RECOMMENDATIONS FOR HUMAN CAPACITY DEVELOPMENT

HIGH LEVEL RECOMMENDATIONS (SOLUTION)	ACTIONABLE PROJECTS / POSSIBLE AREAS OF INTERVENTION
Catalyse Structural Change in the Education System We must attempt to initiate changes which are catalytic to structural change, as it is inevitable that the education system will evolve structurally to reflect the architecture of the 4th industrial revolution over time. Thought must be given to flexibility, agility, speed of accreditation, integration of learning streams, mobility of learners, remote content delivery, cognitive flexibility and the use of technology to enable the efficiency of the skills delivery system.	• Redesign/Alignment of the skills ecosystem for agility necessary for 4IR learning • Prioritise the coordination of the various components and systems within the complete skills ecosystem to a new configuration which is fit for purpose for the skills demands of the 4IR era i.e. Stackable competencies which are micro-credentialed, industry aligned and allow people to enter and exit the system at multiple points as part of a lifelong learning process, introducing relevant technology and devices and digital and future skills (competency skills, digital literacy skills). This systemic change process should be facilitated at the Human Resources Development Council as a priority project for 2020 i.e. have a timeframe associated to the deliverable, assisted by the 4IR Commission and driven by the Digital & Future Skills Forum. Link this ecosystem to cradle to grave nodal network, driven by AI within and across ecosystem components to perform the function of coordination and streamlining. Use the national Digital Skills Strategy as an overarching guideline strategy for skills alignment.

HIGH LEVEL RECOMMENDATIONS (SOLUTION)	ACTIONABLE PROJECTS / POSSIBLE AREAS OF INTERVENTION
Recognise Competency Over Qualification The 4IR economy requires an approach to skills characterised by competencies which are micro-credentialed, industry aligned and allow people to enter and exit the system at multiple points as part of a lifelong learning process. Qualifications become less important than competency and skills such as creativity, critical thinking, problem solving are central to skilling in this new era, requiring a focus on both STEM and arts and humanities education simultaneously. Technology enabled platforms can be used to streamline these processes. The need for social scientists will increase as there is a requirement to navigate complex human issues of ethics, wellbeing, identity etc. in this new era of cyber-physical integration as it impacts and shapes our culture. Technical proficiency in relevant digital skills also becomes paramount.	• Invest in relevant infrastructure – develop minimum infrastructure recommendation for schools for 4IR e.g. DBE must work towards every school having access to internet and no less than 25 computers and a printer, a dedicated room as a maker space for robotics curriculum and a basic set of music and art equipment • Establish a national project for teacher upskilling in digital literacy, critical thinking and creativity skills. • Provide resources for urgent roll out of ECD learning centres • Resource the Department of Basic Education With 4IR Strategic Advisory Capacity a) To drive the implementation of coding & robotics curriculum b) Provide resources for urgent implementation of national roll out of ECD so that 4IR skills can also go to this level • Basic education and Higher Education - within existing curriculum, find ways to teach the skills aligned to the 4IR (critical thinking, solutions, creative thinking) and develop and measure these skills in addition to the content. In this regard use the existing Creative Arts and Life Orientation subjects in the CAPS curriculum. Invest in STEAMIE education.
Leverage the youth demographic to establish South Africa as a nett exporter of skills in the digital economy South Africa's large youth population is ideally positioned to provide critical skills to global markets in the digital economy	• Innovate and realign the Seta's by creating a framework that guides the scope, budget allocations and priority skills development areas relevant to South Africa's 4IR strategy, including the necessary legislative amendments. • Rethink TVET colleges roles as micro learning institutions providing 4IR relevant competencies. • Adequately resource the South African Qualifications Authority to design, test and implement technology solutions for faster turn-around times for accreditation processes. • Consider innovating qualifications assessment criteria to allow for flexible learning pathways and erasing of the boundaries between learning centres and the workplace e.g. broaden definition of unit standards. • Align skills development funding instruments • Intervene in specific areas in Education System (see Figure 51)

HIGH LEVEL RECOMMENDATIONS (SOLUTION)	ACTIONABLE PROJECTS / POSSIBLE AREAS OF INTERVENTION
Invest in strategic projects for mass skills development and industry uptake in identified 4IR areas. Initiatives should be scalable for exponential labour market absorption and skills pipeline development. Engage in skills development PPP initiatives across all of the identified high-growth potential industries. A portion of the skills development levy (SDL) can be used for funding the "PUBLIC PARTICIPATION" part of the PPP initiative. Establish a cradle-to-grave nodal network, driven by artificial intelligence, within and across sectors. This will enable a skills pipeline linking skills related market demand with an identified talent pool. Skills development courses should be competency based and stackable. This will enable quick turnaround times (as soon as 3 months) in terms of skilling and deployment into industry. In addition, multiple exit streams viz. employment, outsourcing and entrepreneurship is part of the nodal network. This creates flexibility in the system, resulting in opportunity for every individual to realise their full potential.	• Resource and scale the NTIP initiative's model, approach and platform for the manufacturing sector and extend to other industries such as the creative industries, tourism and agriculture. NTIP currently has a working model for the manufacturing sector. The model allows a systemic approach to an industry sector with whole value chain participation which is industry driven. The underlying nodal platform driven by AI provides a coordinating mechanism which makes the system efficient, proactive and comprehensive. Funding should come from the Seta's for these projects. The approach will create a skills pipeline linking skills related market demand with an identified talent pool and can show results within a short period of time without sacrificing depth and quality of skills and human capacity development in a multi-dimensional fashion. • Leverage the Youth Employment Service (YES) programme - link this programme to actual vacancies in emerging industries - include 4IR skills training in the time they are with the sponsor - link the youth to fulltime jobs and vacancies in that entity or other organizations in need of skills.

HIGH LEVEL RECOMMENDATIONS (SOLUTION)	ACTIONABLE PROJECTS / POSSIBLE AREAS OF INTERVENTION
	• Establish & resource Creative Industries Hubs and Clusters in townships and rural areas for Digital Content Production including animation, gaming, virtual reality and augmented reality, photography, graphic design, sound production, audio design, film & video production, digital art production, transmedia, digital marketing. Cluster creative industries SMME's in these hubs where a full value chain intervention from skills, to incubation, to content origination, content production and distribution in a networked system is supported, linked to industry. The Gauteng Economic development department is coordinating a process, along with most of the Gauteng metros/municipalities (although it is industry driven) in which industry mentorship and partnership and access to local and African markets is already leveraged. This initiative can be capacitated and scaled with funding from the Seta's as well as PPP arrangements. New foreign owned entrants to our market can be engaged with government as a facilitator, to invest in content production infrastructure via BBBEE equity equivalency processes etc. • Maximise the planned Digital Hubs Rollout - The currently budgeted for and planned government roll out of 100+ digital hubs should be leveraged for 4IR skills development, 4IR awareness programmes and social dialogue regarding 4IR in the SA context. The Hubs should be maximised to include the spaces and technology relevant to the full spectrum of digital skills (ICT + digital creative skills), competency skills (creativity, critical thinking, problem solving, collaboration, negotiation etc.) and entrepreneurship skills.

HIGH LEVEL RECOMMENDATIONS (SOLUTION)	ACTIONABLE PROJECTS / POSSIBLE AREAS OF INTERVENTION
Social dialogue should be encouraged and stimulated for an inclusive national discussion regarding 4IR and its implications for South Africa. **Social Protection systems and processes** must be negotiated and considered with regards to the changing world of work and what this means for both employers and employees.	• A national platform to educate, inform, update on training and other opportunities in the 4IR context should be established. This platform should be an online platform supported by a variety of campaigns in the public domain, events, workshops etc. • Issues such as promoting social dialogue and collective representation of workers and employers, supporting and incentivizing entrepreneurship and harnessing technology for decent work and job creation must be mainstreamed and coordinated in business, labour and entrepreneurship bodies and fora. • Create Social Protection Scheme For Human Capacity In the SMME & Informal Sectors • Human capacity in our informal economy and SMME's requires investment in social protection systems as well as financial mechanisms to boost start up and early stage ventures. Enabling SMME's access to appropriate technology will enhance their growth and ability to scale.

HIGH LEVEL RECOMMENDATIONS (SOLUTION)	ACTIONABLE PROJECTS / POSSIBLE AREAS OF INTERVENTION
Identify key policies and legislation which need to be changed and updated to enable and support the skills ecosystem, the changing world of work and emerging high growth sectors for job creation in 4IR society.	• Attract Critical Skills By Amending Prohibitive Legislation a) Amend section 19(4) of the Immigration Act be amended to specifically reference 4IR related skills. The amendment should better enable highly skilled immigrants to come and apply their trade in South Africa under favourable conditions. The attraction of highly sort-after 4IR skills be assist in accelerating the development of South Africa's knowledge base and industries. These skills must not be restricted to academia but should include entrepreneurs who intend on starting businesses from South Africa. • Amend Labour legislation to accommodate the Gig economy by recognizing Internet project work as legitimate work. This should include incentives for companies to build Gig Economy platforms to leverage South African 4IR skills for global demand. • Copyright & IP protection - The Copyright Amendment bill is currently with the President for signature. While better than the previous version, it is still highly controversial due to a "fair use" clause that has been included which potentially threatens creative content producers' ownership rights, and according to a PWC review of the draft legislation, could lead to inferior content production for academic textbooks and resources – impacting the skills sector significantly. IP protection and ownership is the bedrock of the creative economy so an in depth look at what this bill means in the context of 4IR and the creative economy as an emerging area for the future of work is important.

8.3 INFRASTRUCTURE, RESOURCES & NATURAL ENVIRONMENT

Globally the industrial revolutions have brought about changes that have an impact on physical infrastructure, resources and the natural environment. The fourth industrial revolution is no different. This revolution could aid in bringing together various physical infrastructures including transport, energy, digital communications and water to create new innovative opportunities.

Through these opportunities, new trends have emerged globally. Once such trend includes moving energy infrastructure away from a largescale top-down systems to making use of solar panels and wind energy coupled increasing storage capacity. These innovations are driving the change for infrastructure and resources globally.

In addition to the innovation eluded to above, 4IR technologies are being used to improve efficiency by matching supply and demand, this has a direct impact on infrastructure, resources required and the impact on the natural environment. Furthermore, a global trend for water could move to a more decentralized system rather than a traditional centralized approach. This will be achieved through the use of 4IR technologies however this may still require some work. Lastly, communication globally will be impacted by the use of 5G networks. This will have a direct impact on the infrastructure required through various efficiencies envisaged in the future.

8.3.1 South Africa Diagnostic

It is a priority for this Commission to recommend that the RSA participate actively in international efforts to ensure that technology companies pay a fair share of tax in the countries in which they operate. The infrastructure and other subsidized services and State investments which are recommended below can only be sustainably funded if technology companies are not allowed to avoid and evade tax in the manner in which they currently do so, for instance by transfer pricing and by selling IP to tax havens where the profits are allowed to accumulate, with little or no tax accruing in the countries where the companies actually operate. This avoidance is increasing the gross inequality within and between nations which has to date characterised the 4IR.

South African Infrastructure

South Africa has a moderately decent central system of national economic infrastructure. It has an advanced and well-created transport framework. The air and rail systems are the biggest on the mainland, and the streets in good state. The nation's ports give a characteristic stopover to transportation to and from Europe, the Americas, Asia, Australasia and the two banks of Africa. South Africa is supplied with rich characteristic assets. It is the world's biggest maker and exporter of gold, chromium and platinum – 90% of the world's worldwide platinum mineral assets are assessed to be in South Africa's Bushveld Complex. The test is to maintain and extend its power, water, transport and correspondences framework so as to help financial development and social improvement objectives. ICT infrastructure is at the core of 4IR enablement. Without ubiquitous, secure broadband infrastructure and connectivity, many of the promised benefits of 4IR may not be realised.

4IR has potential to improve the quality of life for the world's population and important for South Africa to remain competitive in the Global Economy. According to the WEF, "in many parts of the world, aspects of the Second and Third Industrial Revolutions have yet to be experienced, complicated by the fact that new technologies are in some cases able to leapfrog older ones." As the United Nations pointed out in 2013, "more people in the world have access to a mobile phone than basic sanitation. In the same way, the 4IR is beginning to emerge at the same time that the third, digital revolution is spreading and maturing across countries and organizations".[93]

The 4IR builds on the 1IR, 2IR and 3IR, hence in order to fully realise the benefits of the 4IR, the first three industrial revolutions need to be at a high level of maturity in the country. In South Africa we still need to address some of the enablers from the first three Industrial Revolutions such as stable power supply with no load shedding. Countries such as China, United States of America (USA), Japan and Germany have stable power grids, and can therefore fully embrace the adoption of the 4IR.

These countries have also bridged the digital divide in as part of the 3IR. As an example, in Germany 96% (79.1m; January 2019) of the population have access to the Internet. [4] In contrast in 2018 the GSMA reported that only 54% (30.8m) of the total South Africa population have access to the internet. [5] Furthermore, Statistics SA reported that only 67% of SA households had at least one member who had access to, or used the internet either at home, work, place of study or internet cafés.

The Huawei Global Connectivity Index (GCI) of 2018 ranked South Africa at "46th out of 79 countries in terms of progress and performance made in broadband, data centres and cloud services."[94] The report states that in general, the country has performed on par levels regarding broadband, data centres and cloud administrations. Pushing ahead, greater interest in ICT framework is important to help and encourage the improvement of ICT in South Africa in order to bring 4IR to fruition.

93 https://www.weforum.org/agenda/2016/01/what-is-the-fourth-industrial-revolution/
94 https://www.itweb.co.za/content/o1Jr5MxEAX8qKdWL

The WEF Global Competitiveness Index 4.0 which measures national competitiveness defined as the set of institutions, policies and factors that determine the level of productivity. South Africa was ranked 67th overall in the World Economic Forum Global Competitiveness Index 4.0.

Figure 39 provides the benchmark comparison between leading 4IR countries in terms of Infrastructure and ICT Adoption.

		Infrastructure		ICT Adoption			
	Overall Country Ranking out of 140	Electrification Rate ranking out of 140	Mobile-cellular Telephone Subscriptions ranking out of 140	Mobile-Broadband Subscriptions ranking out of 140	Fixed-broadband Internet Subscriptions ranking out of 140	Fibre Internet Subscriptions ranking out of 140	Internet Users ranking out of 140
Best Performer overall in category	United States 1	Multiple 1	Multiple 1	United Arab Emirates 1	Switzerland 1	Korea 1	Iceland 1
Worst Performer overall in category	Chad 140	Chad 140	Chad 140	Liberia 140	Sierra Leone 140	Multiple 114 (na/ in most)	Chad 140
Countries:							
Canada	12	1	114	63	12	41	10
China	13	1	94	45	36	7	82
Germany	3	1	42	53	7	66	15
Japan	5	1	34	8	22	3	8
Korea	15	1	52	17	6	1	9
Singapore	2	1	17	4	39	4	24
South Africa	67	102	9	66	99	83	78
United Kingdom	8	1	89	40	10	75	6
Unites States	1	1	51	9	19	40	40

Worst Performing

Figure 39: WEF; Benchmarking Comparison

The Global Competitiveness Report 2018

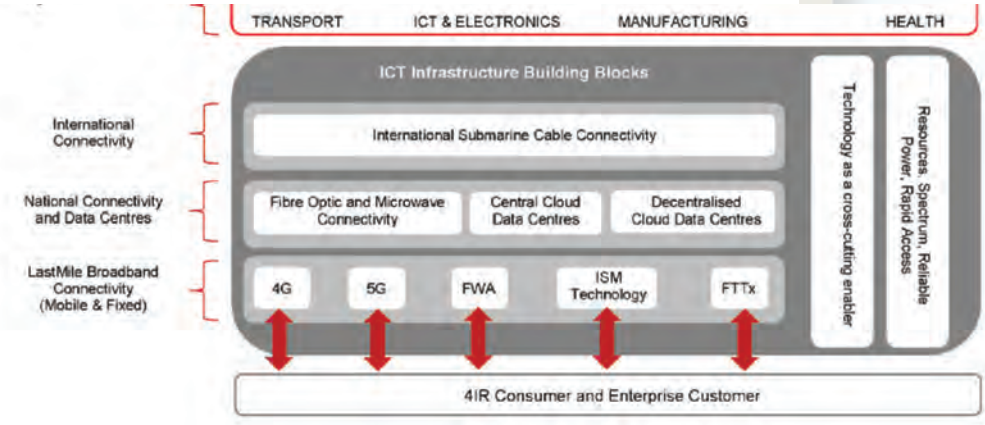
It is clear that as a country we have done well to provide mobile voice connectivity to all citizens, however much work is still required to provide our citizens with mobile and fixed broadband connectivity. This clearly supports the "SA Connect" broadband ambitions.

ICT infrastructure and resources required to enable 4IR

The figure below (Figure 40) provides a high-level view of the relevant ICT infrastructure and resources. Furthermore, the relevant 4IR technologies to optimally manage infrastructure supporting the key economic sectors are reflected.

Figure 40: ICT Infrastructure Framework

Source: Diagram developed by the Infrastructure and resources workstream



8.3.2 SA 4IR Opportunities, Centres of Excellence

Infrastructure is the cornerstone of modern society consisting of a grid like network of roads and rail, water supply, electrical grids, the built environment and digital networks. In the past, we talked of analogue infrastructure but today we speak of digital infrastructure. Future infrastructure is software based, data enabled and has cloud access. Digital infrastructure is set to improve access to information and thereby promote transparency of government processes and activities and in turn, build interconnected empowered communities.

Fibre optic infrastructure

When planning for the digital infrastructure, it is important to take into account the societal technology needs and requirements. Without sufficient broadband, you cannot deploy cloud computing. Without cloud, big data analytics is impractical. And without big data and IoT, you won't have clean relevant data to feed your AI systems. Broadband internet and Data are foundational to the Digital Economy. Getting connected is a necessary first step for access to the digital economy that will lead to productivity improvements and new economic opportunities for individuals, businesses and governments. Four areas of Fibre deployment need to be considered, In-building Fibre, Capillary (Metro) Fibre access, Inter-city Fibre, and Ocean fibre (Submarine cables).

8.3.2.1. In-building Fibre

Fibre inside buildings should be treated the same way as other utilities like water and electricity. All new buildings should be reticulated with Fibre with appropriate conduits from the street into every building unit (office, industrial building, domestic unit-house or apartment in a block, shopping mall, etc.) with the required modems, ready to be used, as currently is the case for water and electricity.

Occupation of the building should not be allowed until the Fibre installation has been done according to minimum prescribed standards, akin to those applied when dealing with water and electricity. In order to promote agility, a digital Fibre installation request, approval and certification process for the builder should be established and run by a non-governmental body; a local Building association with a section focused on in-building Fibre standards.

This body should represent an appropriate area size, such as a section of a large city (Johannesburg, Durban, Cape Town, etc.), or a region of smaller towns or villages, and be run by a group of volunteers (people prepared to work in the interest of the community) for a limited period, e.g. 3 to 5 years. A statutory body will be needed to approve new developments.

8.3.2.2 Capillary (Metro) Fibre access

The Fibre in the building needs to connect to a Capillary access network, and it should not matter who owns it in totality, or parts of it. This network may have to be installed on Municipal land, or Private land owned by an estate or body corporate

8.3.3.3 Inter-city Fibre

A key player in this area is SANRAL (The South African National Roads Agency SOC Ltd). Key recommendations include:

- The process starts with the 17 national roads in South Africa
- SANRAL should appoint an independent committee to approve applications to lay fibre along its roads linking cities
- People in the industry must be part of the approval process, with new representatives being appointed every 3 to 5 years.

8.3.3.4 Submarine fibre

There are more than 378 submarine cable systems globally spanning 1.2 million kilometres connecting close to 100 countries (Figures 41 and 42). More than 50 submarine projects have been proposed into 2021, worth a total investment of $7.2 billion. A third of deployments will be in the Pacific region between Asia, Australia, and the United States followed by the Atlantic as the next locus of activity and then the Indian Ocean. Consortiums of telecommunications carriers traditionally owned submarine cables. But in recent years, major web-based companies, such as Google, Facebook, Microsoft, and Amazon drive investment into their own cables, displacing the traditional Internet providers.

These four companies today own or lease more than half the undersea cable capacity. This increased "level of investment has put significant downward pressure on the price of submarine capacity, which continues to decline at about 25 to 28 percent per year."[95] The three most familiar financing models are through consortiums, development banks and private ownership. The three largest builders of submarine cables are Alcatel Submarine Networks of Alcatel-Lucent (France), TE SubCom of TE Connectivity (Switzerland) and NEC Corporation (Japan). Today China has shown increasing activity from Huawei Marine.

These submarine cables carry over 95% of intercontinental internet traffic. Submarine cable networks connect to terrestrial networks via a Point-of-Presence (POP) to provide critical end-to-end network connection with the help of global network infrastructure of Cable Landing Station (CLS).

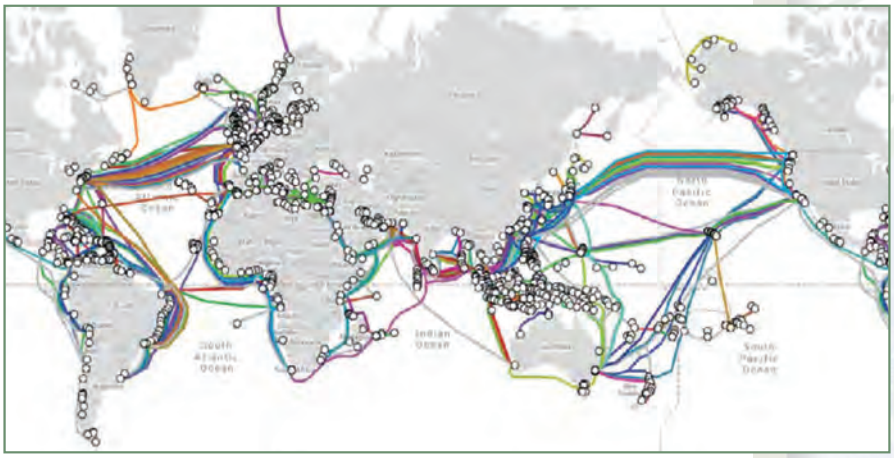
Submarine fibre is key to linking up to the rest of the world, and therefore a key component in enabling our globally integrated national 4IR project. However, our quest ought to be more ambitious than only linking our national traffic to the global network.

There were no hyper scale data centres in South Africa until recently [1]. South Africa must become a global Submarine cable hub. We should also encourage the housing of one or more hyper scale data centres for the global giants; Google, Amazon, Microsoft, Alibaba, etc. for compute, AI and data analytics in the Southern hemisphere between the East and West, and between the Southern and Northern Hemispheres. Several places are recognised, or positioned themselves as Submarine fibre hubs, for example, Egypt (which is a natural hub), Portugal, France (Marseilles), Brazil (Forteleza) and other such places.

95 http://www2.itif.org/2019-submarine-cables.pd

Figure 41: Global Submarine cable map

Source: https://www.submarinecablemap.com [UJ_11]



To make South Africa attractive to Hyper scale data centre owners, there is a need for Submarine cable investments linking the Indian Ocean to the Atlantic Ocean along the South Coast. The Submarine cable (SAFE) carries only 0.01 Tbps. The next cable (SAEx2) is expected to be activated in 2021 with a capacity of 48 Tbps. The combined 48.01 Tbps linking the West to the East coast is small, in comparison to the West coast capacity of 300Tbps and the East coast capacity of 149 Tbps.

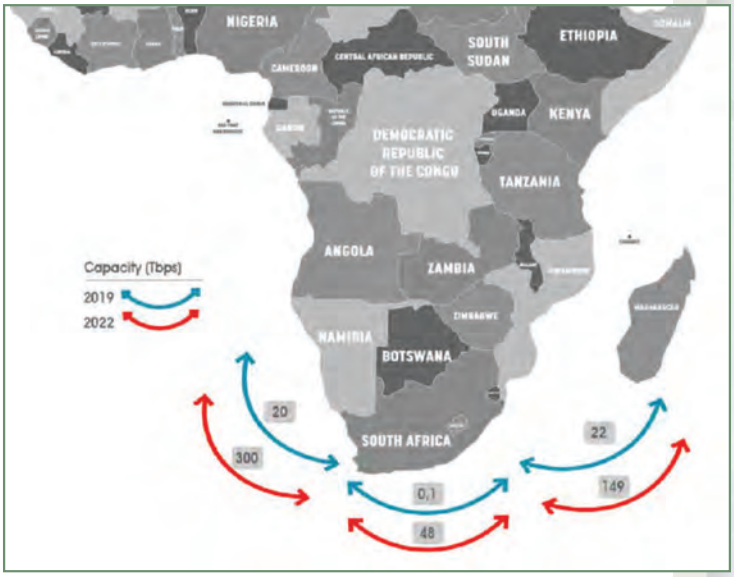


Figure 42: South African Submarine Cable Capacity (Tbps) 2019 and projected 2022

Image produced on behalf of 4IR Infrastructure and Resources workstream, September 2019

A breakdown of the current and expected sea cables and their capacities on our West, South and East coasts is provided below (Figure 43). We have large Submarine cable capacity landing on our shores in both the Indian and Atlantic Ocean. We require more capacity (more Submarine cables) linking East and West

coastline, to feed into other inter-continental Submarine cables and so carry more international data traffic across our South Coast. This will enable South Africa to become a global Submarine cable hub and make it attractive enough for more of the Internet giants to invest in hyper scale data centres in South Africa.

In addition to carrying traffic in new Submarine cables along our coast between international destinations, we should have additional landing points on our coast (Cape Town, Port Elizabeth, East London, Durban, Mtunzini, and other coastal town) to link international traffic to the inland. The map below illustrates this.

In addition to carrying traffic in new Submarine cables along our coast between international destinations, we should have additional landing points on our coast (Cape Town, Port Elizabeth, East London, Durban, Mtunzini, and other coastal cities) to link international traffic to the inland. The map in figure 57 below illustrates this.

Figure 43: African Submarine cable map

Figure 44: Suggested Submarine cables to connect Coastal cities

Image produced on behalf of 4IR Infrastructure and Resources workstream, September 2019

8.3.3 Data centres

Currently South Africa doesn't have adequate data centres to store its citizenry data in its land. Data Protection is paramount in the 4IR era; it sits in the Hyper scale data centre as it is global data. Government cannot access data from other countries even if the real estate is on SA soil. This is to ensure data privacy, security, integrity and safe guarding against undue interference or manipulation. Data centres support future industries and economies with Big Data being "an essential resource for economic growth, competitiveness, innovation, job creation and societal progress."[96] Data centres are the new digital infrastructure to service various industry stakeholders and use cases.

Hyper-scale Data Centres (HSDC) are foundational to building and powering economies of the 21st century and beyond, with data as the new commodity. Hyper-scale data centres will constitute 53 percent of all data centre servers by 2021, account for 55 percent of total traffic within all data centres by 2021 and 94 percent "of workloads will be processed by cloud data centres with only" 6 percent being processed by traditional data centres[97]. There is an increasing role of data centres given the largest data traffic volume is within Data centres (73.4% in 2019). Traffic volume from Data centre to User, and Data centre to Data centre follow at a distant second and third positions respectively.

A growing global grid of hyper scale data centres aimed at supporting the 4IR future currently exists. Most data centres are in the Northern hemisphere, as roughly 80% of the global population live there. The ideal configuration of sea cable hubs in the Southern Hemisphere (and its concomitant hyper scale data centres) will reside in South America, Southern Africa and Australia. South Africa must do everything to, as the CAICT puts it, formulate "policies and strategies to attract submarine cables to their(our) coastlines" – in other words our South African coastline. Attracting hyper scale Data Centres should then become easier.

Spectrum

According to the South African Government, it has set itself the task to pioneer new technologies and take quantum leaps towards the economies of the future, and to drastically improve production levels. It is expected that the 4IR strategy should deliver a blueprint and plan to deal with developments in the short, medium and long-term.

In preparation for 4IR there is an urgent need to overhaul the telecommunication rules landscape. The purpose of the telecommunication review is to align it with the broader approach to the 4IR inspirations of South Africa. There can be no successful 4IR discussions and realistic action plans without an aligned telecommunication framework. As the industry moves into the 5G era, appropriate regulatory conditions, transparent spectrum rules and a clear and predictable policy framework will continue to be key to drive further mobile and broadband developments. Simply put, there can never be a successful 4IR strategy/ policy without a well-planned and considered 5G deployment policy, these are closely related, and policy and regulations should focus on the following areas:

8.3.3.1 5G Spectrum

As indicated above 5G requires a mix of frequencies at sub 1-GHz, 1–6 GHz and above 6 GHz including the mm wave frequencies, to deliver widespread coverage of the population and support a multitude of consumer and enterprise use cases. Therefore, the availability of spectrum, at what frequency, what rules for its use, timelines, and cost will have a major impact on the development of 5G.

96 https://www.digitaltransport.eu/2019/pages/sessions-description
97 https://www.sysgroup.com/resources/blog/cloud-computing-in-2018

8.3.3.2 5G Infrastructure

A full-blown roll-out of 5G services is dependent on the deployment of small cells in the urban areas and to an extent in semi-rural areas. This means that policy makers and regulators should consider removing regulations perceived as obstacles to future 5G cell deployment roll-outs. From a Telecoms industry perspective, regulatory and policy certainty should support, reform and streamline favourable wayleave processes that will allow for timely and cost-effective infrastructure deployment for 5G. Commercially based network sharing can be another factor for consideration in the 5G policy and regulatory framework to reduce operating costs and provide additional capacity in congested areas where space for sites and towers is limited.

8.3.4 High-Performance Computing

Centre for High-Performance Computing (CHPC) is a strategic asset for the country. The CHPC can accelerate scientific research, innovation and a potentially catalyse economic competitiveness, promote leadership in technology and solidify national security. HPC workloads range from astrophysics, Genomics, Weather & Climate, Financial analysis, AI and Big data analytics. South Africa's CHPC infrastructure serves as a foundation upon which we can build the national 4IR initiative. The exponential growth of data, the emergence of AI, extensive spread use of data analytics tools and diffuse penetration of Cloud ushers in new ways to work with data. The traditional HPC workflows of modelling and simulation are transforming to a new converged state of High-performance Computing-Artificial Intelligence-Data analytics (HPC-AI-HPDA).

The public sector stakeholders' consultation feedback indicated compute resource duplication. Multiple State entities either have dedicated standalone compute resources or are leasing capacity from the private sector. On further discussion to understand the pattern of use, it became apparent that the compute resources are not utilised 24/7 but rather during specific designated times usually recurring monthly for a particular purpose. SITA, Weather Bureau, SA Medical Research Council, Council for Geosciences, Agricultural Research Council, South African Social Security Agency Grant Payment are among the public entities requiring compute power.

These entities have varied compute needs and times of required use for processing workloads, leaving significant gaps of protracted times of HPC underutilization. The result is the CHPC & SITA are not working at full capacity. Hence, to embark on a digital transformation journey, we must start with a review, restructure and consolidation of the existing computing capacity to establish a national HPC grid with the multi-cloud on premise facilities located at the CHCP. This national HPC grid would then be supported by a complementary provincial edge grid and Open data platform – Open Data South Africa. SITA must be dismantled. It has never achieved the goals for which it was established and currently is an obstacle to progress and efficiency.

8.3.4.1 Digital Transformation South Africa 2025 – Leveraging CHPC

Digital transformation is a critical pillar of 4IR. Government needs to provide leadership and convince Business, Academic institutions, SMMEs, Parastatals and NGOs to embrace digital transformation starting with the adoption of Cloud 2025 strategy. South Africa must assume the position of being a recognized digital node of the continent that is integrated to the global grid.

High performance computing is the lifeblood of advanced economies in the same way that electricity and roads drive today's economies. The country has a window of opportunity to build on existing capacity and capability at the Centre for High Performance Computing (CHPC) and many other existing State compute resources. In an effort to ensure that state compute resources are plugged into the global ecosystem of tech giants like Google, AWS, AZURE, Alibaba and many others, South Africa must reconfigure existing digital resources. This initiative will form the basic building blocks to start the country on a 4IR trajectory.

The Centre of High-Performance Computing (CHPC) is well placed to serve as government's on premise super cloud unit comprised of a national grid of HPC capacity, white labelled multi-cloud capacity from

Hyper-scale data centres, Net-co managed connectivity network and an open data platform that sits above this CHPC managed HPC/Hyper-scale national grid.

There first needs to be a reconfiguration of existing state computing resources resulting in a transfer of ownership for all of government's high-performance computing resources resident across government (CHPC, SETA, Sentech, Broadband Infraco, Eskom, Transnet, and other similar state-owned enterprises) to the CHPC for management to serve as a foundation to promote technology-driven opportunities for local innovators.

In addition to restructuring these existing computing resources, a grid of HPC facilities needs to be established in the strategic coastal provinces of KZN, Western Cape and Eastern Cape and the economic hub of Gauteng. State entities, national departments, province, municipality, metros, SOEs, universities, research centres, civil society organizations, and business (South African registered) would all have access to the reconfigured grid on a use-on-demand model for cloud, storage and computational power with an application programming interface (API). The establishment of this high-performance computing (HPC) facilities grid needs to be supported by a solid foundation of big data and AI skills and knowledge. The CHPC in particular needs to have more expertise and capacity to assist clients to utilize HPC optimally.

Participation at this global level requires international traffic carrying submarine cables to not only land but also connect our coastal towns and cities to Hyper-scale data centres in South Africa and abroad. This local Hyper-scale data centre network in the coastal towns together with the grid of High-Performance Computing facilities would provide government with the required supercomputing capacity and virtual machines capacity.

The robustness of the grid is dependent on connectivity. Therefore, under the management umbrella of Net-Co, a restructuring and amalgamation of network resources of Broadband Infraco, Sentech, Eskom Telecom, SANRAL, Transnet, PRASA and SITA would happen. Net-Co would make virtual private network &SDN (VPN) and Internet connectivity available to entire national HPC grid, Hyper-scale data and State users.

8.3.4.2 Regional & Continental Grid

Africa's population will reach two billion around 2050 and four billion by the end of this century. Computing, AI and Big data analytics are just as important for the region (SADC) and the continent (Africa) as to South Africa. Therefore, under the leadership of the African Union, regional and continental HPC councils are needed to guide SADC and the other regions in creating a grid of Africa's high-performance computing. This grid should form part of the global grid of hyper scale and HPC.

Open Data South Africa - Platform

A National Open Data Strategy is necessary, detailing the processes and activities related to data treatment along the value chain from collection to use, while ensuring data privacy, promoting data security and driving open data-enabled innovations is necessary. In the digital era, data is the unit of analysis. Today quality data whenever, wherever and however drives industries. Hyper scale and edge data centres form the backbone of the digital infrastructure. Mobility is proving that value lies not in moving things from point to point, Agriculture is not now just about production and sale of food and power is not just about keeping the lights on. Both agriculture and power, among many other areas, can be optimized using effective data collection and analysis. Both will require networks of sensors, some of which already exist. Therefore, a clear data strategy as a country is crucial. We need to clearly state how the country will create new industries and digitally transform traditional industries to be part of the digital revolution.

Data is the most valuable resource of the fourth industrial revolution. Access to quality data whenever and wherever enable global innovations and fuels digital economies. Public data can assist policymakers to take evidence-based decisions, ensure state-public understanding, strengthen public trust, and encourage public engagement with political processes.

Currently millions of both private and public data sets and data points are becoming a commodity. South Africa needs to encourage this new area to grow and mature with clear rules of self-regulation to protect individual privacy and secure citizen data. It will be important to create a market structure that promotes South Africa as a preferred Big Data location for other countries to send their own data sets to create solutions.

All state entities have a repository of data from their interactions with people and business that is stored in various public and private servers. These public datasets range from Driver License, Traffic fines and Vehicle Data – National Traffic Information system, SARS Vat data, Property Data (Individual, Company or Trust), Court proceedings and CCMA Data, CIPC data, Birth data, Death Data, Social Grant Data, Deeds office data, Municipality bill data and Animal registration data and many more. Government must create an open big data platform that will make it possible to access to all this digital data housed within its future hyperscale with open application programming interfaces to those using the data to create products and solutions. Commercial pricing must be considered where appropriate for access to data by the private sector. Research access should be subject to a different pricing structure or should be free, where appropriate.

South Africa must introduce a new speciality of open big data brokers to take public data from multiple Government sources, to analyse and exploit these data pools to create products and solutions. In the recent past the Department of Home Affairs collaborated with banks wherein ID fingerprints data was used by banks for identity verification. We need to explore this model across all government data bases while taking into account privacy and security. Since data are a commodity, the public sector should retain ownership of all of its data and should ensure that its data are not owned by private sector firms which can hold the State to ransom, as happened with the NaTIS system.

Government must also create data lakes within the CHPC platform to perform analysis and AI. Data lakes contain data from the state and Internet data from, for example, social media together with other external data that are in structured or unstructured data sets.

8.3.5 Resources

8.3.5.1 Institutional Restructure

In this section we look at the residual resources (public and private) needed to enable sustainable success of our 4IR national project. These cover the restructuring of current institutional capacity and the building of new capacity, as well as establishing or promoting physical systems which will play a key role in the 4IR.

We need to consolidate our current regulatory bodies because of the rapid trend of merging technologies. ICASA, POPI Regulator, Film and Publications Board must form one institution because everything will be online.

We talk about regulations and or regulating bodies in South Africa. What we need to establish is one regulator from the following organizations: ICASA, Film and Publications Board, POPIA, Cyber Security.

This new organization will deal with all the issues relating to the Internet, Social Media and Data and what was traditionally called the ICT Sector.

This new organization be independent (as ICASA is at present) and funded through the Department of Communications and Digital Technologies. The legislation establishing ICASA should guide the model of independence.

8.3.5.2 Electromagnetic Spectrum South Africa (ESSA)

Today's technology evolution process is outpacing the ten-year cycles of IMT 2020 and beyond journey. There is a need for a private sector led radio/spectrum engineering and open source software research

platform. This initiative will collaborate with academia/research and all public sector institutions dealing with spectrum. Funding would to be set aside from the spectrum fees. ESSA's primary objective is to carry out research and development in the interface of spectrum and software.

The expertise required for ESSA would include Radio Engineers, Software Engineers and computer scientists. The recruitment drive would be in South Africa and the broader continent with an open employment policy to all Africans. ESSA would then collaborate with similar organizations worldwide like 3GPP, ETSI, 5GPP. It must however be emphasized that the primary role of ESSA is radio engineering and software. Its mandate would be research on the regulation of the spectrum and software systems used especially by the public sector (for example, by requiring all public sector entities to use open source software) and to identify key development areas in software and telecommunications where research should be funded. The ESSA should work closely with the universities to develop research into the basic and applied aspects of these topics and would not seek to replace them.

Industry must negotiate with government, especially treasury, to set aside a portion of funds generated from spectrum fees towards this initiative (~20%). The funding of the ESSA is a reinvestment to unlock the spectrum economy. Leveraging spectrum to stimulate the economy will further drive the Data Economy and contribute to innovation and entrepreneurial development.

We need to establish a rural communications support program, to be managed by the private sector and government in partnership. We could use the Digital Fund for this purpose. Alternatively, the digital fund should operate like a Fund of Funds, rather than getting involved directly in funding projects. Funds are entrusted to Social Venture Capital Funds. These Social Venture Capital Funds must identify profitable rural Internet and digital services companies. They must then fund them, similar to how the IDC or DBSA does business. It will still, however, be necessary to find a vehicle to subsidize connections to most of the more remote rural districts, where telecommunications structures are usually not commercially viable.

One of the most important areas that will advance the country towards 4IR is if we fully adopt Open Source Architecture and Infrastructure. Public and Private Sector should establish Open Source South Africa. (OSSA) This organization will drive Open Source Development in South Africa. In the same way that South Africa is a member of the ITU, ICANN etc OSSA will join all the Open Source groups in the World and take an active role in the development of Open Source Infrastructure.

8.3.6 Open Source South Africa (OSSA)

Software has grown to be central to everything and the Open Source communities are driving most innovation in the world. The IT sector is almost over 60% Open Source. The telecommunications sector is lagging behind. There are processes to drive Open Source in the 5G space and beyond.

New developments are seeing Telecommunications networks built using white boxes (X86) and no more expensive proprietary IP infrastructure. While this is still new, it is gaining momentum. IoT architecture is driven by open source community. Even spectrum-based technologies such as Radio Access are now driven by virtualized open source technology. For Africa, this lands itself very well because of our past and the opportunity that technology will give to lower barriers to entry. The intention of the Open Source community is to move workloads from hardware to software. As we all know proprietary hardware is what increases the cost of telecommunications infrastructure.

It is because of this background that Africa should be investing more in the open source software knowledge and skills. India and China have already taken this route giving these two countries strategic entry into the global technology eco-system. South Africa should focus more on the software side of the 5G eco-system because entry into software is not prohibitive. Open Source eco-system will ultimately be the driver of telecommunications eco-system including spectrum-based infrastructure. Edge compute is using Open Source and spectrum is getting virtualized using open source technology.

Open Culture

Lastly, an open innovation culture needs to be fostered in order to ensure we are able to harness all the benefits of the 4IR collectively. We need to make use of non-proprietary platforms and hardware that are easily accessible to all. We need to emphasize the use of open infrastructure, both digital and physical. Open data laws that adhere to democratic principles need to be conceptualized. Open architecture for networks needs to be created to reduce the barriers to entry for new players in the infrastructure space. Seeing as democracy in the second machine age is borderless, in the digital world, we need to conceptualise laws that take into consideration such factors.

Information modelling for future network designs

New models are coming up with new ways to design the networks. Work being done at the Open Network Foundation (ONF) suggests that we need to look at what is happening at the information level, not network level for designing the network. Information modelling can be likened to understanding the characteristics of the information, information flows and patterns, including what kind of information, where is it from, where is it going and how is it getting there. Information modelling argues for the analysis of information and uses that insight to inform the design of the network. This is a test case for future infrastructure design models for SMART Networks.

Today we design networks taking as many eventualities as possible into account irrespective of whether they will happen or not. This could lead to a lot of wastage and inefficiencies in the network usage. There is a shift from protocol models to software defined standards. ONF SDN models – building solutions leverage network disaggregation, white box economics, open source software, software defined standards to revolutionize the carrier industry network.

Artificial Intelligence (AI) Institute

South Africa should legislate the establishment of an Artificial Intelligence (AI) Institute (possibly situated in the Centre for Advanced Computing?) which will comprise a public-private partnership. It will be responsible to keep abreast of and support capacity building in:

- Neural networks
- Natural Language Processing (see annexure B)
- Computer vision

The AI institute will partner with TensorFlow and be part of all the current and future global initiatives of AI. As a result, the AI institute will be responsible for the country's computer vision and deal with arising ethical issues but will not replace the role of the universities in carrying out basic research on these issues. .

In the early 1940s UK Premier Winston Churchill believed that we first shape our buildings, and thereafter these buildings shape us. Today we have - in addition to buildings - the full potential of 4IR digital smart technologies, which should have an even larger impact on humans.

We should establish Institutional capacity (A 4IR neuroscience institute, situated at e.g. the CSIR) to participate in the recent global emergence of institutions to study the impact of 4IR technologies and their embedding in physical places and spaces on human mental wellbeing.

Autonomous vehicle

The technology exists, despite sceptics who state that "rational" autonomous vehicle technology is not yet up to the task of dealing with irrational human drivers". Trials are underway and legislation in many countries promotes technology development by allowing increasing autonomous driving to be trialled (test beds) . Many trials have been launched with success. (See annexure C). We need South Africa to enact legislation to enable a similar legal environment which promotes the development and use of Autonomous vehicles Testbeds.

Drones and Robotics infrastructure

Cloud robotics is the combination of Cloud computing and robotics and is differentiated from traditional robotics by its use of teleoperation and cloud technologies. Other technologies which enable or enhance Cloud robotics include 5G, IoT and AI. The regulatory methodologies for incorporating drones into legal systems range from outright bans on the use of commercial drones, through to permissive legislation, to a strategy of waiting to observe the efficacy of other nations' policies before acting.

Blockchain infrastructure and electricity Infrastructure and Platform

Initially associated with cryptocurrencies, Blockchain projects have been launched in other areas. (See Appendices 10, 11 and 12). Blockchain "is a distributed ledger technology in the form of a distributed transactional database, secured by cryptography, and governed by a consensus mechanism" i.e. distributed ledgers recording transactions on a decentralized infrastructure. Blockchain, on the other hand, "offers infrastructure leaders the opportunity to not only increase efficiency and reduce costs, but evolve how physical commodities are distributed and consumed".[98] Blockchains requires that all transactions be verified cryptographically, which then slows them down because they require a considerable amount of energy ensuing in a limitation to scaling. Sierra Leone is the first nation to use blockchain technology for its elections, and the Estonian government is a very advanced user of Blockchain technology. They use it for digital government services such as online tax returns, e-Voting, mandatory national Identity cards, digital cabinet meetings, etc. Estonia is an exceptional digital innovator and provides cybersecurity advisory services to other countries and organisations (See next section).

Post Office physical infrastructure

To be used for cases when government services cannot be accessed virtually. This could include instances with the elderly who may be uncomfortable with using virtual government services, or where government services are not accessed with free Wi-Fi. To promote agility, we should both allow skills to immediately be imported from outside South Africa on the condition that similar local skills also directly be developed to take over from overseas skills, in areas such as IoT, wireless and wired technologies, and cybersecurity.

Language Resources and 4IR

South Africa has 11 official languages, while countries like Zambia and or Cameroon have more than 200 languages each. Nigeria has more than 300 languages. Africa is home of more than 2000 languages. Most of these languages are in West Africa. Most of these languages do not have a written word. They are mainly spoken languages. A number of research organizations have been working on approaches to record the history of these languages. Africa today has over One Billion people and it is predicted that by 2050 Africa will have double the population of today and by 2100 Africa will have over 4,3 Billion people.

98 https://www.forbes.com/sites/ellistalton/2018/01/22/why-blockchain-is-key-to-transforming-how-physical-infrastructure-works-and-how-we-think-about-it/#3702a14c4875

In South Africa, the democratic parliament through legislation established the Pan South African Language Board - Act number 59 of 1995. The principle target of the Act is to advance and make conditions for the improvement and utilization of legitimate dialects.

The website of PanSALB is abridged as pursues:

- Develop the 11 official languages
- Promote multilingualism
- The constitution alludes to the foundation of PanSALB in segment 6 when portraying language rights.
- "Initiate studies and research aimed at promoting and creating conditions for the development" of all the 11 official languages plus Khoe and San and South African sign language.[99] Another PanSALAB focus is lexicography and terminology. This is done through nine lexicography units. This are based in South African universities.

Modern Language Development

In the digital world languages are developed online. Most developed world Lexicons are digital. This means that the language's vocabulary and dictionaries are amended in the software code of major word processing such as Word or Google Docs etc. Similarly, these languages are searchable in all major search engines such as Google, Bing, Safari or Yahoo.

8.3.7 Global Lexicon ecosystem

Lexicon development is one of the fastest growing sectors in the digital world. Organizations such as World Wide Web Consortium (W3C), Unicode Consortium, ICANN, Internet Engineering Task Force (IETF) and many others are working to develop standards in the dictionary, language, and code.

These developments require resources and qualified teams of engineering and linguists to effectively participate and contribute in these global developments.

South Africa is not active at all in these forums. This is visible through the work being done by our local lexicon units and language research teams. The language that has kept abreast of all these developments is Afrikaans. In Japan, technologies have been developed to provide direct translation between Japanese language and English.

A good example is if you write a Xhosa word in this word processor, the word will be underlined red. This is the same in the mobile phone as it is in computers.

Natural language processing, a discipline of AI, can only work with data and language that machines understand. If we really want to participate in 4IR we need to "digitize" African languages. This process will require people who understand the granularity of this task and where to start. It is, however, not an impossible task. Software is available, what is needed are skills to code.

The initiative will require a budget and leadership. It is recommended that a Task Team be established with full resources and commence with this task no later than 2021.

2020 can be a year of training coders. The SETA responsible for the arts can finance this program.

99 https://cisp.cachefly.net/assets/articles/attachments/03470_pansoutafrlanboaaa10.pdf

The Task Team must also work with ZADNA in order to protect South African domain names as they represent the country's heritage. The names of places and plants that represent heritage are being taken by individuals for social and business use.

The same Task Team must also look at Wikipedia in particular with regards to the correctness of the history of South Africa. The Task Team will advise on how best to address this challenge.

Innovative Energy Distribution

Energy consumption is set to increase exponentially in the next 10 years mainly driven by the growth of the technology sector. The communications sector is projected to use 20% of the world's electricity by 2025. There are an estimated 17 billion connected devices, with IoT devices making up 7 billion of this figure. This number is expected to increase to 34.2 billion by 2025. WhatIs estimates that energy consumption of wireless cloud technologies increased 460% between 2012 and 2015.

The increase of internet-connected devices have been described as a "new round of household electrification". This indicates that we need to rethink how we generate and distribute energy. South Africa's main generator and supplier of energy, Eskom needs to revise its business model if it wishes to serve the needs of hyper scale data centres in South Africa. If not, there must be a provision that allows for hyper scale data centre owners to build their power stations. Both Facebook and Google only utilise green energy for their hyper scale data centres. The same must be allowed in South Africa.

As South Africa plans for how we manage the growth of the digital economy, we need to think about how we generate and consume electricity. The primary power producer in South Africa, Eskom, was built to serve the growing electricity needs of the mining sector in Gauteng. The founding Chairman of Eskom stated that cheap and reliable electricity was the most essential tool in driving industrial development in South Africa. The same thinking must be applied when analysing the growing technology sector and its energy demands in our country. With that being said, this section will explore power consumption in the digital economy and fourth industrial revolution and provide recommendations for how South African can find innovative ways to serve the growing electricity demand.

Power consumption in the digital economy requires innovative ways of generating and supplying electricity. Global technology companies such as Google and Facebook utilize green energy in most of their data centres, eliminating their reliance on the national grid. In Ireland data centres are projected to consume one in every 3kWh generated by the year 2025. Put simply, a third of all electricity generated will be used by data centres. This excludes electricity usage by IoT devices and other forms of technology. To mitigate risks in scenarios like this we must give data centres the autonomy to generate and distribute electricity themselves. Clean energy sources must be promoted such as solar and wind. With a growing demand for bandwidth, power consumption is set to rise. It will be extremely difficult for the government to be the sole provider of electricity. According to Van Heddenghem, electricity consumed by digital devices and infrastructures is growing faster than 7% per year. Global electricity demand is set to grow at 3%. The emergence of hyper scale data centres has led to companies like Google signing exclusive Power Purchase Agreements(PPAs) with several European governments. These agreements allow Google to buy power from renewable energy plants at an agreed price on a long-term basis. Since 2010 Google alone has enabled 3 Billion Euros investments into renewable energy projects globally. These agreements are beneficial in helping countries to reach their environmental objectives. Google is currently the largest buyer of renewable energy in the world. This should not, however, be seen as an alternative to the large technology companies paying a fair share of tax in the countries in which they operate.

The energy requirements of edge computing also require alternative clean sources of power. Each 1mW of data received at the edge requires -18,000x -60,000x(19-60W) of power generated at the power plant. Increasing IoT devices are require power to compute at the edge. The emergence of 5G has also led to

higher energy consumption. Given that 5G is set to be the driver of IoT devices, edge computing and small cells will require reliable and cheap energy. 5G has multiple power challenges such as 1000x traffic with over 100000 more devices connected. South Africa's reliance on coal as our main power source will no longer be feasible given its impact on the global environment. It is for this reason this section advocates for the use of clean energy sources.

If we wish to meet the power demands of the digital economy and fourth industrial revolution, we need to efficiently use power. In terms of efficient power usage, South Africa needs to leverage Artificial Intelligence to help improve energy efficiency. This can be done on an individual, municipal and national level. Google currently makes use of DeepMind AI to reduce its energy consumption by over 30% in its hyper scale data centres. Google does this by using sensors to collect data on power consumption and feeds it into the DeepMinds neural network which then identifies what actions Google can take to minimise energy usage while also satisfying all of its constraints. This can be applied to micro and macro energy grids all over South Africa. AI application in energy enables demand-side flexibility, both on the price and incentive. This plays a big role in reducing overall costs. However, the savings in energy consumption at the macro-level are unlikely to be on the same scale as the controlled environment within a hyperscale data centre.

Built Environment

- **Smart Harbours**

It is noted that global trade is increasing, vessel sizes and cargo volumes have increased substantially, placing additional pressure on ship berths, yards and the broader harbour infrastructure. As the 4IR era is in motion, ports are therefore becoming increasingly interested in smart solutions that will help optimise operations, promote efficiency and reduce logistics costs, all without requiring major investment in new infrastructure and equipment. Major Significant shipping transportation paths go along the South African coastline in the south Atlantic and Indian seas. Around 96% of the country's exports are passed on via ocean, and the eight business ports are the courses for exchange between South Africa and its southern African accomplices just as center points for traffic to and from Europe, Asia, the Americas and the east and west shorelines of Africa. Turnaround times for stacking and offloading at SA ports are much more slow than those for example Singapore. The utilization of data analytics and AI should assume a significant role in modernizing the ports and drastically expanding their productivity.

- **Smart Railways**

South Africa has a broad rail network – the fourteenth longest on the planet – associating with systems in the sub-Saharan area. The country's rail foundation, which interfaces the ports with the remainder of South Africa, speaks to about 80% of Africa's aggregate.

Improving the country's 20 247km rail system is a top government need, with ventures intending to expand cargo rail volumes and increment piece of the overall industry of compartment traffic. In Oct 2018, Transnet tested successfully the first 4km goods train, in future it will increase manganese volumes railed between the mines in Hozatel through Sishen to Saldanha,

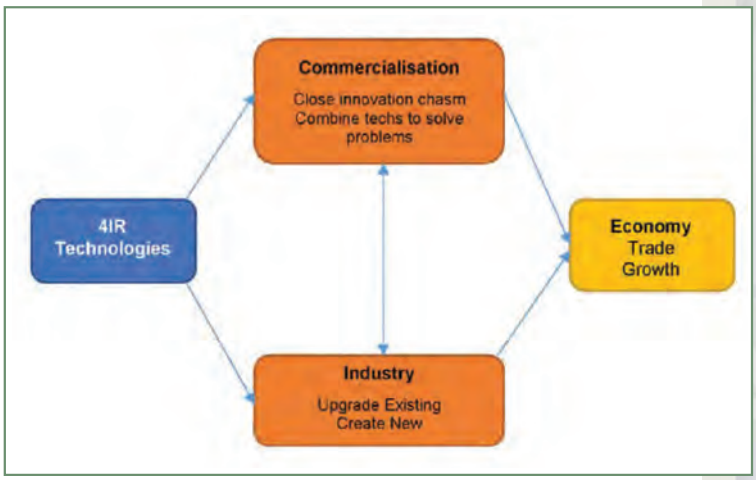
In general, the freight and passenger rail networks are extremely inefficient. Much more use must be made of sensors, data analytics and AI to improve the efficiency of the rail networks, including maintenance and operations, dispatch, scheduling, signalling and other functions.

8.4 ECONOMY GROWTH AND INCLUSIVITY

8.4.1 South Africa Diagnostic

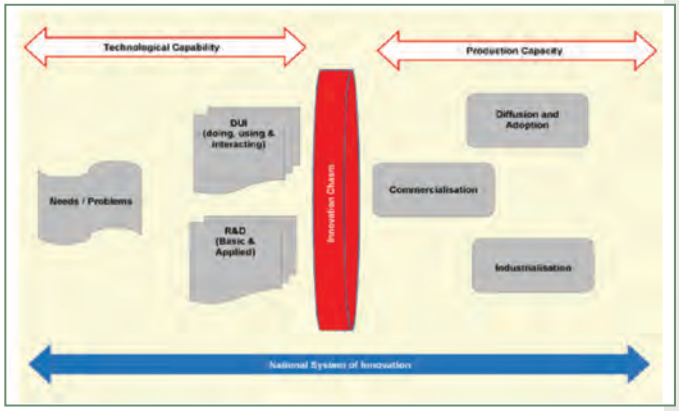
In South Africa the context of Commercialization and Industrialization is for financial and economic benefit through the alleviation of poverty, inequality, and unemployment as outlined in the NDP. Technologies of 4IR have been in existence for some time, thus opportunities are on enabling commercialization, upgrading existing industries and creation of new industries. Identify 4IR technologies fit to solve challenges facing South Africa. Figure 45 shows a proposed approach.

Figure 45: A proposed approach to commercialisation and industrialization



The proposed approach and all activities leading and related to commercialization and industrialization take place within the ambit of the South Africa national system of innovation. The precondition is identification of needs/problems, the start to solve is either through basic and applied R&D, and/or learning by doing, using and interacting (DUI). The output is then translated into commercially viable products and services, and as identified by the OECD in 2007 the innovation chasm persist in the South Africa national system of innovation. The innovation chasm remain a challenge, and the work of the Commission must aim to offer new insights and way forward. Figure 46 shows the conceptualisation from idea to commercialization and industrialization.

Figure 46: A conceptualisation of idea to commercialisation and industrialization



Technology can lead to many commercialization and industrialization opportunities, as show in Figure 47.

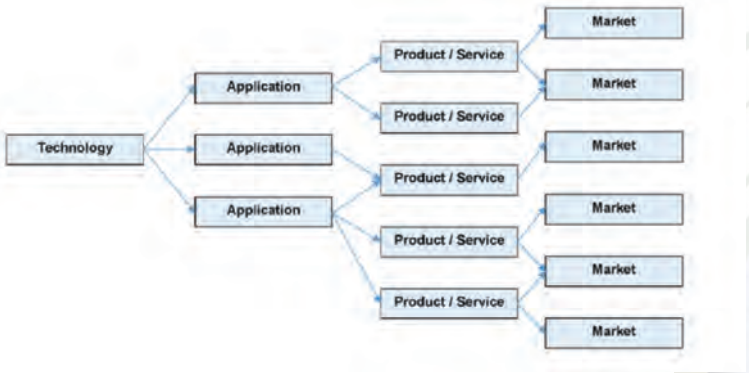


Figure 47: The Technology, Application, Product/Service and Market framework
Source: Amadi-Echendu and Rasetlola (2011)

8.4.2 4IR industries of focus

While many look at it with only the eyes of emerging fusion of technologies like Artificial Intelligence and Data Sciences; the fourth industrial revolution really present more than that for South Africa. As we interrogate the entire value chain of this revolution which in a holistic manner, we see that this very technology and low carbon future that is brought by the fourth industrial revolution is unthinkable without energy storage in order to level renewable energy sources. It is true that Fourth Industrial Revolution encompasses the Internet of Things, however, goes beyond simple device connectivity toward being an Internet of Everything. The realization of 4IR requires sustainable energy supply, with climate change on the doorstep the energy system must transition to low carbon.

Looking at the initial stages of the 4IR, there is one component that plays a critical role; Calcium Fluorite (CaF2) also known as Fluorspar. Fluorspar is a mineral made basically out of calcium fluoride (CaF2). It is commonly categorised by CaF2 content as either metallurgical level (60% to 85%), clay grade (85% to 96%) or corrosive grade (97%+). Acidspar is the most noteworthy type of fluorspar and has the most noteworthy aberrant use in downstream businesses. In the Fourth Industrial Revolution CaF2 is setting off to be a significant player in crude material. Fluorspar is the overwhelming source for the synthetic component fluorine (F), and attributable to F's extraordinary concoction properties, it is to a great extent vital in its utilization. A portion of its uses include steel pickling, aluminium refining, fluoropolymers and fluorochemicals, making fluorspar vital to driving the computerized financial growth later on.

Fluorite is a broadly occurring mineral, which is found in enormous deposits in numerous zones. Eminent deposits happen in China, Germany, Austria, Switzerland, England, Norway, Mexico, and both the territories of Ontario and Newfoundland and Labrador, in Canada, with the biggest deposits being in South Africa. The steel and aluminum industry have the most popular demands for the substance while fluoropolymer and fluorochemical industry, evaluated development rates that compare to levels of over 50% over the normal worldwide gross domestic product (GDP) development rate of about 2.35%. Though South Africa has the largest reserve of CaF2, Asian Pacific (APAC) is accounted for the maximum share of the global fluorspar market. The APAC fluorspar market is driven by the presence of robust automotive manufacturing industry, which keeps the demand high for steel and aluminium However with the advent of the Fourth Industrial Revolution a bigger demand will be that of battery storage, specifically Lithium ion (Li-ion) batteries.

Li-ion batteries are found in electronics, mobile phones, laptops, tablets, Electric Cars, Robots and other machinery. These are all hardware components of the Fourth Industrial Revolution. Li-ion batteries consist of three major elements: Lithium Hexafluorophosphate (LiPF6), Electrolytes and Cathodes.

Fluorochemicals Salient market characteristics are as follows: The global fluorochemicals market size is anticipated to be valued at USD 31.28bn by 2024, at which point it is expected to reach 5.49mn tons; the global fluorochemicals market share is fragmented, with large number of manufacturers, such as DuPont, Daikin, Solvay, Asahi Glass, Arkema and Honeywell and Dongyue, dominating the international market. NECSA HF subsidiary, Pelchem remains a leading regional player in the industry; and in South Africa, a large growth is expected in the industry with the completion of the Nokeng open pit mine in Gauteng province. This mine will utilise two deposits, with an expected 630, 000 tpa crude fluorspar ore, 180,000 tpa Acidspar and 30,000 tpa Metspar. First production from the mine was expected in January/February 2019.

Other country's key economic sectors

China focuses on electronics production, India focuses on software, Brazil focuses on Small Business for services, German on Precision Manufacturing. What could South Africa focus on? With abundant sun and win, energy storage has potential to transform South Africa's energy mix, thus provide sustainable energy in the era of 4IR.

State of SA today

The GDP of South Africa increased by 3.1% in the second quarter of the year 2019 as announced by Statistic South Africa. The mining and quarrying industry increased by 14.4% and contributed 1.0 percentage points to GDP development. Increased generation was accounted for mining of iron mineral, manganese metal, coal and 'other' metal ores including platinum. Finance, land and business services increased by 4.1% in the subsequent quarter. Increased monetary action was accounted for money related intermediation, land exercises and business administrations. The exchange, food provision and settlement industry increased by 3.9%. Increased monetary action was accounted for in all exchange divisions aside from the nourishment and refreshments major group. General taxpayer supported organizations increased by 3.4%, fundamentally credited to an expansion in work. Conversely, the farming, forestry and fishing and development ventures diminished by 4.2% and 1.6% respectively and each contributed -0,1 of a percentage point to GDP growth. The unadjusted genuine GDP at market costs for the initial half year of 2019 increased by 0.4% contrasted with the initial half year of 2018. On the social side, South Africa is characterised by high levels of poverty, unemployment and inequality. As such and without a suitable response, the era of 4IR could make things worse. How our economy is structured:

8.4.3 Current GDP contributions

Nominal GDP Q3 contribution:

1. Finance contribution: 20%
2. Government services: 18%
3. Trade: 15%
4. Manufacturing: 13%
5. Transport & Communication 10%
6. Mining: 8%
7. Agriculture: 16%

8.4.4 Sectors that are growing vs shrinking

In 2016, a decrease in production in the mining and manufacturing sectors led to reduced growth and GDP of South Africa. 2017, however saw the recovery of the economy, returning the growth to 1.3%.

Major economic indicators for South Africa (2015-2017) are shown below:

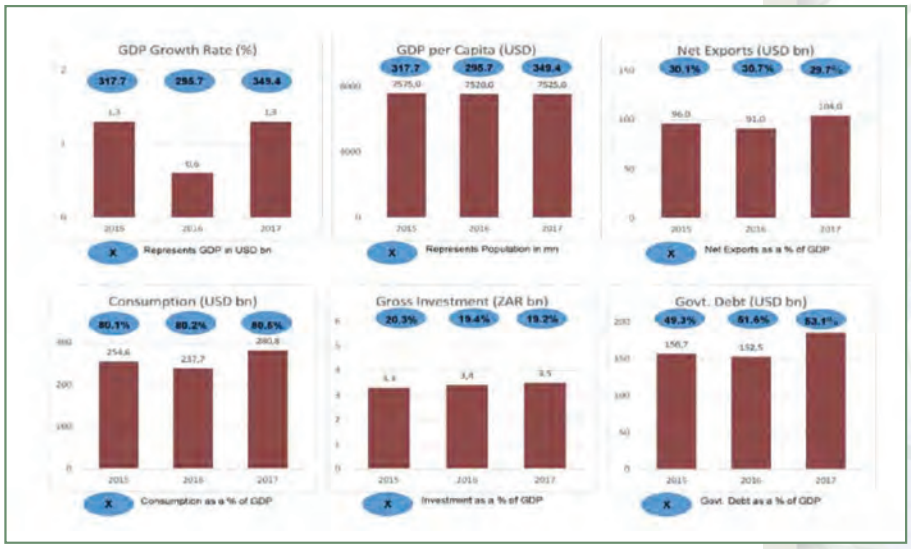


Figure 64: Major economic indicators for South Africa (2015-2017)

Although, in the last decade, the services sector has, by far, been the largest contributor to South Africa's GDP. Growth in Manufacturing (which includes chemicals) has been more moderate.

Composition of South Africa's GDP (ZAR tn, 2008-2017) is show below:

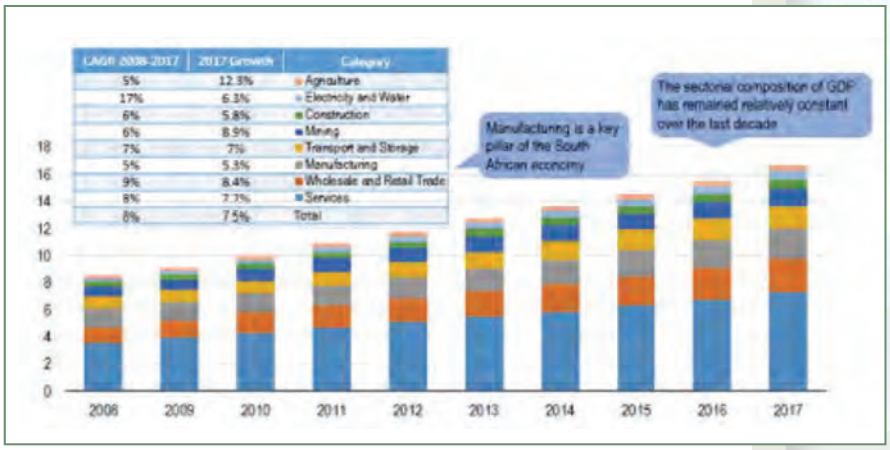


Figure 65: Composition of South Africa's GDP (ZAR tn, 2008-2017)

8.4.5 SA 4IR Opportunities, Centres of Excellence

Consultation with the public urged that 4IR must viewed with the lenses to solve on challenges facing South Africa. SMMEs are viewed are central to the challenge of poverty and unemployment, thus ensuring SMMEs participation is critical. For industries 4IR must be viewed in the context of industrial challenges, one being strengthening and upgrade of existing industries through adoption of technology and/or combination. Innovation is the overacting concept to enable commercialization of technologies, thus strengthening the national system of innovation. Challenges in industries include high operating and maintenance cost, shutdown cost, aging and outdated machinery, workforce skills mismatch, etc. The focus on developing new industry, sector and firm level capabilities was emphasised. On new industries, 4IR could enable new and grass roots innovation to emerge. For South Africa this is imperative for achieving an inclusive society. Policy relevance and alignment to enable the realisation of 4IR emerged strong.

Opportunities must be created to prepare studentpreneurs and overall entrepreneurship development across higher education for new SMMEs. Intellectual property law, where universities hold the IP on new ideas, was raised as a bottleneck to commercialization. On the basis of commercialization being about creating value for gain – economic and/or social - it implies that South Africa is missing out on developing opportunities for gain. In essence, the current national system of innovation reinforces the innovation chasm. A review of the IP system and associated policies, laws and regulations are necessary, and it must emphasise anticipation of the 4IR world. Current instruments meant to drive innovation are found to be failing, a need to review mandate, and either strengthen, remove or implement new suitable instruments. Collaboration among government, large companies and SMMEs was raised as a key. A need to understand barriers for collaboration across industries, sectors and value chain is recommended.

A definition of an enabling environment must be established, and it must allow for circumstance and context. Opportunities require different enabling environments to thrive. Resources are available in South Africa; it is viewed as failure to make effective use of the resources with reinforcing loops for progress. Grant, funding and financing instruments are not coordinated; thus, windows of opportunities are being missed. A review of the overall national system of innovation is encouraged. Adoption of 4IR technologies would require new business models, thus guiding industry for adoption of new business models is essential. Mechanism to encourage innovation across industries must be investigated. Perhaps consider an approach of ecosystems for different opportunities.

8.5 STAKEHOLDER RELATIONS AND GOVERNANCE

Globally, efforts are under way to adapt policy and regulatory regimes in order to harness the 4IR to achieve national and international goals. This effort spans both developed and developing countries, both democracies and authoritarian states, and both cultural and ideological divides. The USA, the EU, China, and Russia, amongst many others, are accelerating policy and legislative reforms in order to harness technological change to meet national objectives. In the UK all new legislation will be challenged for any negative impacts on innovation, and a new Regulatory Horizons Council will be set up to consider how to support the 'rapid and safe' introduction of new technology. In South Africa, the process is under way, and the PC4IR plays a critical role: we aim to provide recommendations to guide the actions of both legislators and policy makers within government to implement a coherent national response.

The thematic scope of such policy and legislative reform is vast. It covers the thematic domains of each of the Work Streams of the Commission, and more. Since the technologies of the 4IR have the potential to impact on every economic sector and on every sphere of private life, the 4IR is positioned as a 'cross-cutting' policy and legislative consideration. Some examples (not covering the full scope of the 4IR) include policy and legislation related to data access, data privacy, education, skills development, research and development, industrial policy, trade, business development, AI, cyber-security, biotechnology, and autonomous vehicles, amongst many others. The work stream will engage with specialist researchers to develop a detailed mapping

of global regulatory responses to the 4IR, to serve as a baseline for the development of recommendations for South Africa.

The WEF suggests that "Industry self-regulation is a key governance tool in many industries, such as healthcare, mining or professional sports, and can also be applied to speed up appropriate governance of the use of technology in new industries." This is an area that South Africa may explore. What is clear is that we require experts and a variety of stakeholders to collaborate to define and shape the required policy and legal frameworks and ethically driven principles to ensure that regulation, policies and laws do not slow down the uptake of 4IR.

Government must design policy processes which allow for the active participation of users and citizens such as persons with disabilities, people living in rural areas with no access to internet, educational institutions, academics and any individual with an interest in the matter. This collaborative principle offers an advantage from traditional policy processes, where "there can be a gap between policy development and implementation because the policy has been formulated in isolation from its users."[100]

100 http://pdronline.co.uk/blog/2017/09/people-powering-policy

CHAPTER NINE: Recommendations

9.1 INTRODUCTION

After extensive research, analysis, consultations, and stakeholder engagements, a number of recommendations have arisen. The Presidential Commission on the Fourth Industrial Revolution has categorised these recommendations as major and minor, in relation to their priority levels.

9.2 KEY RECOMMENDATIONS

Collectively, these reports reflect the key findings of the Commission, namely:

9.2.1 Invest In Human Capacity related to 4IR

On a more fundamental level, we must attempt to initiate changes which are catalytic to structural change, as it is inevitable that the education system will evolve structurally to reflect the architecture of the 4th industrial revolution over time. Thought must be given to flexibility, agility, speed of accreditation, integration of learning streams, mobility of learners, remote content delivery, cognitive flexibility and the use of technology to enable the efficiency of the skills delivery system. The 4IR economy requires an approach to skills characterised by competencies which are micro-credentialed, industry aligned and allow people to enter and exit the system at multiple points as part of a lifelong learning process. Qualifications become less important than competency and skills such as creativity, critical thinking, problem solving are central to skilling in this new era, requiring a focus on both STEM and arts, humanities and entrepreneurship education simultaneously. Technology enabled platforms can be used to streamline these processes. The need for social scientists will increase as there is a requirement to navigate complex human issues of ethics, wellbeing, identity etc. in this new era of cyber-physical integration as it impacts and shapes our culture. Technical proficiency in relevant digital skills also becomes paramount. Investments in the current and future workforce are also central to success in the 4IR. This includes the immediate requirement to reskill the youth and retrain the current workforce for future skills. Workforce skills development also entails the introduction of micro-learning into all disciplines to ensure that professional development is continuous and enables worker flexibility.

9.2.2 Build Infrastructure and owning some significant 4IR infrastructure, such as hyperscale data centres, fibre-optic network and undersea cables.

Digital Infrastructure is the bedrock of the country's 4IR future. To this end, this Commission recommends the accelerated implementation of the Policy On High Demand Spectrum and Policy Direction on The Licensing Of a Wireless Open Access Network (WOAN) as a step towards universalising access to the internet, particularly for the poor and geographically isolated. Social Infrastructure, that is, the basic services that are foundational to a country's economy, are central to achieving the society, industries, and the economy of the future. As such, the production and delivery of energy; the extension and improvement of water infrastructure to enable water desalination; health, especially in enabling the National Health Insurance (NHI) implementation and educational infrastructure inclusive of augmented and alternative communication systems for people with learning disabilities. are not only necessary for transitioning to the 4IR but are fundamental for wellbeing.

9.2.3 Create Platforms For Citizen Participation.

The 4IR must become a citizen's initiative, rooted in communication amongst sectors of society, to ensure awareness, inclusive participation and a collaborative construction of the desired path forward. To this end, the work of the Commission should be viewed as ongoing to the extent that consensus building will be a continuous process.

9.2.4 Establish a creative AI, Big Data Analytics, Blockchain, and Cybersecurity

Institute alongside an African AI Forum. The establishment of the creative 4IR institute will focus on African 4IR solutions in the areas of Science, Technology, Engineering, Arts, Mathematics, Innovation and Entrepreneurship (#STEAMIE). The creative 4IR Institute may drive a continental music on blockchain initiative for resolving the issue of payment of royalties for Artists from waiting for years within a space of 24 hours. Research and Development capabilities are critical and must be embedded within the state, for the generation of new knowledge and relevant technology applications in sectors such as health, agriculture, education, energy, manufacturing, amongst others. The institute's mandate should also include training, to be delivered across various sections of society.

9.2.5 Own government strategic data and secure Citizens' Data

Data sovereignty will save money for the government and create new income streams when the data is mined. Big Data Analytics will enable the government to make data driven decisions and develop data driven policies. The principal opportunity in the 4IR is the storage of large sums of data. This is critical for building e-government services across sectors such as health, transport and justice. However, this opportunity must be safeguarded through the bolstering of cybersecurity capacity and capabilities. For instance, the state's existing cybersecurity company, Comsec, could be strengthened to execute its mandate in a manner that is relevant for the requirements of the 4IR.

9.2.6 Incentivise Future Industries and Applications of 4IR Technologies

For the industries of the future to emerge, new forms of incentives are required, incorporating subsidies and tax breaks, to support the acquisition and application of advanced technologies in the manufacturing of goods and delivery of services. The DTIC acknowledges the country's position as a laggard in digital or smart industries and will require support to develop SMMEs into globally competitive industrial players. It is envisaged that the emerging SMMEs, working in technology fields, will develop solutions that address South Africa's development challenges as well as unemployment and service delivery. The state, as the largest and most powerful purchaser in the country, has a significant role to play in the application of 4IR technologies across priority sectors.

9.2.7 Update Regulation

Finally, to achieve the above changes, the regulatory environment must be adapted to enable the desired progress. This exercise requires the legislature to be trained to become science literate in order to implement changes that are holistic, integrating the specific logics of technologies, the industries they impact, the people who will both consume and produce them and the agility requirements to compete on a global stage.

9.3 EXTENDED RECOMMENDATIONS

- Implement 4IR safety and security smart surveillance systems at all our borders and ports in order to monitor porous borders while creating smart ports. Porous borders are the biggest threat to South African's safety and security. There are persistent safety and security issues at our ports. Our smart surveillance system would enable a proactive approach in dealing with our porous borders and our ports.

- Establish a 4IR fund building on the current Universal Access and Service Fund (UASF) that is expanded to cover more sectors. Economic participation, entrepreneurship, prosperity, wealth creation and future of jobs, especially for the youth, women and people with disabilities, in the 4IR era. The 4IR fund will among other vital deliverables assist in positioning Africa as the world leader in the provision of new minerals that drive 4IR.

- Ownership of a government Southern African Development Community (SADC) geostationary telecommunications satellite for quality connectivity of marginalised communities in the SADC

region, at no cost to them, so that they may access 4IR applications, especially for smart health, smart learning, smart ammunition, smart minerals, smart agriculture, smart contracts and smart financial services. The bird will create an enabling environment that opens opportunities for shared economy that will empower all Africans to change their material social conditions and alleviate poverty, inequality and youth unemployment. We will create the much-needed redundancy by large global enterprises. The geostationary satellite will add value in setting up an African central exchange for voice, data and other communication media. It will also enable smart contract for the African Continental Free Trade Agreements (AfCFTA). The SADC-owned geostationary satellite will result in significant increase in gross domestic product (GDP).

- South Africa's industrial policy should be revisited in the light of 4IR
- An Institute which makes legislature scientifically literate should be established.
- A universal database should be maintained by ARC for agriculture, MRC for health, ARMSCOR and Denel for security, Department of Tourism for tourism, and Department of Transport for mobility.
- SAASTA, South African National Space Agency and Denel should investigate the application of Drone Technology
- NEDLAC should investigate and make available the jobs of the future
- South Africa should explore the creation of risk capital fund
- Establish the Post Bank as a state-owned bank that will be a digital bank, which will incorporate 4IR systems like Artificial Intelligence and blockchain technology. This bank will be sustained through funds from the National Student Financial Aid Scheme (NSFAS) as well as government departments in the way that they pay their suppliers, employees as well as all stakeholders.
- Redesign/Alignment of the skills ecosystem for agility necessary for 4IR learning
- Prioritise the coordination of the various components and systems within the complete skills ecosystem to a new configuration which is fit for purpose for the skills demands of the 4IR era i.e. Stackable competencies which are micro-credentialed, industry aligned and allow people to enter and exit the system at multiple points as part of a lifelong learning process, introducing relevant technology and devices and digital and future skills (competency skills, digital literacy skills).This systemic change process should be facilitated at the Human Resources Development Council as a priority project for 2020 i.e. have a timeframe associated to the deliverable, assisted by the 4IR Commission and driven by the Digital & Future Skills Forum. Link this ecosystem to cradle to grave nodal network, driven by AI within and across ecosystem components to perform the function of coordination and streamlining. Use the national Digital Skills Strategy as an overarching guideline strategy for skills alignment.
- Establish a national project for teacher upskilling in digital literacy, critical thinking and creativity skills. Reimagine the role of the teacher in the classroom where they are not the source of knowledge but the facilitators of learning by creating our own solutions that empower the child, the teacher and the parents to support their children irrespective of their level of education. Focus on continuously equipping teachers on the subject matter they are teaching, not just the 5-day, 10-day workshops by creating blended earning platforms. Universities can ensure that every teacher can understand 4IR and the curriculum especially in the foundation phase where one teacher teaches all the subjects
- Invest in relevant infrastructure – develop minimum infrastructure recommendation for schools for 4IR e.g. DBE must work towards every school having access to internet and no less than 25

computers and a printer, a dedicated room as a maker space for robotics curriculum and a basic set of music and art equipment

- Provide resources for urgent roll out of ECD learning centres
- Resource the Department of Basic Education With 4IR Strategic Advisory Capacity -
  a) To drive the implementation of coding & robotics curriculum
  b) Provide resources for urgent implementation of national roll out of ECD so that 4IR skills can also go to this level
- Innovate and realign the Seta's by creating a framework that guides the scope, budget allocations and priority skills development areas relevant to South Africa's 4IR strategy, including the necessary legislative amendments.
- Rethink TVET colleges roles as micro learning institutions providing 4IR relevant competencies.
- Adequately resource the South African Qualifications Authority to design, test and implement technology solutions for faster turn-around times for accreditation processes.
- Consider innovating qualifications assessment criteria to allow for flexible learning pathways and erasing of the boundaries between learning centres and the workplace e.g. broaden definition of unit standards.
- Align skills development funding instruments
- Introduce foundation skills (digital literacy, literacy and numeracy) and competency skills (creativity, critical thinking, complex problem solving) in ECD and primary education
- Resource DBE for implementation of the coding and robotics curriculum
- Develop industry informed academic, vocational and occupational curriculum for secondary education with career pathway opportunities for students i.e. invest in industry value chain partnerships with skills institutions and school for learner uptake into jobs.
- Mainstream the arts in ECD and Primary school: A properly run arts programme in schools has both cognitive and social benefits, particularly for children from ECD through primary school levels, where their cognitive development potential is in its prime. These include critical thinking skills, increased IQ, increased creativity and abstraction ability, and a positive impact on other other learning areas, literacy and reading skills and potentially improved mathematics performance. Key studies on the impact of music for example on learning show that engagement with musical activities develops the spatial reasoning, visual spatial intelligence and perception ability areas of the brain. This means that process ability, conceptual ability, memory and recall, social and kinaesthetic intelligences and mathematical ability are directly impacted by engaging with these activities. Use the existing Creative Art subject in the CAPS curriculum to stimulate whole brain cognitive development, creativity and critical thinking by innovating the current arts curriculum to provide properly designed music and arts education in ECD and the phases of primary school. The curriculum does not have to be changed, but merely enriched. Pilot this in a community across several schools or in a district for measurement, evaluation and replication on a wider scale.
- STEAMIE not STEM Education: By the same token, STEM learning without the arts, innovation and entrepreneurship is limiting. The reference to the arts doesn't just imply the creative arts disciplines, but the Social Sciences in general. The priority skills in the 4IR era are competency skills ('soft' skills) coupled with technical skills. The need for social scientists will increase as the requirement

to navigate complex human issues of ethics, wellbeing, identity etc. in the 4 IR environment increases. The articulation of how we interact as humans with this new cyber-physical integration as our reality and how this defines us and shapes our culture is the preserve of a new generation of social scientists. The jobs of the future are predicted to require more sophisticated social and human skills as technology automates many jobs. It is these elements of competency that will set a job seeker apart in the 4 IR environment. All technical and scientific training should include a mandatory social science subject/module/focus to provide a balanced and competency driven skills profile.

- Leverage the youth demographic to establish South Africa as a nett exporter of skills in the digital economy. South Africa's large youth population is ideally positioned to provide critical skills to global markets in the digital economy
- Creation of a 4IR Horizontal SETA: 4IR focus should be imbedded into the SETAs by amending the Chapter 3 and Chapter 7 of the Skills Development Act to specify that SETA's will have a focus on 4IR related skills development initiatives that will attract a set-aside budget. In order for this to happen, a framework needs to be created to qualify what falls within the scope of 4IR. In years 1-2, the SETA's would be required to ensure that 20% of their annual budget is spent on 4IR-related initiatives. In years 3-5 this would increase to 50%. Thereafter SETA's would be expected to have all of their budget aligned to relevant 4IR related initiatives by 2028. 4IR would be mainstream by then. Coordination across SETAs is of utmost importance. A separate entity (a horizontal or super-SETA) needs to oversee the 4IR-related initiatives and have SLA's signed with the vertical SETA's.
- Invest in strategic projects for mass skills development and industry uptake in high growth potential industries. Initiatives should be scalable for exponential labour market absorption and skills pipeline development. Engage in skills development PPP initiatives across all of the identified high-growth potential industries. A portion of the skills development levy (SDL) can be used for funding the "PUBLIC PARTICIPATION" part of the PPP initiative. Establish a cradle-to-grave nodal network, driven by artificial intelligence, within and across sectors. This will enable a skills pipeline linking skills related market demand with an identified talent pool. Skills development courses should be competency based and stackable. This will enable quick turnaround times (as soon as 3 months) in terms of skilling and deployment into industry. In addition, multiple exit streams viz. employment, outsourcing and entrepreneurship is part of the nodal network. This creates flexibility in the system, resulting in opportunity for every individual to realise their full potential.
- Resource and scale the NTIP initiative's model, approach and platform for the manufacturing sector and extend to other industries such as the creative industries, tourism and agriculture. NTIP currently has a working model for the manufacturing sector. The model allows a systemic approach to an industry sector with whole value chain participation which is industry driven. The underlying nodal platform driven by AI provides a coordinating mechanism which makes the system efficient, proactive and comprehensive. Funding should come from the Seta's for these projects. The approach will create a skills pipeline linking skills related market demand with an identified talent pool and can show results within a short period of time without sacrificing depth and quality of skills and human capacity development in a multi-dimensional fashion.
- Leverage YES Programme: Youth Employment Service - link this programme to actual vacancies in emerging industries - include 4IR skills training in the time they are with the sponsor - link the youth to fulltime jobs and vacancies in that entity or other organizations in need of skills.
- Establish/Resource Creative Industries Hubs and Clusters in Townships for Digital Content Production including animation, gaming, virtual reality and augmented reality, photography, graphic design, sound production, audio design, film & video production, digital art production,

transmedia, digital marketing. Cluster creative industries SMME's in these hubs where a full value chain intervention from skills, to incubation, to content origination, content production and distribution in a networked system is supported, linked to industry. The Gauteng Economic development department is coordinating a process, along with most of the Gauteng metros/ municipalities (although it is industry driven) in which industry mentorship and partnership and access to local and African markets is already leveraged. This initiative can be capacitated and scaled with funding from the Seta's as well as PPP arrangements. New foreign owned entrants to our market can be engaged with government as a facilitator, to invest in content production infrastructure via BBBEE equity equivalency processes etc. as well local mobile companies (MTN, Vodacom, Cell C, Telkom, Virgin Mobile, Rain and other mobile network operators) to procure content from this network of township producers who are being mentored by industry to ensure quality content delivery.

- Maximising the planned Digital Hubs Rollout: The currently budgeted for and planned government roll out of 100+ digital hubs should be leveraged for 4IR skills development, 4IR awareness programmes and social dialogue regarding 4IR in the SA context. The Hubs should be maximised to include the spaces and technology relevant to the full spectrum of digital skills (ICT and digital creative skills), competency skills (such as, creativity, critical thinking, problem solving, collaboration, negotiation) and entrepreneurship skills.

- Ring-fence UIF funds: Ring-fence a percentage UIF funds to use towards upgrading skills of the unemployed. By leveraging these funds unemployed individuals can be re-skilled within the six month timeframe of their UIF benefits cover and potentially job ready again.

- A national platform to educate, inform, update on training and other opportunities in the 4IR context should be established. This platform should be an online platform supported by a variety of campaigns in the public domain, events, workshops etc.

- Issues such as promoting social dialogue and collective representation of workers and employers, supporting and incentivizing entrepreneurship and harnessing technology for decent work and job creation must be mainstreamed and coordinated in business, labour and entrepreneurship bodies and fora.

- Create Social Protection Scheme For Human Capacity In the SMME & Informal Sectors. Human capacity in our informal economy and SMME's requires investment in social protection systems as well as financial mechanisms to boost start up and early stage ventures. Enabling SMME's access to appropriate technology will enhance their growth and ability to scale.

- Attract Critical Skills By Amending Prohibitive Legislation

  a) Amend section 19(4) of the Immigration Act be amended to specifically reference 4IR related skills. The amendment should better enable highly skilled immigrants to come and apply their trade in South Africa under favourable conditions. The attraction of highly sort-after 4IR skills be assist in accelerating the development of South Africa's knowledge base and industries. These skills must not be restricted to academia but should include entrepreneurs who intend on starting businesses from South Africa.

- Amend Labour legislation to accommodate the Gig economy by recognizing Internet project work as legitimate work. This should include incentives for companies to build Gig Economy platforms to leverage South African 4IR skills for global demand.

- Copyright & IP protection - The Copyright Amendment bill is currently with the President for signature. While better than the previous version, it is still highly controversial due to a "fair use" clause that has been included which potentially threatens creative content producers' ownership

rights, and according to a PWC review of the draft legislation, could lead to inferior content production for academic textbooks and resources – impacting the skills sector significantly. IP protection and ownership is the bedrock of the creative economy so an in depth look at what this bill means in the context of 4IR and the creative economy as an emerging area for the future of work is important.

- Develop flagship full-spectrum incubator networks for AI and robotics that can build skills, knowledge, intellectual property, infrastructure, institutional linkages, and technological capabilities. Incubator networks must include business, government, academia, and civil society. Networks do not require large fiscal allocations, but can serve to enhance co-ordination, strengthen systems of innovation, link skills supply and skills demand, link technology developers and potential users, and connect pockets of excellence in a way that enables South Africans to be more globally competitive.
- Make it easier for skilled people to enter South Africa.
- Establishment of a flagship social science research programme that focusses on the 4IR. This will build intellectual capital to benefit policy development, institutional programming, evidence-based decision making, and thought leadership.
- Review tax structure on processed minerals used in 4IR components e.g. components for robots and robotics that are produced within the borders of our country. Impose a tax that will be less than when the minerals are exported without them being processed. These taxes will incentivise companies to build factories within the country and create products that speak to the future of the country and ultimately create jobs.
- Use virtual reality to train our health officials (Doctors, nurses and other professionals in the hospital) to ensure that they have the necessary experience to help the people within the hospital. Ensure that these virtual reality systems will be relevant and help within our medical fraternities and ecosystem.
- Government should improve the different funding agencies and leverage the experience and track records of venture capital firms that have proof that they can fund entrepreneurs for growth. Funders (public and private sector) should work together possibly through private partnerships to fund businesses in an agile way and in a way that aligns with Fourth Industrial Revolution opportunities. Duplicated funds across multiple government departments can possibly be pooled for Fourth Industrial Revolution aligned businesses. Government has a funding strength while there is funding mandate experience in Private Sector funders. We need to bring these strengths together for agile, efficient funding of SMMEs aligned to the 4IR.
- Government should provide free Wi-Fi hotspots within rural areas.
- Smart government: Empower and arm policymakers, parliamentary members and leading political parties with new age technology policies, for the responsible and conscious use of technology. Focus on data privacy and data protection laws and regulation, digital taxation draft law, (adopt the Turkey draft law), develop tax policies that can better account for operations of digital and virtual companies that have seen exponential growth as their services have become ubiquitous.
- Unwavering Energy resources: Accelerate non-fossil fuels energy resources, conclude PPP arrangements for alternative, sustainable and cost-effective energy to empower high economic growth sectors to ensure

- One stop destination for massive hyperscale data centres: Invest in digital infrastructure, prioritizing backhaul and last-mile transport networks and capitalize on the undersea cables landing in the country's offshore to ensure South Africa becomes a one stop destination for hyperscale data centres. Localize manufacturing of components used for seamless connectivity, fibre optic cables, accessories, semiconductors, mobile devices
- Knowledge economy skills: An overhaul of the basic education to include soft skills from early childhood, Investing in high end computing facilities, machine learning/artificial intelligence special academic institutions (R&D) with practical real time projects exposure, to underpin the knowledge economy; innovative learning methods to empower the disable and all those coming from under-served areas.
- Cultivate the small business ecosystem: intentional investment to the SMME ecosystem in the commercialization of high value 4IR projects, beneficiation and unbundling of projects in key economic sectors.
- In light of recent retrenchments due to adoption of 4IR technologies, it is recommended that government considers incentive package for companies that upskill their workforce for the era 4IR and beyond.
- In view of the need to create new products and services to grow the economy, all grades in secondary school level must offer an introductory course in industrial revolutions and technologies of 4IR. At university level, each year of study must include a course on how technologies of 4IR could be used to build a smart South Africa. Students must collaborate across faculties and universities on project basis, with presentation each quarter, and final presentation at the final year of study.
- Start-ups and SMMEs must be provided free access to all 4IR technology platforms (including university laboratories) across the country and expert advice for the purpose of product and business model development. Technology Innovation Agency and the CSIR could jointly execute this recommendation.
- Intellectual property regime to be reconsidered in view of the need to be dynamic and enable speedy commercialization of research output into product and services.
- The DTIC and DSI to conduct a 4IR industry audit, and companies that are found to be at risk of being disrupted by 4IR must be assisted to upgrade and transition through the adoption technologies of 4IR and new business models. Owing to the rapid pace of change, such an audit must be conducted on a regular basis.
- The current carbon intensive energy system is hindrance for new investment, it is recommended that a suite of 4IR technologies be identified and utilised for upgrade and transition towards a low carbon energy system and economy.
- Data remain a barrier for our people to be participant of 4IR across the region, as a start, it is recommended that government considers engagement with SADC member states to ensure that data purchased in this region can be used across.
- South Africa takes a policy position, in line with NDP, to set itself up as a regional financial centre within Africa. This would include things like setting itself up as a fintech hub (sandbox, etc) and adopting agile governance principles. Even the digitisation of government to enable ease of doing business. Policy, law and regulation should align with such an overall policy.
- South African adopting a policy position to have tech hubs using similar thinking to Special Economic Zones (SEZs). This includes looking at the business support environment, having a visa

that allow us to attract top talent, making it easy for international firms to set up business here, as well as making it cost effective for entrepreneurs to start high tech businesses. The idea is that we are competing globally anyway and it is better to have firms operate here and us learning from them than our talent leaving to go to other hubs.

- Start a 4IR/tech/innovation fund as a PPP to invest in local innovation. This has to be run by specialists that ensures that bankable projects with smart business plans are invested in.
- South Africa must develop a platform that facilitates the matching of funding needs with investment opportunities. The platform should serve as a 'one-stop-shop' for 4IR related funding, including access to business support services that we help with the development of smart and sustainable business models and the provision of advice to help bankable projects provide the information necessary to help them match with available products while further helping investors more accurately assess the risk available in an investment opportunity. This should also be run as a PPP with the PC4IR playing a key role in its deployment.
- Policy labs and regulatory sandboxes: Globally (or at least in democratic states), there is also increasing recognition that public participation is critical. The USA and the EU have adopted systems of Policy Labs - multi-disciplinary government teams experimenting with innovation methods, more precisely design, to actively involve citizens, academia and business at multiple levels of the public service and policy development process. Government in partnership with small business, corporates, academia, and civil society can, through Policy Labs.
    - Identify the needs of citizens, policy-makers and academics in the context of policy-making through a review of the literature, policy procedures and semi-structured interviews with citizens, policy-makers and academics;
    - Determine if, where and how design research might enhance policy-making by facilitating workshops with citizens, academics and policy-makers from Policy Labs;
    - Develop and test tools, methods and metrics to support the effective use of design research in policy-making with Policy Labs and facilitating further workshops with citizens;
    - Deliver a robust and commonly accepted Design for Policy Toolkit to stakeholders that will be widely disseminated to academics, policy-makers and designers;
    - Test the impact of a policy on the impacted stakeholders and the economy prior to implementation.

  South Africa should adopt a similar policy and regulatory process to harness the positive effect of the 4IR on its economy, society and government. Regulatory sandboxes are partnerships between business and government to test products in a controlled environment to determine their impact on consumer, business and the economy prior to following a complicated regulatory process. The WEF suggests public-private collaborative governance where governments can design policies that leave more opportunity for the private sector to contribute innovative solutions. For example, in Rwanda the government partnered with the WEF to draft and adopt drone regulations that take into account the drone's mission in addition to its physical specifications. This approach encourages clear policy setting, enabling government to develop a new kind of policy maker, regulator and legislator.
- Data policy in South Africa is led by the Department of Communication and Digital Technology. However, from a strategic point of view, data policy is cross-cutting, in that it impacts on other strategic areas, such as Industry 4.0, artificial intelligence, biotechnology, and capability-building. Across this broad scope, several strategic principles may guide data policy. Globally

there is a policy tension between the imperative of open data and the imperative of data privacy. Achieving a balance between these two opposing principles is an important part of an overall approach to data policy.

Clear measures must be adopted to reduce the cost of data for the poor. If one places the digital divide at the centre of the analysis, the question of data costs for poor people in South African might be the most critical issue in the overall South African response to the 4IR.

A national data policy is required to steer the rollout of 5G networks. Splicing is an option that merits exploration, taking into account questions of data access and questions of enabling Industry 4.0 in South Africa. South Africa must support data sovereignty and internalise the beneficiation of South African data. Sectoral responses are also required. For example, ongoing review of the impact of the 4IR in the financial sector is needed in order to safeguard financial stability. Cyber security is increasing important to national security. South Africa's cyber security systems may require enhanced artificial intelligence capabilities. Finally, South Africa's Information Regulator protects data privacy and helps South Africa meet international privacy standards. This function may in future play a greater role and require expanded capabilities, funding and support.

- Research, Development, and Innovation (RDI): Building RDI capabilities is strategically central. More progressive governments have a significant focus on RDI. Without the strengthening of innovation systems and RDI capabilities, South Africa will not be positioned to move towards the technological frontier, enhance competitiveness, or harness new technologies towards developmental aims. RDI policy could include increased support directed through existing instruments, such as research chairs, centres of excellence, the National Research Foundation, and research programmes within universities and science councils. New instruments and mechanisms may also be considered. The Department of Science and Innovation (DSI) is the lead department for 4IR related RDI policy. The Department has proposed the establishment of a 'Converging Technologies Platform' (CTP) as a potential hub for 4IR RDI. The CTP would be guided by a policy advisory service, the 'Inclusive Development Platform' (IDP).

  Building capabilities through education and RDI is a prerequisite for national economic competitiveness, but to harness strengthened capabilities towards economic objectives may require dedicated policy interventions. Industrial and economic development policy options include incentives, SME programmes, and incubators. Some countries, for example Italy, have introduced a R&D tax incentive for industry 4.0 start-ups. A tax deduction related to training and skills development as well as building of manufacturing plants is an option. Digital innovation hubs, technology incubators, and SME development programmes all have the potential to support new businesses and SMEs. Incubators could be domain specific (for example, AI incubator, ecommerce incubator, 3D printing incubator) or converged (for example, 3D bioprinting incubator).

  Local manufacturing hubs must be mandatory supported by enabling policy and law, South Africa's youth must have access to funding structures to solve local problems through local design (from Define (the problem), Ideate, Prototype, Test) and implement. Funding and support should be accelerated when these manufacturing hubs are solving issues that address unemployment, poverty and inequality.

- Public sector innovation Smart cities and human settlements: The technologies of the 4IR could be harnessed to strengthen the capacity of government to provide service delivery. This requires the building of internal government capabilities across a range of technological domains, including the use of AI and data analytics in governance, as well as the use of 4IR technologies to deliver services as diverse as health, security, sanitation, housing, environmental protection, economic development, and education, among many others.

A national policy framework could provide guidelines for unique programmes within South Africa's metropolitan areas, as well as for non-metro human settlements. A national policy framework could make provision for devolved policy-making, while at the same time establishing a mechanisms for the managers and strategic actors involved at the city level to interact, develop cohesive programmes, and foster mutual learning. Government entities must be geared towards rapid innovation, duplication and fragmentation across state owned entities must be addressed urgently. Innovation and funding cannot be restricted to monopoly, unskilled, slow transforming state entities, South Africa's youth and small business must lead innovation and must be funded accordingly.

- Future Minerals: keep strategic mining licenses and ownership of critical minerals that will be the driver of 4IR and beyond localized at no less than 70%. South Africa will be vital in the effort to meet growing demand for Manganese (Mn), Lithium (Li), Calcium Fluorite (CaF2), Platinum, Chromium, Zinc, Copper, Cobalt, Bauxite and Rare Earth Minerals (Neodymium, Dysprosium, ytterbium and Cerium which are all sitting under our ground. All these must be kept within our borders.
- Beneficiation: This will be very critical in ensuring that we grow our economy and create much needed jobs. Beneficiation will looks at specific areas where we are already excelling or entering like HF (Hydro Flourite) production, electrolytes, cathode and more.
- Support the commercialisation of local innovations and start-ups through microloans, hubs with subsidised bandwidth, entrepreneurial and leadership training. And establish a Risk-Fund.
- Agriculture sector: Opportunity to finance agricultural co-operatives and to incentivise support for small farmers from commercial agriculture to adopt technologies such as satellite imaging from drones, the IoT and Artificial Intelligence.
- Adapt 4IR Technologies like AI, big data, IOT to strengthen the manufacturing and the agriculture sector by encouraging the use of technology while training and creating jobs for skilled personnel.

Consultation Period

- Wanting to hear from South African business, government, labour, academia and SMMEs; dates for consultations across SA; channels for submitting feedback & deadline of 30 November for feedback)
- Case studies of 4IR use in SA - pockets of excellence: submit videos, images or writeups (can be used on the website/portal)
- Initial stakeholder consultations were held to solicit valuable input. It must be noted that this is a first draft and stakeholder consultations are ongoing. The first draft attempts to establish a framework and identify
- A challenge noted in investigating solutions for South Africa for 4IR is that multiple sectors and stakeholders are working on solutions, but in isolation of each other. The urgency to respond to 4IR necessitates that there is coordination and integration of work with common strategies developed for implementation across sectors. A human-centric strategy will require a significant contribution from all stakeholders involved. Business (Big Business, SMMEs and Labour), Government, Academia and Civil Society will be required to establish synergies based on trust, responsibility and accountability. A prerequisite for the success of such an initiate will require a resolute commitment from each stakeholder towards a common goal. A committed stakeholder coupled with a suitably enabled environment would create the possibility for South Africa to realise its full potential.

Way Forward

Consultations and further research, finalising the strategy with key recommendations, initial report to Cabinet and President in March 2020.

Development of Scenarios and Next steps

As we consider the future of South Africa, the work will pivot towards an analysis of the **choices** that confront the country. It is important to embrace the language of choice as it also references a key difference in the way in which we will participate in the future, as free and fully informed protagonists in our own future. Indeed, there are **dilemmas** to be resolved: what ought to be prioritised; what sacrifices should be made; what innovations are needed to leapfrog our current constraints; who leads and who follows. These are not simple dilemmas. Indeed, they are compounded by the urgency imposed on us by the full breadth of our history.

The balance of our choices and dilemmas will result in the generation of **Scenarios**. Herbst and Mills (2006) state that "scenarios are a way of producing alternative futures based on various mixtures of assumptions, facts, trends and areas where extra understanding is needed for a particular scenario project." Inevitably, our scenarios will hold together the best and worst outcomes, recognising that the primary function of understanding socio-economic impact is to produce the best possible path forward for all South Africans, including those not yet born. The Critical Uncertainties and Drivers for Change are part of the main considerations when developing scenarios.

Critical uncertainties include:

- Corruption
- External networks, relationships and power structures
- Peace and stability
- Foreign and local investment
- External networks, relationships and power structures

Drivers for Change include:

- Economy
- Society
- Infrastructure
- Environment and Natural Resources

The Commission will over the next few months consult Business, Government, Academia, Small, Medium, Micro Enterprises (SMMEs) and Citizens to gather inputs for the development of the Scenarios. The Commission will, through the consultation sessions, refine and recommend a Scenario for the country in 4IR. The scenario will be reviewed against the WEF Global Competitiveness Criteria and the UN Human Development Index to ensure that the country can optimise its competitiveness and the wellbeing of South Africans.

ANNEXURE A: Emerging Trends, Increasing & Decreasing Roles In Selected Industries

Source: Nedlac Futures of Work in South Africa, March 2019: Analysis of selected industries, pg. 64-93. Institute of Futures Research

	SECTORS	TRENDS DRIVING INDUSTRY CHANGE	ENVISIONED FUTURE	INCREASING ROLES	DECREASING ROLES
1.	Healthcare	Aging populations The rise of non-communicable diseases. Intelligent, connected 'wearables. Shift from short term prevention to long term overall well-being (wellness) Informed and empowered consumers.Flipping the health care delivery model from business-to-consumer (B2C) to consumer-to-business (C2B).	Business and care delivery models, aided by digital technologies, may help to address today's problems and may build a sustainable foundation for affordable, accessible, high quality health care for all.	Recreational wellness therapist Nurse practitioner Home Health aide Online caregivers VR experience designers Care-bots App developers (linking medical devices)	Medical and clinical lab technologists Medical transcriptionists Dental lab technicians Dental hygienists Opticians dispensing Medical records and health info clerks
		Data interoperability, security, and ownership moves to the forefront Aging workforce, rising demand for health care services and reduction in physician working hours are driving shortages of appropriately skilled people		Geriatric carer Medical tourism Geneticist Drome monitors (new delivery models) Co-bot surgeons Wellness monitors	Pharmacy aides Medical equipment preparers Medical insurance claim clerks Trainers (replaced by VR applications)

	SECTORS	TRENDS DRIVING INDUSTRY CHANGE	ENVISIONED FUTURE	INCREASING ROLES	DECREASING ROLES
2.	Informal Sector	Rise of collectives and cooperatives. Supermarkets and other retailers creating offers to service consumers at the lower end of the market are encroaching on what was the sole domain of spaza shops and informal operators. Opportunities opening up through recycling Gig economy Digital platforms Digital proficiency Connectivity	Changing mental models will continue to 'de-stigmatise' the notion of not having a full-time job.	Gig-like services Elder care specialists Personal security services Informal banks (stokvels) Day care specialists Crafters (makers movement) Networking specialists (connecting people) Home care specialists (Social) media specialists Data analysts for informal sector App developers to connect informal traders & service providers	

	SECTORS	TRENDS DRIVING INDUSTRY CHANGE	ENVISIONED FUTURE	INCREASING ROLES	DECREASING ROLES
3.	Energy Sector: Oil & Coal	Legislation and regulation around carbon emissions Technology innovation Water, food and climate change Globalised, urbanised, connected world	Urbanisation as well as an increased consumer focus on environmentally friendly and healthy lifestyles could encourage cycling, walking and car sharing as alternative forms of mobility Green energy focus	Solar technicians Designers of solar systems Energy optimisers Multi-source grid managers Solar Engineers Wind energy technicians Process automation specialists Data analysts Forecourt destination managers Re-trainers (enabling oil & coal workers to acquire new skills) Designers of wind energy systems	Mining plant operators Oil & coal extraction workers Power plant operators Inspectors, testers, samplers, weighers Procurement clerks Material recording and stock-keeping clerks Excavating, loading & dragline operators Conveyor operators Mapping technicians Oil refining plant operators
					Planning & expediting clerks Geological & petroleum technicians Drilling & boring machine setters & operators Crushing machine setters & operators

	SECTORS	TRENDS DRIVING INDUSTRY CHANGE	ENVISIONED FUTURE	INCREASING ROLES	DECREASING ROLES
4.	The Transport Sector	Self-driving cars Autonomous trucks Aviation and other things taking flight. Remote-controlled cargo ships Machine learning leads to optimisation	The rapid pace of urbanisation puts added pressure on already strained infrastructure, which needs to be designed to absorb such growth, and be as efficient as possible Along with the pressures, come opportunities – the increased size of cities widens their power and tax base and enables a greater investment in public transport	Data analysts AI & machine learning specialists System optimisers Infrastructure designers Transport hub experience managers Solution designers Transport concierge Drone operators VR training development Blockchain management of transport routes & bookings Supply chain & logistics specialists	Taxi & bus drivers Cashiers & ticket clerks Route monitors Cargo vessel crew Train drivers Cargo & freight clerks Parking lot attendants Truck drivers Route monitors Railroad brake, signal & switch operators Weighbridge Operators

	SECTORS	TRENDS DRIVING INDUSTRY CHANGE	ENVISIONED FUTURE	INCREASING ROLES	DECREASING ROLES
5.	Public Sector	Fragmenting global order Expanding individual power Technological advances Demographics: Millennials are pushing innovation and getting involved in government	In most countries across the globe, the public sector is transforming, downsizing, revamping, and being overhauled The pace and dimensions of this change are unprecedented - driven by budgetary constraints and new approaches to public service delivery Public Sector refers to all levels of government	Digital transformation specialists Digital currency people Embassies taking a bigger role as business developers & facilitators People facilitating optimisation across departments Process automation specialists "Connectors" across departments – to identify opportunities for working together Cybersecurity monitors & professionals AI ethics officers & coders People facilitating optimisation across departments Re-purposers: people turning concrete jungles into greener spaces	Accounting, bookkeeping & payroll clerks Administrative staff (capturing & sharing info) Material recording & stock-keeping clerks Ballot/vote counters Couriers & messengers Order clerks Internal auditors Roles that are duplicated across departments Roles that build unnecessary levels of hierarchy into the system – move towards flatter structures

	SECTORS	TRENDS DRIVING INDUSTRY CHANGE	ENVISIONED FUTURE	INCREASING ROLES	DECREASING ROLES
6.	Services Sector	Globalisation enables a more mobile workforce Demographic shifts are having interesting effects on the service sector Innovations in technology mean that machines have the ability to aid and sometimes replace people. Advanced user interfaces enable computers to respond directly to a wider range of human requests, thus augmenting the work of highly skilled labour, while allowing some types of jobs to become fully automated	The service industry isgenerally believed to require person-to-person contact in the delivery of mostly intangible products Market trends in the service industry are being influenced primarily by the use of technology to streamline operations, provide resources to staff, and, in some cases, to replace the need for staff	Digital transformation specialists Human machine integrative coaches User experience designers AI testers AI & machine learning specialists Augmented reality journey builder Gig-designers Bot-managers Artists that create sensory-focused items Repurposing agents (for waste & redundant items)	Client information &customer service clerks Rental clerks Telemarketers Mass travel agents Tour guides Legal clerks Data entry clerks Freight clerks Credit analysts Financial analysts Brokerage clerks Cashiers & tellers Procurement clerks Accounting & payroll clerks
				Experience agents (travel agents that design & book customised experiences	

	SECTORS	TRENDS DRIVING INDUSTRY CHANGE	ENVISIONED FUTURE	INCREASING ROLES	DECREASING ROLES
7.	The Education Sector	Globalisation: Within the next ten years, the majority of the world's population will consist of the middle class increasing pressure to provide better education for more people; The stakes are great: inequality of opportunity can translate into disparities in well-being, and drive political and social unrest	In an increasingly globalised and connected world, education is the heart of economic and social prosperity	Designers of learning offers for mobile devices Curated knowledge specialists Learning progress analysts	Registration clerk Accounting & bookkeeping Mediocre teachers Librarians Proofreaders
		Digitisation. Improved user interfaces and algorithms building upon big data could have a significant impact on Education and how it is taught Ageing	– enhancing competitiveness and improving the lives of every single person	Transition coaches (preparing people for next jobs) Special needs education facilitators Education experience customisers Blended learning customisers AI coders for teaching and learning Cross disciplinary integration of knowledge	Printing press operators Teachers that just share content Education that is nor personalised/ customised Office & administrative clerks Attendance control clerks Facilities teaching outdated skills & materials Statistics assistants

	SECTORS	TRENDS DRIVING INDUSTRY CHANGE	ENVISIONED FUTURE	INCREASING ROLES	DECREASING ROLES
8.		Digital building blocks such as big data, the Internet of Things (IoT), artificial intelligence and machine learning, as well as blockchain New physical systems such as autonomous vehicles, advanced robotics, additive manufacturing, advanced materials and nanotechnologies Advances in science such as next-generation biotechnologies and genomics, and new energy technologies	Urbanisation demands a different organisation of the food system in which the preservation of foodstuffs becomes strategic. This is accompanied, in middle-income developing countries, by a dietary transition stimulating new food categories, and by the demand for convenience and ready-to-eat foods The key changes relate to demographics, the management of individual household finances, and time constraints	Biotechnologist Robotics specialists & engineers Alternative packaging advisors Sensor specialists & technologists Recipe developers Transport economist Data analysts Nutritionists Creators of experiences (developers of the processing facility or the farm as a destination)	Sorters Cutters Packers Quality checkers Payroll and accounting clerks Supply of plastic packaging Administrative clerks Logistics clerks Control clerks (e.g. pressure, temperature) Moving materials at processing facilities (forklift drivers, vehicle drivers, cargo-handling equipment)

	SECTORS	TRENDS DRIVING INDUSTRY CHANGE	ENVISIONED FUTURE	INCREASING ROLES	DECREASING ROLES
		The Internet of Things (IoT): In combination with blockchain, could enable real-time product tracking, reduce adulteration and shed light on supply and demand imbalances Mobile applications have the potential to connect consumers with an overabundance of food to those in need Online marketplaces could link consumers directly to farmers, dramatically simplifying supply chains. Leverage big data and advanced analytics to better understand supply and demand imbalances			

	SECTORS	TRENDS DRIVING INDUSTRY CHANGE	ENVISIONED FUTURE	INCREASING ROLES	DECREASING ROLES
9.	Financial Sector	Rapid digital adoption Software platforms, digitisation and the development of applications Better connectivity Customer preferences and expectations Emerging alternative models of lending and capital raising Technologies like big data analytics and artificial intelligence Non-traditional players are entering the market	In South Africa, our financial services sector is made up of specialist firms, insurers, personal finance providers as well as retail banks. A number of driving forces are shaping this industry	Conversational interface designers Compliance expert Mixed reality experience designer Cloud banking Cybersecurity expert Platform creators Investor protection specialist Interconnectors between business & customers, employers & employees, sellers & buyers	Data entry clerks Insurance underwriting clerks Telemarketers Tellers Credit analysts Statistics clerks Accounting & auditors Claims adjustors & examiners Administrative service managers Tax examiners & revenue agents

	SECTORS	TRENDS DRIVING INDUSTRY CHANGE	ENVISIONED FUTURE	INCREASING ROLES	DECREASING ROLES
				Financial services & fin-tech concierge Hyper-personalisation inventors Interaction policy writers Financial ecosystem creators	
10.	Mining Industry	Drones, proximity sensors & improved communication systems Software applications for efficiency Autonomous trucks & loaders Improved methods of collecting & using data Collaboration between business, Labour, communities & government Methods & technologies to re-mine existing waste dumps	In South Africa mining has had a significant effect on our how economy, and in many places, our societies developed. At the moment the sector is under pressure. Falling commodities prices and the depletion of easier-to-reach ore bodies put pressure on the profitability of mining operations. Mining in South Africa is mostly deep and therefore risky and expensive	Payroll & timekeeping clerks, inspectors, sorters, weighers, samplers Procurement clerks Crushing 7 grinding machine operators & setters Surveying & mapping technicians Rock splitters Excavating & loading machine & dragline operators Conveyor operators	Specialists in re-mining of waste dumps Workplace & worker experience reformers Underground drone operators Application developers Data analysts Collaborator Re-designers of underground operations Autonomous truck & loader supervisor

	SECTORS	TRENDS DRIVING INDUSTRY CHANGE	ENVISIONED FUTURE	INCREASING ROLES	DECREASING ROLES
				Freight & cargo agents Crane, hoist & winch operators Truck & ship loaders Tool & die makers	
11.	Manufacturing Industry	Changes in consumer preferences Slowing of individual consumption in traditional markets Volatile currency Middle income growth in Africa Automization & digitization – crashing of the value chain, elimination of some roles Technologies such as mobile apps, sensors, next generation robotics, autonomous things, AI, 3D printing, wearables, nanotechnology & advanced materials will change product types and production processes	SA has a well-established and diverse manufacturing base supported by fairly efficient transport & logistics systems Competition from low-wage, high productivity nations like Brazil & China will continue to have a significant effect on our sector	Digital manufacturers Worker experience creators Factory automation Value chain "greeners" Digital fluency trainers Production line worker coaches & re-skillers Creators and facilitators of customised offers Supervisor: Autonomous things Africa markets analyst	Cargo & freight agents Inspectors, testers, sorters, weighers, samplers Machine setters & operators Procurement clerks Packing & filling machine operators Machine feeders & offbearers Assembly line workers Payroll & timekeeping clerks Timing & device adjusters Mould makers Mechanical drafters
					Patternmakers Painting & coating workers

	SECTORS	TRENDS DRIVING INDUSTRY CHANGE	ENVISIONED FUTURE	INCREASING ROLES	DECREASING ROLES
12.	Auto-motive Industry	Increasing environmental pressure tied to emissions Changing customer preferences	Towards 2030 the industry may experience structural shifts in market demand, with full electric or hydrogen fuel cell vehicles entering the market	Non-fossil fuel energy technologists Cyber-security experts (for in-vehicle systems) Value chain "greeners" Digital fluency trainers In-vehicle info-tainment system developers Production line worker re-skillers Robot engineers System optimisers	Assembly line work-ers Welders, cutters, solderers,brazers Procurement clerks Inspectors, testers, samplers Crane, hoist & winch operators Automobile testers Car salespeople Mechanics & diag-nosticians Machine setters & operators

	SECTORS	TRENDS DRIVING INDUSTRY CHANGE	ENVISIONED FUTURE	INCREASING ROLES	DECREASING ROLES
13.	Agricultural Industry	Mobile services for farmers for market access Big data, analytics & blockchain Gene-editing technologies Advanced precision agriculture technologies Climate change	Consumers may demand that their food meet minimum sustainability & health requirements This information can be made available to them by packing-based blockchain apps. Consumers may switch their diets to plant-based or cell-grown alternatives or demand that the animals they eat are fed less insect-based proteins		Pesticide handlers& applicators Payroll & timekeeping clerks Fence erectors Purchasing agents Cooling equipment operators Inspectors, samplers, weighers Drying & cooling equipment operators Fishers & related fishing workers General farm worker Product representatives

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