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D1.1 Demand analysis towards DIGITAfrica

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Executive summary

This deliverable presents the findings of Tasks 1.2 and 1.3 of the DIGITAfrica project. Its twofold objective is: (i) to provide a comprehensive overview of the existing digital research infrastructure landscape in five African partner countries—Tunisia, Senegal, South Africa, Kenya, and Cameroon; and (ii) to capture the demand and strategic needs of the research and innovation ecosystems through stakeholder consultation.

The assessment of RI capacities was conducted via a combination of desk research, surveys, and expert interviews. It highlights a heterogeneous and fragmented RI landscape, with strong engagement in fields such as artificial intelligence (AI), data science, high-performance computing (HPC), and Internet of Things (IoT), but also reveals significant gaps in hardware availability, digital infrastructure, technical staff, and funding. The country-specific analyses underscore critical needs, including improved access to testbeds and experimental platforms, stable and high-speed connectivity, and human capital development to retain skilled researchers.

To complement the supply-side analysis, a stakeholder workshop was held in Cape Town in April 2025, gathering over sixty participants from academia, policy, and industry. The workshop confirmed that national priorities across the partner countries are aligned with the strategic goals of the African Union's Digital Transformation Strategy (2020–2030) and STISA-2024. Participants emphasized the need for federated, accessible, and interoperable digital RIs that can support cross-disciplinary and cross-border research collaboration.

Key challenges identified include insufficient public and private investment in digital RIs, lack of access to AI and HPC resources, limited mobility and collaboration opportunities, and a shortage of structured training programs. Stakeholders also expressed strong demand for open science platforms, data-sharing tools, and AI-powered research environments that could operate across national boundaries.

This report sets the stage for the next phases of DIGITAfrica by establishing an initial catalogue of digital RIs, identifying critical challenges, and gathering actionable insights from early community engagement. These outcomes will be the basis for the co-design of an integrated, user-driven RIs for the digital science community in Africa.

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Abbreviations

Abbreviation	Definition
IoT	Internet of Things
AI	Artificial Intelligence
NREN	National Research and Education Networks
RI	Research Infrastructure
AU	African Union
FAIR	Findable, Accessible, Interoperable, Reusable
ERIC	European Research Infrastructure Consortium
EOSC	European Open Science Cloud
HPC	High-Performance Computing
ML	Machine Learning

1 Introduction

The primary objective of the work carried out in Task 1.2. and Task 1.3 is to assess the current capacities of research infrastructures (RIs) in the field of Digital Sciences across selected African countries, and to understand the demand and needs of the corresponding research and innovation ecosystems. This deliverable presents the outcomes of these activities after the first six months of the DIGITAfrica project.

1.1 Methodology

The methodology developed for this assessment is structured around two complementary components: (i) analysis of existing RI capacities, and (ii) assessment of demand, starting with the identification of gaps and opportunities through direct stakeholder engagement.

Analysis of RI Capacities

The first and central component of the methodology focuses on evaluating the availability, accessibility, and maturity of digital science RIs in the African context. This includes infrastructures supporting High-Performance Computing (HPC), Artificial Intelligence (AI), data science, IoT, next-generation communication networks and related experimental platforms.

Key actions include:

- Collection and classification of RIs currently operating in the partner countries, including institutional platforms, data centres, testbeds, and virtual research environments.
- Evaluation of each RI's scale, technical features, services provided, access modalities (e.g. open vs. restricted), and integration with international networks.

The tools that we used to carry out this analysis are

- Surveys: A pilot survey was carried out in Tunisia to assess physical and experimental infrastructure, research domains, human resources, collaborations, research outcomes, funding and needs, major challenges, and future vision.
- Desk Research: Review of national digital and science strategies, reports from past projects (e.g., SLICES, SoBigData), and existing RI databases to provide background and comparative analysis.
- Interviews with experts: In-depth discussions with key stakeholders and decision-makers to explore specific issues.

This analysis forms the basis for the development of a Catalogue of Digital Science Research Infrastructures, as well as for identifying opportunities for coordination, sharing, and federated access across national and regional initiatives.

Demand Analysis

The demand analysis component aims to capture the needs and expectations of stakeholders regarding digital science RIs. The initial action in this process was the inaugural consultation workshop, held on 24–25 April 2025 at the University of Cape Town (UCT). This workshop

brought together over sixty participants, including researchers, infrastructure managers, policymakers, and industry representatives, to discuss:

- National and regional priorities for digital science research.
- Existing challenges and opportunities in RI development.
- Potential areas for collaboration and capacity building.

Insights from this workshop provide a foundational understanding of stakeholder needs

The current phase of the analysis focuses on the five African countries represented in the DIGITAfrica consortium. In a second phase of the project, the methodology will be extended to a broader set of African countries, aiming to provide a continent-wide perspective and support regional policy alignment and investment strategies.

1.2 Document structure

This deliverable is structured as follows. Section 2 presents an in-depth analysis of RI capacities in each of the five DIGITAfrica partner countries, including national context, research communities, available infrastructures, and associated challenges. Section 3 details the demand analysis, beginning with the inaugural consultation workshop and outlining key thematic insights and implications for the design of the future DIGITAfrica RI. Section 4 concludes the document with recommendations for the development of a pan-African Research Infrastructure in Digital Science.

2 Analysis of RI Capacities

This chapter presents an in-depth analysis of RI capacities in Africa that support experimental-based research in Digital Sciences, with the overarching goal of identifying existing strengths, current limitations, and critical infrastructure gaps. The assessment adopts a multi-dimensional methodology, designed to ensure a comprehensive and inclusive overview of the RI landscape across the five DIGITAfrica partner countries. The following complementary activities have guided the analysis:

- **Desk Research**: A thorough review of publicly available resources has been conducted to map existing infrastructures, facilities, and initiatives. This includes collecting data from institutional reports, white papers, national and regional strategies, and open-access datasets. The objective is to build a foundational understanding of the current RI ecosystem, its distribution across countries and regions, thematic focus areas (e.g., AI, IoT, cybersecurity, HPC), governance models, and levels of maturity.
- **Survey**: To complement the findings from desk research, a pilot stakeholder survey has been conducted in Tunisia to collect first-hand insights on the usage, accessibility, and challenges of digital research infrastructures. The survey targeted academic institutions, research centres, and other relevant actors involved in experimental research. The survey aims to gather first-hand insights on infrastructure usage, accessibility, funding models, technical capacity, and perceived gaps, across the various application domains related to digital science. While limited to the Tunisian context within the scope of the DIGITAfrica project, the methodology and lessons learned are designed to be replicable in the other African partner countries, enabling broader and more comparative assessments in future phases of the project.
- **Workshop**: A consultation workshop has been organized at the University of Cape Town (UCT) Graduate School of Business Conference Centre to validate and further expand the preliminary findings from the desk research and survey. This participatory event has brought together key stakeholders-such as researchers, infrastructure managers, policymakers, and regional organizations-to reflect on the analysis, provide feedback, and co-develop recommendations. The workshop also served as a forum for knowledge exchange, highlighting best practices, successful models, and opportunities for cross-border collaboration in building digital research capacity.

2.1 The role of research infrastructures in the African context

The *African Union's (AU) Digital Transformation Strategy for Africa (2020-2030)* [1] outlines a framework to enable the continent's transition to a digital economy. The strategy prioritizes infrastructure development, digital skills, public service delivery, and innovation ecosystems to support sustainable growth and regional integration. Within this broader framework, Research Infrastructures (RIs) play a critical enabling role in supporting

experimental science, data-driven research, and innovation activities across digital and interdisciplinary domains.

In parallel, the *Science, Technology and Innovation Strategy for Africa 2024 (STISA-2024)* [2] identifies four core pillars that guide the development of the science and innovation landscape in Africa:

- Upgrading and building research infrastructure
- Enhancing technical and professional competencies
- Fostering innovation and entrepreneurship
- Providing an enabling environment for STI development

These pillars are intended to be interdependent and mutually reinforcing. In particular, the first pillar aims to address the persistent gaps in physical and digital infrastructures required to support high-quality research and technological innovation in Africa. It encompasses both the development of new infrastructures and the modernization of existing ones. Relevant examples discussed in [2] include:

- High-performance computing and data centres
- Experimental testbeds for digital technologies (e.g., 5G, IoT, AI)
- Advanced networking infrastructures (e.g., NRENs and cross-border connectivity)
- Distributed platforms for data sharing, open science, and collaborative experimentation

In the context of digital sciences, the availability and accessibility of such infrastructures are fundamental to supporting research that requires scalable computational resources, large-scale data processing, and high-capacity communication infrastructures.

In [2], several common limitations across the African continent are also identified, including: i) uneven distribution and fragmentation of existing RIs; ii) limited availability of funding and investment mechanisms for large-scale infrastructure; iii) constraints in technical capacity for infrastructure operation and maintenance; and iv) insufficient integration of national infrastructures into regional or continental frameworks

Addressing these challenges requires coordinated planning at national and regional levels, supported by coherent policies and multi-stakeholder engagement. Among the most positive developments in this area we can we highlight **AfricaConnect**[1], which aims to establish high-capacity regional data networks for research and education in the whole of Africa, and to improve the volume and reliability of connectivity to the global research and education community. Similarly, the **African Open Science Platform**[2], is a pan-African initiative aimed at promoting open science practices across the continent. AOSP's strategic objectives include the development of federated networks of computational facilities, implementation

[1] Website: https://international-partnerships.ec.europa.eu/policies/programming/projects/africaconnect_en (Accessed: 26/05/2025).
[2] Website: https://aospea.org (Accessed: 26/05/2025).

of open science policies, and capacity building in data science and artificial intelligence. Nonetheless, further effort is required to align investments in infrastructure with national research priorities and the objectives of continental strategies such as STISA-2024. Additionally, it is critical to create a skilled workforce capable of operating and leveraging modern research infrastructures effectively.

The DIGITAfrica project engages five African partner countries: Cameroon, Kenya, Senegal, South Africa, and Tunisia. The remaining of this section analyses the current landscape of available RIs supporting experimental research in Digital Sciences across these nations. In particular, the aims of the following sections are:

- To provide a map of key stakeholders, including academic institutions, research centres, and innovation hubs active in Digital Sciences within each partner country.
- To compile a comprehensive catalogue of existing RIs pertinent to Digital Sciences, detailing their capacities, specializations, and accessibility.
- To examine country-specific obstacles to RI development, such as funding limitations, technical skill gaps, policy constraints, and infrastructural disparities.

This analysis will provide strategic recommendations to enhance RI capabilities and support the objectives outlined in the African Union's Digital Transformation Strategy and STISA-2024.

2.2 RI capacities in Tunisia

2.2.1 Overview of national context

2.2.1.1 Economic Overview

In 2023, the country's GDP growth was recorded at just 0.04%, a sharp decline from 1.59% in 2019, reflecting the prolonged impact of the COVID-19 pandemic and ongoing global economic instability. According to the latest World Bank Economic Update for Tunisia, economic growth is expected to reach 1.4% in 2024 and rise to 1.9% in 2025, driven by improved rainfall and gradual stabilization in key sectors. While the manufacturing sector continues to face challenges, the resilience of tourism and agriculture is helping to support the recovery.

The economic structure remains largely service-oriented, with the services sector contributing 62.11% of the GDP in 2023. This is followed by industry at 23.51%, fabrication (manufacturing) at 15.14%, and agriculture at 9.47%. The relatively modest share of agriculture is notable given Tunisia's rural demographics, and it reflects ongoing issues like water scarcity and underinvestment in modern farming techniques. Unemployment remains a major socioeconomic challenge. In 2023, the national unemployment rate stood at 15.11%, with a stark gender disparity: 20.45% of women were unemployed compared to 12.82% of men. These figures reflect ongoing barriers to labor market inclusion, particularly for women and young graduates.

Given the previous indicator, the investment in research and development (R&D) has been remaining limited, with only 0.75% of GDP allocated in 2019, signaling a need for greater innovation-driven growth.

2.2.1.2 Education and Human Capital

Tunisia invests heavily in education, dedicating 6.73% of its GDP to the sector in 2023, which is one of the highest rates in the region. The adult literacy rate is relatively high at 85.21% in 2022, though gender disparities persist: female literacy is at 78.26%, compared to 92.57% among men.

Tunisia has shown a growing interest in technical education, with 17.2% of students enrolled in Information and Communication Technologies (ICT) programs in 2021. This trend reflects a positive shift toward digital and tech-driven fields. In the same year, ICT graduates accounted for 15.3% of all graduates—a solid outcome that confirms sustained engagement in the sector. However, to fully leverage this momentum, it is essential to ensure that academic programs remain aligned with the evolving needs of the labor market.

A key challenge remains the high rate of brain drain among ICT engineers, many of whom seek opportunities abroad due to limited local prospects and the attractiveness of life in Europe. Tackling this issue will require not only strengthening the relevance of training and employment pathways but also creating a more dynamic local ecosystem—offering competitive career opportunities, favourable working conditions, and incentives for innovation and entrepreneurship.

2.2.1.3 Digital Readiness, Internet Connectivity and Digital Infrastructure

Tunisia has made significant strides in enhancing its digital landscape, yet challenges remain in achieving comprehensive digital readiness. As of January 2023, approximately 9.8 million Tunisians were internet users, representing a penetration rate of 79%. Mobile connectivity is particularly robust, with mobile cellular subscriptions reaching 129 per 100 people in 2022, and 4G networks covering 94.9% of the population. However, fixed broadband subscriptions remain relatively low at 14.14% in 2023, indicating a reliance on mobile networks for internet access.

In terms of digital infrastructure, Tunisia had 818.33 secure internet servers per million people in 2023, reflecting moderate progress in establishing a secure online environment. The country's performance in the Network Readiness Index 2023 further highlights areas for improvement, with an overall score of 41.57 and a global rank of 96th. Breaking down the pillars: Technology scored 42.34, People 36.75, Governance 49.41, and Impact 37.79. These figures suggest that while governance structures are relatively strong, there is a need to enhance technological infrastructure and human capital development to fully leverage digital opportunities (https://networkreadinessindex.org/country/tunisia, last consultation 31 May 2025).

Overall, while Tunisia has achieved commendable progress in mobile connectivity and governance, bolstering fixed broadband infrastructure and investing in digital skills development are crucial steps toward improving its digital readiness and fostering inclusive digital growth.

2.2.1.4 Regulatory Bodies and Governance Frameworks (specific to ICT)

Tunisia has established a robust institutional framework to support intellectual property protection, digital governance, and data security, reflecting the country’s growing commitment to fostering a knowledge-based economy. These institutions play a critical role in strengthening the digital and innovation ecosystem, which is essential given Tunisia’s current socioeconomic and educational landscape—marked by high literacy rates, strong public investment in education (6.73% of GDP in 2023), and a rising interest in digital and technical fields such as ICT.

At the forefront, the Ministry of Communication Technologies and Digital Economy coordinates international cooperation and aligns national digital policies with global standards, supporting Tunisia’s integration into the global digital economy. Complementing this effort, the National Authority for the Protection of Personal Data, which is the oldest authority of its kind in Africa and the Arab world, champions a culture of privacy through education and compliance support, helping safeguard citizens in an increasingly connected society. On the intellectual property front, INNORPI (Institut National de Normalisation et de Propriété Industrielle) ensures the protection and standardization of industrial property and promotes product quality and innovation, which are key factors in improving industrial competitiveness. The National Cybersecurity Agency (ANCS, Agence Nationale de la CyberSecurité) plays a strategic role in defending national digital infrastructure against cyber threats. Lastly, the National Telecommunications Authority (INT, Instance Nationales des Telecommunications, https://intt.tn/, founded in 2001) regulates the telecom sector

to ensure fair access, competition, and service quality. Together, these institutions provide the legal, regulatory, and technical backbone needed to support Tunisia's ambitions in digital transformation and innovation-led growth.

2.2.2 Identification of research and innovation communities in Digital Sciences

A survey was designed and conducted among various Tunisian research structures to obtain a comprehensive overview of the current state of research and digital capabilities with a focus on digital sciences. As a matter of fact, in 2023, Tunisia recorded a total of 522 research structures, including 501 laboratories and 21 research units. These were distributed across six major fields: 109 in exact and natural sciences, 121 in engineering and technology, 130 in medical and health sciences, 60 in agricultural and veterinary sciences, 65 in social sciences, and 37 in humanities and arts. Out of these, the survey specifically focused on 34 structures directly involved in ICT, as well as a selection of more than 50 others in medical, agricultural, and social sciences, which fall within the broader scope of digital sciences.

The data collection covered key dimensions including physical and digital infrastructure, research areas, human resources, partnerships, funding, and scientific output. The survey was launched on April 14, 2025, and by May 31, responses had been received from 27 research structures.

Main Sections of the Questionnaire

As depicted in Table 1, the questionnaire is composed of three main sections, each designed to collect specific information from the research structures.

Table 1: Main Sections of the Questionnaire

Section	Items
Section 1: Identification of the Research Structure	• Identification and Type of Institution • Human Resources for the Current Year • Main Research Areas in Digital Sciences • Main Research Areas Related to Digital Sciences • National and International Collaboration • Funding Sources • Annual Research Outputs
Section 2: Research Infrastructure	• Structure Internet access • Hardware Infrastructure for Processing and Storage • Experimental Infrastructure
Section 3: Major Challenges and Future Vision	• Challenges Encountered • Future Vision

Preliminary outcomes

The preliminary outcome of the questionnaire reveals that the majority of respondents, approximately 84%, are affiliated with research laboratories, followed by 7% from research centers, and 4% from research institutes. In terms of institutional affiliation, the participants are distributed across eight different Tunisian universities, as illustrated in Figure 1. The University of Sfax represents the largest share with 26%, followed by the University of la Manouba with 22%, and the University of Carthage with 19%. Other institutions include the University of Jendouba (11%), University of Monastir (7%), University of Gabès (4%), University of Tunis El Manar (4%), and the University of Sousse (7%), reflecting a broad representation from across the national academic landscape.

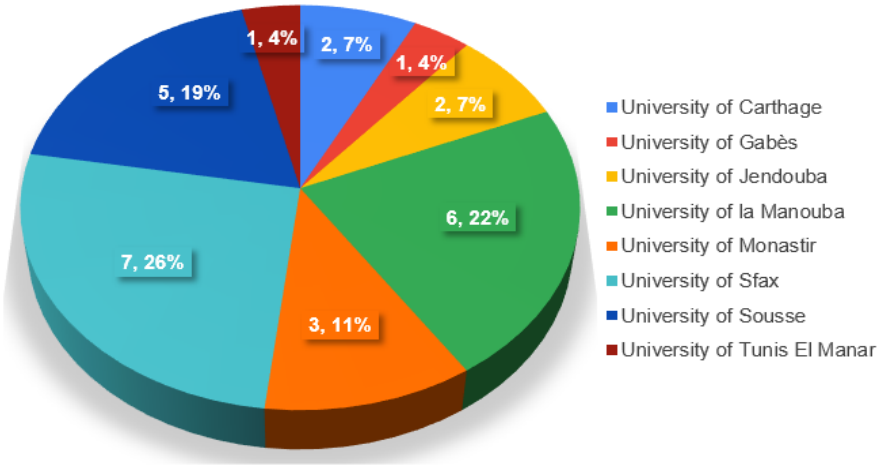


Figure 1: Affiliation of the respondents.

The second set of results highlights the fields of activity and application domains of the respondents (see Figure 2). A significant proportion (40%) are involved in Information and Communication Technology (ICT), with a strong emphasis on Artificial Intelligence (AI), Internet of Things (IoT), data analysis, cloud computing, networks, security, and blockchain technologies. Other notable fields include agriculture (20%), health (11%), and both engineering sciences and human and social sciences, each representing 6% of the total (see figure below).

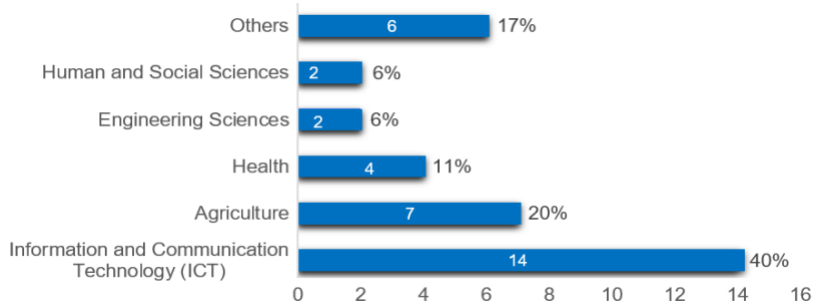


Figure 2: Application domains of the survey respondents.

In terms of research staff and human resources, the data reveals significant variation across institutions. The number of senior researchers ranges from 4 to 45, with an average of 11.23, while junior researchers span from 6 to 135, averaging 26.7 per structure. The presence of PhD students is also notable, with numbers ranging from 2 to 80 and an average of 27.78,

indicating strong involvement in advanced academic research. Additionally, institutions host up to 36 master's students, with an average of 18. However, a critical observation emerges regarding technical staff, whose numbers are considerably low ranging from 0 to 9 with an average of only 1.92. This underscores a common challenge across institutions: a lack of sufficient technical support to meet the growing demands of research activities.

Digital research areas

In terms of digital research areas, the data (see Figure 3) clearly highlights a strong emphasis on data analysis and data science (77.8%), artificial intelligence (AI) (66.7%), and the Internet of Things (IoT) (40.7%), followed by fields such as cybersecurity (25.9%), blockchain (22.2%), cloud computing, embedded systems (29.6% each), and high-performance computing (18.5%). These core digital domains reflect the growing progress of digital transformation in research. Complementing these are several related fields, which demonstrate the interdisciplinary reach of digital technologies. Most notably, health stands out with 57.7%, followed by agriculture (50%), biotechnology (30.8%), and social networks and others (each at 30.8%). Additional areas include geomatics (19.2%) and social mining (15.4%). This broad engagement across both digital and applied domains underscores the central role of digital sciences in driving innovation across critical sectors like health and agriculture.

We notice that there is a particularly strong emphasis on artificial intelligence (AI), Internet of Things (IoT), and data sciences and analysis, highlighting their growing importance in shaping current research trends. Furthermore, among the related application domains, agriculture and health emerge as the most prominent areas, reflecting a focused interest in applying digital technologies to address essential societal and developmental challenges.

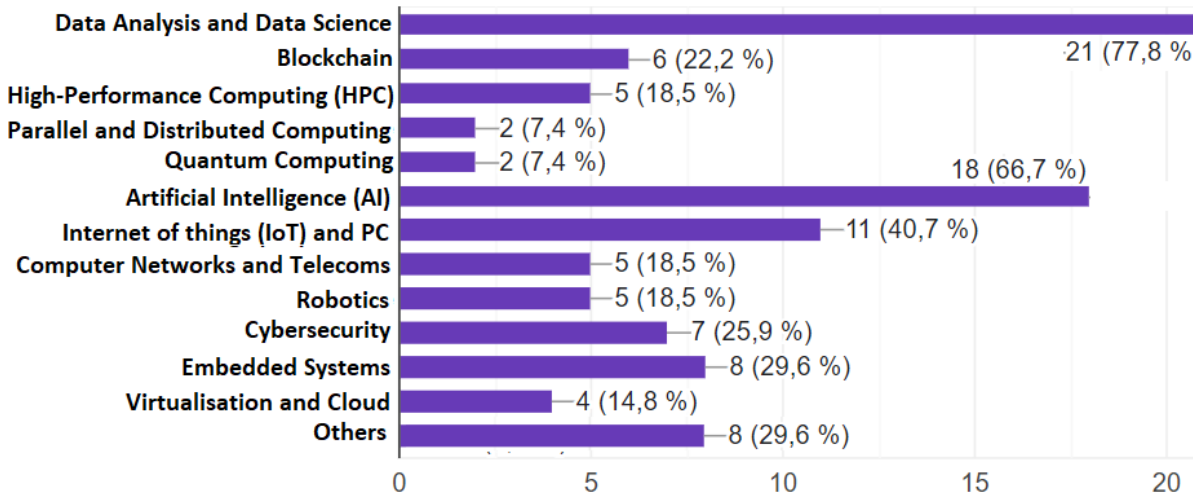


Figure 3: Distribution of research areas.

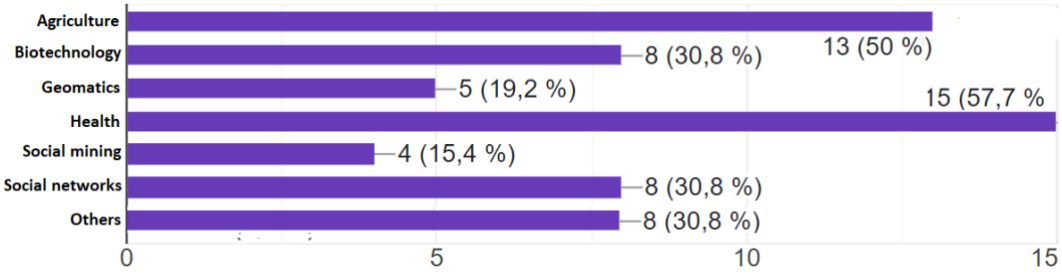
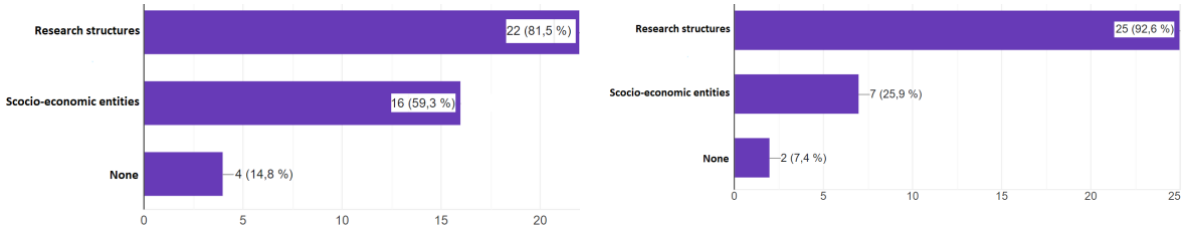


Figure 4: Distribution of application areas.

Collaborations and funding sources

Among the respondents, 81.5% reported national collaborations with research structures, while 59.3% collaborated with socio-economic actors, and 14.8% indicated having no national collaborations (see Figure 5). At the international level, 92.6% engaged with research structures, and 25.9% collaborated with socio-economic actors, while 7.4% reported having no international collaborations. In terms of project participation, involvement in research projects ranged from 0 to 5 nationally (with an average of 1.54) and from 0 to 11 internationally (average of 1.96). For socio-economic projects, the average participation was 1.24 at the national level and 0.34 at the international level. We conclude that international engagement is strong; national collaboration needs strengthening through local networks.



(a) National collaboration (b) International collaboration

Figure 5: National and international collaborations

Regarding funding sources, 92.6% of respondents reported receiving public funding, while 55.6% indicated support from international cooperation. Additionally, 25.9% obtained funding through research contracts, and 3.7% reported income from service provision. **We conclude that** public funding remains the primary financial support, but diversification through international cooperation and contractual activities is also significant.

2.2.3 Catalogue of research infrastructures for Digital Sciences

The national research system in Tunisia is based on a diverse set of scientific structures, overseen by the Ministry of Higher Education and Scientific Research (MESRS). Some of these structures are also jointly supervised by other sectoral ministries, notably the Ministry of Health (via Public Health Institutions – EPS) and the Ministry of Agriculture.

There are four main types of structures:

- **Research Laboratories (LR)**, which are the basic units of research and are mostly affiliated with universities. They represent the operational core of academic research. In 2023, there were 501 of them.
- **Research Units (UR)**, lighter or emerging structures, which may operate in a complementary manner to laboratories. Their number has been declining, reaching 21 in 2023.
- **Specialized Units (US)**, located within public health institutions or research centers, and tasked with specific missions in targeted domains (e.g., health, energy, materials).
- **Research Centers (CR)**, autonomous structures, often with their own legal status, dedicated to priority areas such as biotechnology, energy, water, or nanotechnology. These centers may host both LR and US, with a total of 59 such structures recorded in 2023

The research structures are generally specialized in one or more specific disciplines within broader scientific fields, with the following distribution by scientific domain in 2023.

Table 2: Distribution of research structures by scientific domain (2023)

Domain	LR	UR	Total
Exact and Natural Sciences	107	2	109
Engineering and Technology	117	4	121
Medical and Health Sciences	122	8	130
Agricultural and Veterinary Sciences	60	0	60
Social Sciences	62	3	65
Humanities and Arts	33	4	37
Total	**501**	**21**	**522**

In 2022, the national research system mobilized a total of 25,803 **personnel**, including: Researchers: 13,802 (Category A: 5,021, Category B: 8,492, Technologists: 289), Doctoral and postdoctoral researchers: 11,005, and Research support staff: 996. Women accounted for 59% of the total workforce, reflecting strong integration in national research activities

Between 2019 and 2022, the number of scientific publications increased by 20%. In 2022, Tunisia ranked 12th worldwide in terms of scientific output relative to GDP, with a total of 10,579 publications. That same year, the rate of international co-publications reached 58%. France stood out as Tunisia's main partner, accounting for 23.5% of international co-publications

Specialized Research Centres

In 2023, Tunisia had 10 centres encompassing a total of 59 structures (LR and US)

Centre	LR	US	Total
Centre de Biotechnologie de Borj Cedria	6	2	8
Centre de Biotechnologie de Sfax	6	5	11

Centre de Recherche en Microélectronique et en Nanotechnologie de Sousse	1	2	3
Centre de Recherche en Numérique de Sfax	2	1	3
Centre de Recherche et des Technologies de L'énergie de Borj Cedria	4	5	9
Centre de Recherche et des Technologies des eaux de Borj Cedria	5	3	7
Centre National de Recherche en Sciences des Matériaux de Borj Cedria	3	3	6
Centre National des Sciences et Technologies Nucléaires	2		2
Institut National de Recherche et d'analyse Physico-Chimique	3	5	8
Centre de Recherche des Etudes Islamiques de Kairouan	1		1
Total	**33**	**26**	**59**

Research centres play a strategic role in Tunisia's scientific ecosystem. While university-based research focuses primarily on academic goals and fundamental advancements, research centres and certain Specialized Units (US) are geared toward more applied and results-oriented research. Their mission is to generate exploitable outcomes, address the country's concrete needs, and contribute to technological, economic, and social development.

They are generally equipped with substantial resources for development, experimentation, and testing, including technological platforms, pilot units, and high-precision equipment. These assets help accelerate technology transfer, validate innovative solutions, and support the emergence of high-value-added projects. Research conducted within these centres has led to numerous innovations, industrially viable prototypes, and a significant number of patents filed nationally and internationally.

It is also worth noting the existence of institutions with a specific status which, in addition to conducting research activities, provide high value-added services for public health and innovation. The **Institut Pasteur of Tunis (IPT**) is a prominent example. Founded in 1893 and operating under the supervision of the Ministry of Health, the IPT combines scientific research, vaccine and serum production, epidemiological surveillance, and training. Historically engaged in the fight against infectious diseases such as cholera and poliomyelitis, the Institute has made decisive contributions to public health

2.2.3.1 Research Infrastructure (Equipment and Technological Platforms)

In this context, several centres stand out due to the richness of their infrastructure and strategic positioning. Four of them serve as key pillars for the development of integrated digital projects aligned with DIGITAfrica's priorities: digital infrastructures, smart sensors, applied artificial intelligence, and innovative public services.

Sfax Digital Research Centre (Centre de Recherche en Numérique de Sfax - CRNS)[3]: This center specializes in artificial intelligence, image processing, e-health, digital tourism, and e-government. It hosts the SM@RTS lab, dedicated to intelligent systems and AI applications, along with a platform for prototyping, testing, and validating digital solutions. The CRNS is

[3] Website: https://crns.rnrt.tn (Accessed: 08/06/2025).

distinguished by its strong focus on societal needs, active participation in collaborative projects, and direct contributions to the development of public digital services

Sousse Research Centre in Microelectronics and Nanotechnology (Centre de Recherche en Microélectronique et Nanotechnologie de Sousse – CRMN)[4]: The CRMN focuses on smart sensors, embedded systems, and nanotechnologies. It includes a laboratory for embedded systems integration and advanced equipment for material characterization and the fabrication of miniaturized devices. Its technological environment is particularly suited for the development of smart hardware and connected devices.

Centre for Research and Energy Technologies – Borj Cedria (Centre de Recherches et des Technologies de l'Énergie – CRTEn)[5]: This centre focuses on renewable energy, smart hybrid systems, and energy conversion. It includes specialized units for the development of energy-related nanomaterials and platforms that integrate energy monitoring, control, and conversion using digital tools. The CRTEn demonstrates strong expertise in the convergence of energy and digital technologies to optimize resource use.

Centre for Water Research and Technologies – Borj Cedria (Centre de Recherches et des Technologies des Eaux – CERTE)[6]: The CERTE specializes in sustainable water management, treatment processes, environmental sensors, and the valorisation of hydrological data. It is equipped with advanced hydrological modelling tools, telemetry systems, and a laboratory for environmental biotechnology and water quality control. This centre holds valuable expertise in leveraging environmental data, enabling innovative AI applications in water management.

2.2.3.2 National-Level Research Support Infrastructure

Beyond the specialized equipment and facilities available in research centres, the Ministry of Higher Education and Scientific Research has established transversal infrastructure to support research activities. In this regard, the El Khawarizmi Computing Centre (CCK) plays a strategic role by providing the foundational digital infrastructure for the higher education system.

The CCK manages the National University Network (Réseau Universitaire National – RNU), which connects all higher education and research institutions in Tunisia to the Internet. This fibre-optic network operates on a 20 Gbps backbone and is linked to the European GÉANT network through the regional ASREN infrastructure. The CCK also operates a recently deployed sectoral cloud designed for the secure hosting of scientific platforms, research databases, and collaborative tools. This sectoral cloud further provides researchers with essential services such as high-performance computing, data backup, and access to shared digital services.

[4] Website: https://crmn.rnrt.tn (Accessed: 08/06/2025).
[5] Website: https://www.crten.rnrt.tn (Accessed: 08/06/2025).
[6] Website: https://certe.rnrt.tn (Accessed: 08/06/2025).

This infrastructure strengthens the country's capacity to develop a connected, open digital research environment that meets international standards in cybersecurity and performance

2.2.4 Key challenges for RI development

The rest of the survey addressed key challenges in research infrastructure (RI) development, focusing on infrastructure gaps, connectivity issues, human capital, funding constraints, and strategic actions

Infrastructure Gaps

The current infrastructure faces significant gaps that hinder progress in advanced technology fields, as summarised in Figure 6. There is a notable shortage of essential hardware such as GPUs, storage systems, and specialized PCs, which are critical for supporting AI and robotics development. Additionally, the absence of dedicated AI platforms and experimental testbeds further limits the ability to conduct practical research and testing. Without adequate computing resources and specialized software, it becomes challenging to foster innovation and experimentation in these cutting-edge areas. Addressing these deficiencies is crucial for enabling robust technological growth and development.

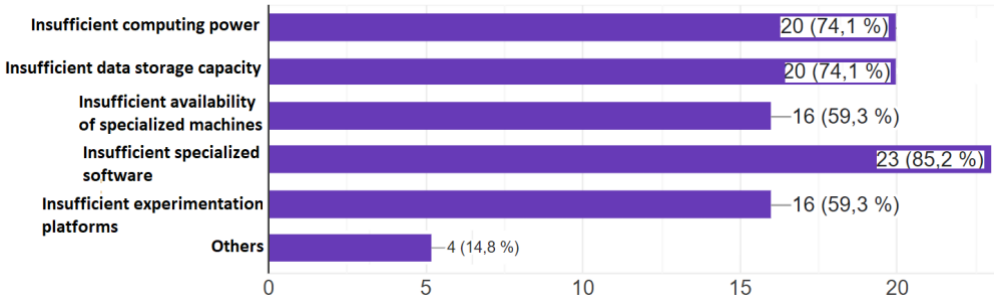


Figure 6: Gaps in software and hardware resources

Connectivity issues

Insufficient bandwidth and unstable network infrastructure hinder researchers' ability to access and share large datasets, collaborate remotely, and utilize cloud-based computational resources essential for advanced research. The study highlights the urgent need for high-speed internet and improved network stability to support robust local networks and seamless cloud access.

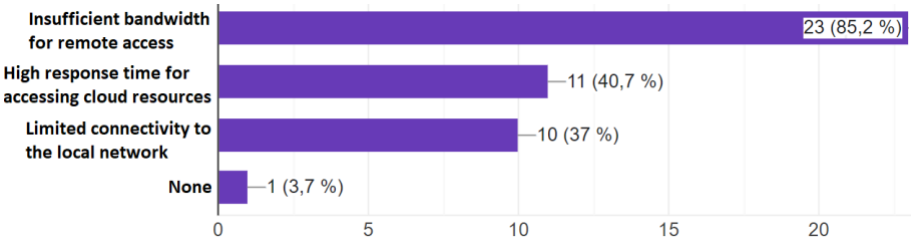


Figure 7: Network connectivity issues

The research capacity study reveals significant challenges related to software access, particularly the difficulty in obtaining scientific databases and specialized software. Limited

availability and restricted access to these critical resources impede researchers' ability to conduct comprehensive literature reviews, perform advanced data analysis, and utilize domain-specific tools.

Human Capital

The assessment of research capacities, as illustrated in Figure 8, highlights significant human capital challenges within the research ecosystem. Chief among these are issues related to capacity building in emerging technologies, which 85.2% of respondents identified as a major challenge. Additionally, 77.8% of participants cited difficulties in researcher participation in international conferences, and 66.7% pointed to problems with researcher mobility—both of which are crucial for exposure, collaboration, and knowledge exchange. Challenges in talent retention were also notable, with 55.6% of respondents expressing concern. These findings underscore the difficulties in attracting and retaining PhD students and the lack of strong career incentives, which can hinder the development and sustainability of a robust research workforce. Furthermore, 48.1% highlighted inadequacies in training programs, reinforcing the need for more structured and targeted support for early-career researchers. Together, these insights indicate a pressing need to invest in human capital development to strengthen overall research capacity.

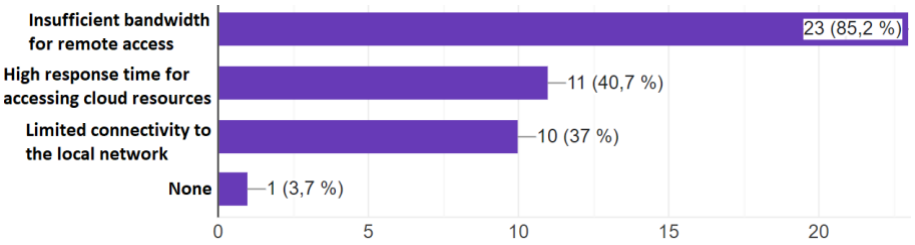


Figure 8: Human capital

Funding

Figure 9 highlights significant funding challenges impacting research capacity. The most critical issue is insufficient public funding, reported by 92.6% of respondents, likely compounded by administrative barriers. Additionally, 85.2% cited inadequate support for PhD and postdoctoral researchers, while 70.4% noted difficulties accessing international project funding. Insufficient private investment, reported by 59.3%, further underscores the need to diversify funding sources and streamline funding processes to support a sustainable research environment.

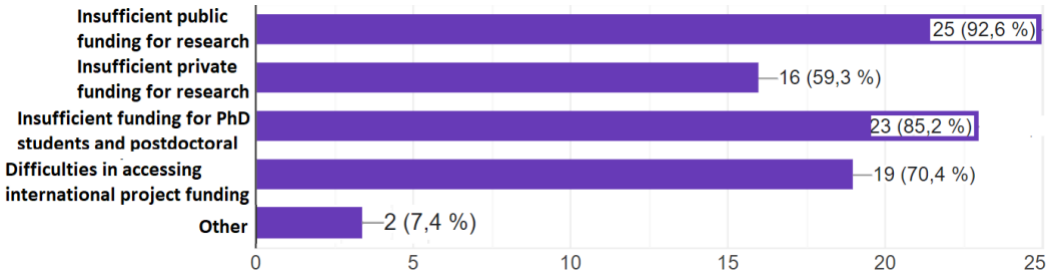


Figure 9: Funding challenges

The overall assessment reveals critical shortcomings across multiple dimensions of the research ecosystem, including infrastructure, hardware, software, digital connectivity, human capital, and funding. These gaps collectively hinder the development, execution, and global competitiveness of research activities. Without adequate support in these foundational areas, the potential for scientific advancement and innovation remains severely constrained. Addressing these deficiencies is therefore essential to strengthening research capacities and fostering a more resilient and innovative research environment.

Strategic Actions identified

Table 3 highlights key strategic actions prioritized to strengthen research capacity. The most common approaches include fostering external collaborations for data sharing (84.6%) and engaging in socio-economic impact projects (84.6%). Talent attraction and retention (80.8%) and enhancing international or regional cooperation (76.9%) are also widely emphasized. In contrast, fewer institutions are investing in high-performance computing or data management infrastructure, and very few focus on result deployment or hiring full-time researchers, indicating a need to balance immediate collaborations with long-term capacity building. Notably, the last three actions—deployment of results, highlighting research outcomes, and hiring full-time researchers—were additional proposals introduced by one research structure and were not part of the original questionnaire. These suggestions underscore the need to promote research visibility, support result deployment, and secure dedicated research staff as part of a more comprehensive strategy.

Table 3: Summary of strategic actions to develop RIs

Strategic Action	Response Count	Percentage
Search for external collaborations to facilitate the research data sharing	22	84.6%
Participate in projects with socio-economic impact	22	84.6%
Offer incentives to attract and retain talent and researchers	21	80.8%
Develop international/Inter-African cooperation	20	76.9%
Search for collaboration with socio-economic entities	19	73.1%
Search for external collaborations in order to access high-performance computing resources.	13	50%
Invest in local infrastructure dedicated to high-performance computing	10	38.5%
Invest in local infrastructure dedicated to data management	9	34.6%

2.3 RI capacities in Senegal

2.3.1 Overview of national context

Senegal, a West African nation, boasts a surface area of 196,712 square kilometres and a coastline spanning approximately 700 kilometres. Its population, estimated to be 18,593,258[7] individuals in 2024, comprises approximately 50.6% men and 49.4% women. The country's population exhibits a relatively youthful demographic, with over half of its inhabitants being under the age of 19, and 75% being 35 or younger. The median age stands at 18 years, with a per capita GDP estimated at US$ 1,706.4 in 2023[8]. Furthermore, Senegal scored 39.10 in the 2024 Network Readiness Index (NRI), which evaluates each country's capacity to capitalize on digital technologies, ranking 101st out of 133 economies[9].

Administered into 14 regions, 46 departments, and 172 communes, including 46 arrondissement communes and 385 rural communities, the population concentration is notably high, with 47% of the population residing within the three western and central regions: Dakar, Thiès, and Diourbel. These regions collectively cover less than 5% of the nation's territory. Notably, the Dakar region houses 22% of the population and spans 0.3% of the national territory. Life expectancy at birth has significantly increased, rising from 64.7 years in 2013 to 68.9 years in 2023. The literacy rate stands at 59.2%.

In 2022, the student population reached 269,556, with a parity index of 0.96 in favor of boys. The number of students per 100,000 inhabitants increased modestly, from 1,145 in 2014 to 1,520 in 2022. Likewise, the gross enrollment ratio improved by 9.4 percentage points, rising from 6.7% in 2015 to 16.1% in 2022. Despite these gains, progress remains insufficient, as the student ratio continues to fall short of UNESCO's recommended benchmark of 2,000 students per 100,000 inhabitants. Furthermore, it is noteworthy that only 20.2% of public elementary schools currently have access to internet connectivity. Additionally, several concerns regarding the limited capacity of research within universities are noted. For instance, investment in research and development remains low, falling short of the minimum standard of 1% of GDP (0.6% of GDP in 2015). Public research and development initiatives primarily focus on the agri-food sector, with key players such as the "Institut sénégalais de Recherches Agricoles - Senegalese Institute for Agricultural Research" (ISRA) and the "Institut de Technologie Alimentaire - Institute for Food Technology" (ITA).

Senegal's Digital Technology Park, part of the "Digital Senegal 2025 (SN2025)" strategy, is a testament to the country's commitment to becoming a regional hub for ICT. The park fosters innovation and entrepreneurship, providing infrastructure and support for startups and research in digital technologies, contributing significantly to capacity building and job creation in the tech sector. The country also promotes digital education through its Digital

[7] Website: https://www.ansd.sn/Indicateur/donnees-de-population (Accessed: 16/06/2025).
[8] Website: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=SN (Accessed: 16/06/2025).
[9] Website: https://portulansinstitute.org/wp-content/uploads/2024/11/nri-2024-3.pdf (Accessed: 16/06/2025).

University UN-CHK. Furthermore, through PAP2A (Adjusted and Accelerated Priority Actions Plan) and SN2025 programs, the Senegal government has launched a new strategy, called Data Economy, that aims for making data a driver of socio-economic growth, inclusiveness, innovation and international openness by 2028.

Also, Senegal has validated its national strategy on artificial intelligence (SNIA) and recently, its "New Deal Technologique - Technological New Deal[10] " which fosters new digital governance approaches. Indeed, the "New Deal Technologique, Horizon 2034" is an extension of the *National Transformation Agenda "Senegal 2050"*, a bold initiative that strengthens Senegal's digital sovereignty and puts innovation at the service of social and economic progress. The twenty members of the National Digital Council have been appointed and entrusted with the responsibility of overseeing the implementation of the "New Deal Technologique" initiative.

As part of its strategic vision, the Ministry of Higher Education, Research and Innovation (MESRI) has undertaken the development of a national space ecosystem through an ambitious Earth observation satellite program. This initiative aims to support Senegal's economic and social development by leveraging space technologies. A major milestone was achieved on August 16, 2024, with the successful launch into orbit of GAINDE-SAT 1A, the country's first satellite entirely designed and built by Senegalese engineers.

Additionally, the recent installation of the TAOUEY High Performance supercomputer at the "Cité du Savoir" within CINERI marks a significant leap forward in the nation's technological capabilities.

2.3.2 Identification of research and innovation communities in Digital Sciences

ASCII[11] (Senegalese Association of Researchers in Computer Science). The goals of ASCII organization as follows: unifying all local or abroad Senegalese researchers in Computer Science Senegalese who are trying to combine relationships and solidarity wherever they are; promoting the development of research in Computer Science in Senegal in all its forms to reach the well-being of the country's population; developing collaboration between academics and industrialists; developing research axes for the development of Senegal. Since 2010, ASCII organizes an annual scientific conference CNRIA that serves as a forum for exchanging ideas, proposing solutions, discussing research challenges, and sharing experiences between researchers, professionals, and development actors.

The Senegalese Ministry of Communication, Telecommunications, and Digital Economy, in collaboration with GIE AI Hub Senegal and the French Embassy in Senegal, has launched the SEN Hub AI project to promote the development of Senegal's artificial intelligence ecosystem. The vision of AI Hub SN[12] is to position artificial intelligence as a strategic driver

[10] Website: https://www.newdealtechnologique.sn/ (Accessed: 16/06/2025).
[11] Website: https://ascii.org/ (Accessed: 26/5/2025).
[12] Website: https://ai-hubsenegal.sn/ (Accessed: 26/5/2025)

of national development in Senegal by fostering a robust ecosystem that empowers researchers, businesses, and startups.

DSTN (Digital Science and Technology Network)[13], a multidisciplinary research network, was built by six ACEs (African Centres of Excellence) such as ACETEL (Nigeria), CapIC (Nigeria), ENSEA (Ivory Coast), MITIC (Senegal), CEA-SMIA (Benin), OAK-Park (Nigeria), in partnership with INRIA and IRD. DSTN experts foster to meet the challenges of digital transformation in Africa by promoting identification of key scientific priorities within ACEs thematic networks, collaborative research, training programs tailored to the job market and socio-economic partnerships. Besides, DSTN community targets researchers within five priorities fields such as Data Sciences and applications, Big Data and Ethical Artificial Intelligence, High Performance Computing, Cybersecurity, Internet of Things and SDN-based white spot areas.

2.3.3 Catalogue of research infrastructures for Digital Sciences

The CINERI (National Cyber-Infrastructure for Higher Education, Research, and Innovation, https://cineri.sn/), founded in 2022, is tasked with managing the shared digital infrastructure of the higher education and research sectors. Its mission includes addressing challenges related to the deployment of the IT network that connects administrative and research entities, data storage, and the use of the high-performance supercomputer for both public and private scientific projects.

The recent installation of the "TAOUEY" high-performance computing system is able of executing complex calculations at exceptional speeds. It serves as a vital tool for processing large-scale data and conducting advanced simulations across a variety of sectors, including meteorology, climate modeling, scientific research, financial analysis, and agriculture. Nevertheless, due to inconsistent electricity supply, the infrastructure is not used efficiently. The Senegalese government has been proposing strategies to enhance the power supply system as well as network connectivity.

snRER (Senegalese National research and education network (NREN) interconnects public Universities Senegalese and aim to provide Internet connectivity and an access to the TAOUEY HPC. Currently, snRER network is managed by the CINERI.

WACREN (West and Central African Research and Education Network, https://wacren.net/en/) provides shared infrastructure for universities across West and Central Africa to collaborate on tech-based development as well as an interconnection through the pan-European GÉANT network. It is co-funded by European Union (EU) through the AfricaConnect 2 and AfricaConnect 3 projects. The WACREN network connects and interconnects national research and education networks (NRENs). So far, WACREN has connected six countries (Ghana, Togo, Benin, Nigeria, Burkina Faso, and Ivory Coast) to high-speed technology. Other West African countries like Senegal with snRER are willing to join the project.

[13] Website: https://ace-partner.org/dstn/en/ (Accessed: 26/5/2025).

2.3.4 Key challenges for RI development

The key barriers for the development and effective use RIs in Digital Sciences include:

- Limited funding: Sustainable financing remains a critical bottleneck. There is a need to establish dedicated funding channels for long-term, infrastructure-driven research. Governments could incentivize industry participation in research through grant schemes or tax incentives. National policies should also prioritize funding for research relying on RIs. In addition, international financial institutions—such as the IMF and the World Bank—could recalibrate their education investment strategies to place greater emphasis on higher education and research, rather than focusing predominantly on primary and basic education with short-term indicators like literacy and enrolment rates.
- Inadequate infrastructure: The current digital and research infrastructure in many regions is insufficient. Partnerships with local telecommunications providers could facilitate access to testing infrastructure and real-world data. Promoting joint research initiatives and shared infrastructure models would also enhance resource utilization. Additionally, greater involvement of national governments and domestic private actors in developing and maintaining digital infrastructures is essential to ensure strategic autonomy and broaden access to digital services.
- Skills gap and brain drain: Addressing human capital challenges is essential. This includes curriculum reform and enhanced faculty development to align training with emerging technological demands. Collaboration mechanisms—such as sharing expertise, specialized equipment, and digital content (e.g., in HPC and AI)—could help retain talent and reduce dependence on external knowledge sources.
- Weak research ecosystem: Africa's research ecosystem often suffers from fragmentation and limited interdisciplinary collaboration. Greater interaction between engineering, social sciences, and business faculties can help develop context-aware solutions. Research programs should strive to be globally competitive while remaining grounded in local needs. Investment in cutting-edge research centres is crucial for fostering innovation and developing solutions tailored to regional priorities.
- Low international visibility: To raise the international profile of African research, increased collaboration and networking are essential—particularly in response to calls for international research consortia. Furthermore, the adoption of open-access platforms for publishing data and research outputs can enhance the visibility and accessibility of African science globally.

2.4 RI capacities in South Africa

2.4.1 Overview of national context

The South African research landscape, which contributes to diverse research toolkits and infrastructure, was spearheaded by the South African Research Infrastructure Roadmap (SARIR) of 2016. This initiative, undertaken collaboratively by the government and international partners such as the European Union, aimed to provide the Department of Science and Technology with a cohesive strategy that prioritises the development of national research infrastructure as a crucial enabler for development and innovation.

With this bold step in empowering research communities to conduct studies and foster innovations in their fields, the RI umbrella addressed three themes: the provision of research facilities, the provision of research services, and the provision of research resources. At this juncture, SARIR regarded research as multidisciplinary, supported by essential physical infrastructure such as high- performance computing systems and high-capacity networks, as well as e-data management that encompasses archiving, dataset and collection storage, among other data management practices.

Moreover, human capital was viewed as a strategic asset in achieving research excellence and driving knowledge generation and exploitation within the South African context. To this end, a shift in how RIs would be developed and provisioned in South Africa took a new direction; RIS were to be driven by the necessity for national exploitation by researchers before seeking international partners. A classification of research infrastructure and their target groups was further developed to understand the capital expenditure, operational scope, and the needs that the RIs would address. For instance, small equipment and departmental equipment RIs are established to cater to the needs of specific research groups. Departmental and medium-sized infrastructures were set up to support departments within an institution, or in some cases, the entire institution. Medium-sized infrastructures and national large-scale infrastructures are intended to serve the entire scientific community while also aiming to extend its scope, in the future, to the global scientific community; however, this was not a priority at the time. Concurrently, they were to be managed in a transparent and accountable manner.

All this was an effort to ensure that the South African economy would first benefit from this innovation, while positioning South Africa as a prime research destination. Success stories of such an approach are drawn from the SKA programme, which has emerged as a success and a poster child for South African research.

2.4.2 Identification of research and innovation communities in Digital Sciences

South Africa hosts a vibrant ecosystem of research groups, innovation hubs, government initiatives, and industry-academic networks that drive digital sciences. These span academic centres of excellence in AI and data science, tech incubators and innovation hubs, national funding programs, industry partnerships, and international collaborations. Below is an

overview of key communities and institutions in the country's digital science landscape, organized by category, along with a summary table for quick reference.

2.4.2.1 University Research Groups and Centres

South African universities have established dedicated research groups and centres focused on digital sciences – including artificial intelligence (AI), data science, machine learning, and software engineering. Many of these are nationally recognized and often collaborate across institutions:

Centre for Artificial Intelligence Research (CAIR): A prime example of a multi-university initiative, CAIR is a distributed research network with nodes across eight universities, funded primarily by the Department of Science and Innovation (DSI). Established in 2011, CAIR conducts foundational and applied AI research in areas like machine learning, knowledge representation, ethics of AI, and more. It operates on a hub-and-spoke model with established groups at universities such as UCT, UKZN, UP, Stellenbosch, UWC, and UJ.

Wits Institute of Data Science (WIDS): The University of the Witwatersrand (Wits) hosts WIDS, an interdisciplinary institute focusing on research, innovation, and training in data science and machine intelligence. WIDS aims to be world-leading and straddles both academia and industry needs, acting as a hub to coordinate data-driven research and innovation across the university. It supports new training programs, research projects, and industry partnerships to produce skilled data scientists and innovative research outputs.

Stellenbosch University's School for Data Science and Computational Thinking: Launched in 2019, this is a faculty-level entity designed to drive data science in an interdisciplinary way. It has a vision to be a "world-class institution in data science and computational thinking, driving impactful work in and for Africa". The school spans all ten faculties, building programs that tackle pressing challenges via data science, and it embodies a transdisciplinary approach (e.g. projects in health, agriculture, finance, and more). Notably, Stellenbosch has attracted leading researchers (for example, a top quantum computing scientist was recently appointed) to bolster its capacity in emerging digital domains.

University of Johannesburg (UJ) – Institute for Intelligent Systems (IIS) & Centre for Applied Data Science (CADS): UJ has made digital innovation a strategic priority through entities like the IIS, a flagship institute driving Fourth Industrial Revolution (4IR) research. The IIS focuses on 4IR-enabling technologies – including robotics, AI, Internet of Things (IoT), advanced communication (5G/6G), big data analytics, and more – as the basis for research and industrial solutions. It positions UJ as a leader in applying these technologies to African problems (from healthcare to mining). UJ's newly established (2022) Centre for Applied Data Science (CADS), within its School of Consumer Intelligence and Information Systems, brings together computer scientists and domain experts to promote and accelerate data-intensive research and teaching for data-driven knowledge discovery. CADS exemplifies a multidisciplinary approach, uniting business analytics with data science R&D, and offers postgraduate programs (Masters/PhD in Applied Data Science).

Other Notable Groups: Many universities host specialized labs or chairs. For instance, University of Cape Town (UCT) contributes via groups like its Knowledge Representation and Reasoning unit (part of CAIR) and data-focused initiatives (UCT hosts the CAIR Directorate and is developing open data science platforms). University of KwaZulu-Natal (UKZN) has an AI and machine-learning group (as a CAIR node) focusing on deep learning, language processing, and related AI applications. North-West University (NWU) hosts a deep learning research unit (another CAIR node) studying theory and applications of neural networks. University and University of Limpopo are emerging research nodes (e.g., focusing on swarm intelligence and speech technology respectively). Additionally, the University of the Witwatersrand's School of Computer Science & Applied Mathematics is noted for having one of the highest concentrations of AI researchers in Africa, and the University of Johannesburg's Institute for Intelligent Systems hosts industry-sponsored research chairs (like the Nedbank Research Chair in AI/Data Science, which partners with the banking sector to apply machine learning to finance).

2.4.2.2 National and Regional Innovation Hubs

South Africa's digital innovation ecosystem is bolstered by technology hubs, incubators, and science parks that nurture startups, support tech experimentation, and help commercialize research. Key hubs include:

Wits Tshimologong Digital Innovation Precinct (Johannesburg): Located in Braamfontein and spearheaded by Wits University (with government and industry support), Tshimologong is a prominent university-based incubator. Setswana for "new beginnings," Tshimologong is Johannesburg's high-tech address where the incubation of start-ups, the commercialisation of research, and the development of high-level digital skills for students, professionals and unemployed youth takes place. Since its launch in 2016, it has become a focal point for world-class African digital entrepreneurs, hosting accelerators, hackathons, and innovation programs (with backing from corporate partners like IBM, Microsoft, and banks such as JP Morgan for fintech acceleration). Tshimologong also houses an IBM Research Lab (IBM's second lab in Africa, opened in 2016) which anchors industry-academic collaboration in big data, AI and quantum computing. This precinct illustrates how a partnership between academia, industry, and city government can create a thriving tech cluster, offering co-working space, mentorship, and linkages to investors.

The Innovation Hub (Pretoria, Gauteng): Situated in Tshwane, The Innovation Hub is a science and technology park and incubator established by the Gauteng Provincial Government. It serves as the innovation agency of Gauteng, aiming to drive economic development through technology entrepreneurship. The Hub hosts multiple business incubators and accelerators under its roof (collectively known as "Maxum"), supporting startups in Smart Industries (ICT and advanced manufacturing), as well as biotech and green economy sectors. As a province-backed initiative, it provides state-of-the-art facilities, mentorship programs, networking events and access to funding for tech ventures. Over the years, The Innovation Hub has cultivated a robust community of innovators and facilitated collaborations between startups, universities (many spin-offs of the University of Pretoria are incubated here), and government research agencies. It exemplifies regional government commitment to fostering a digital innovation ecosystem.

Cape Innovation and Technology Initiative (CiTi) / "Bandwidth Barn" (Cape Town): CiTi (recently rebranded to UVU Africa in 2023) is one of Africa's oldest tech incubators, founded in 1999. Its flagship facility, the Bandwidth Barn, is a well-known incubator and co-working space that has supported hundreds of startups. CiTi/UVU Africa is a non-profit public-private partnership that works with government, academia, and industry to promote an inclusive digital economy. It runs various sector-focused programs: for example, a Fintech hub, a virtual reality and gaming incubator, and a township-based tech hub (Khayelitsha Barn) to broaden tech entrepreneurship beyond city centres. Collaboration opportunities abound – CiTi regularly engages university students (e.g., internships and hackathons), partners with corporates for accelerator challenges, and has international links (such as a recent UNDP-backed creative tech hub initiative). As a community catalyst, it provides mentorship, skills training (incl. coding programs), and access to investors, thus plugging gaps between academic innovation and market deployment.

mLab Southern Africa: mLab is an example of a specialized incubator focusing on mobile and digital solutions. Founded with support from the World Bank/InfoDev and hosted initially at The Innovation Hub (with expansions to other regions), mLab supports young entrepreneurs in app development, mobile tech and IoT. It offers co-creation space and runs coding skills initiatives. (While not as large as the hubs above, mLab complements them by targeting youth and lean startups in the mobile arena.)

Other Regional Hubs: In Durban (KwaZulu-Natal), the SmartXchange initiative is an ICT incubator supported by the eThekwini Municipality to grow digital media and tech startups in the region. In Cape Town, universities like Stellenbosch have their own incubators (e.g., LaunchLab at Stellenbosch University, which was recognized as Africa's top university incubator for 2017–2020). LaunchLab helps convert university research into viable businesses and invites collaboration from other universities and corporates. Across the country, a network of such hubs and labs (often supported by public-private partnerships) provides fertile ground for innovation in software, AI, fintech, e-health, and other digital domains. They often welcome collaboration through startup pitching events, corporate innovation challenges, and research commercialization partnerships.

2.4.2.3 Government Programs and Funding Bodies

The South African government actively supports digital science R&D and innovation through various policies, funding instruments, and national initiatives:

Department of Science and Innovation (DSI): The DSI (formerly DST) is the lead government department for research and innovation. It funds university research and human capital development in digital fields via the National Research Foundation (NRF) and specialized programs. DSI has established Centres of Excellence (CoEs) and Research Chairs (SARChI) that bolster research in ICT-related areas. For example, CAIR (described above) is primarily funded by DSI as a national AI research network. DSI also oversees the National Integrated Cyberinfrastructure System (NICIS), which includes the Centre for High Performance Computing (CHPC) in Cape Town, the national research network (SANReN), and data centres – critical infrastructure that supports data-intensive science and innovation nationally. Moreover, in 2019 the government convened the Presidential Commission on the Fourth Industrial Revolution (PC4IR), which produced a strategy to leverage digital tech for

economic growth. A key PC4IR recommendation – now being implemented – was the creation of a national AI institute.

Department of Communications and Digital Technologies (DCDT): This department leads on digital transformation policy (e.g., broadband, digital skills, and digital government). Notably, DCDT partnered with academia to launch the Artificial Intelligence Institute of South Africa (AIISA) in late 2022. In collaboration with UJ and TUT, DCDT established this institute as an "innovation engine for public and private sectors" to drive AI R&D aligned with national 4IR goals. The AI Institute will focus on applied projects (e.g., AI in mining, agriculture, public services, etc.) and help coordinate national AI efforts. DCDT is also involved in initiatives like the Digital Economy Masterplan and supports innovation hubs (for example, it has provided policy support for community ICT centres and start-up funding schemes).

Technology Innovation Agency (TIA): TIA is a national public entity under DSI that specifically bridges the gap between research and commercialization. Its mission is to support innovators, start-ups, and researchers in turning ideas into marketable products. TIA runs a range of funding programs such as seed funds, technology development grants, and innovation challenge calls (some targeting ICT solutions). It often co-invests in university spin-offs and provides incubation support. In 2024, TIA (with the Department of Science and Innovation and other partners) launched a R300 million seed fund to boost South African tech start-ups, signalling increased commitment to digital entrepreneurship. Collaboration opportunity: researchers can approach TIA for commercialization funding or participate in its programs to pilot new digital technologies.

National Research Foundation (NRF): The NRF manages competitive research grants and the South African Research Chairs Initiative. Through these, it funds many projects in computer science, AI, data science, and related fields at universities. For example, there are NRF SARChI chairs in areas like Machine Learning, Big Data, Cybersecurity, etc., that anchor research groups and connect internationally. The NRF also co-funds international collaboration programs (like SA/European Union projects in data infrastructure, SA-UK Newton Fund partnerships in digital tech for development, etc.), making it a key facilitator for academics seeking research funding or partnerships.

Council for Scientific and Industrial Research (CSIR): As South Africa's premier science council, the CSIR hosts significant R&D programs in ICT and digital tech. It virtually hosts the CAIR network's coordination and runs its own Next-Gen Enterprises and Institutions cluster which researches AI, robotics, data analytics, cybersecurity and smart industry applications. The CSIR's Office for Digital Advantage has led projects on e-government and digital skills. It's also the implementing agency for NICIS (managing CHPC and allied cyberinfrastructure). Government often relies on CSIR for applied research that can be commercialized or used by the public sector, meaning CSIR frequently partners with universities and companies on project consortia.

Funding and Innovation Networks: Another long-running program is the Telkom Centres of Excellence (CoE) Programme – a collaboration between Telkom (the telecommunications company), government, and universities. Launched in 1997, this program established CoEs

at various universities to conduct ICT research and train postgraduates. It is "a collaboration with over 50 industry players and the government" and has successfully produced hundreds of Masters and PhD graduates while contributing to telecoms and software innovations. The Telkom CoEs (about 15 active centres at any time) cover fields from distributed multimedia to wireless communications and have provided a pipeline of talent and research output for South Africa's ICT sector. This model of industry-supported academic labs is a cornerstone of the country's digital research community.

2.4.2.4 Industry Networks and Private-Sector Collaboration

A hallmark of South Africa's digital science ecosystem is the strong link between industry and academia, often facilitated by networks and joint initiatives:

Industry Tech Hubs and Forums: The Silicon Cape Initiative (in Cape Town) is a well-known private-sector-driven community that aims to connect tech startups with investors and mentors, branding Cape Town as Africa's "Silicon Valley." Founded by tech entrepreneurs in 2009, Silicon Cape works alongside incubators (like CiTi) and hosts networking events, advocating for the tech ecosystem. In Gauteng, similar networking forums and meetups (e.g., the Jozi Hub community, and Geekulcha for youth developers) bring together software engineers, data scientists, and entrepreneurs, creating informal collaboration opportunities and knowledge sharing outside academia.

Joint Research Chairs and Labs: Several corporations invest in university research through sponsored chairs and labs. For example, as mentioned, Nedbank (a leading bank) sponsors the Nedbank Research and Innovation Chair in 4IR at UJ's Institute for Intelligent Systems. This Chair provides leadership in banking-related machine learning, AI and data science, expanding research aligned to industry needs while training students in those skills. Another example is Absa bank's Chair in Data Science at the University of Pretoria (aimed at fintech and statistical machine learning research). Such industry-funded positions ensure that academic research remains connected to real-world problems and often come with opportunities for student internships or joint research projects with the sponsoring company.

Collaborative R&D Projects: Major tech companies have set up R&D partnerships in South Africa. IBM Research, notably, opened its second African research lab in Johannesburg at the Tshimologong Precinct, as part of a partnership with Wits University. This lab (IBM Research Africa) works on cutting-edge projects in AI, cloud and quantum computing, engaging local researchers and students. The IBM Q Network partnership allows Wits and other African academics to access IBM's quantum computing resources, a collaboration which connects 15 African universities via Wits to global quantum research. Such alliances give South African scientists a foothold in international projects and give companies a local innovation presence. Similarly, SAP (enterprise software firm) established a co-innovation lab and Microsoft has run joint digital skills programs with universities. Siemens and Huawei have also launched initiatives (often training-focused) with local institutions on topics like IoT and networking.

Industry Associations and Events: The private tech sector is represented by organizations like the Information Technology Association of SA (ITA) and the Technology Innovation

Agency's Industry partners, which often interface with universities. Annual conferences and hackathons (e.g., AI Expo Africa, Deep Learning Indaba, SA Innovation Summit) serve as meeting grounds for academia and industry. The Deep Learning Indaba in particular, while an academic initiative originally, has grown into Africa's largest AI gathering – it was started by South African researchers and rotates across the continent, fostering a community of practice that includes students and companies interested in AI research. South African universities play a big role (the inaugural Indaba was at Wits in 2017) and companies like Google, DeepMind, and Amazon have sponsored and attended, offering another avenue for international-industry-academic collaboration and talent scouting.

In essence, private sector initiatives – from multinational R&D labs to local startup networks – actively collaborate with South African academia. They provide funding, practical problem statements, and in many cases equipment or data, while drawing on the expertise and fresh ideas of researchers and students. The benefit is mutual: companies get innovative solutions and skills, and universities increase their impact and connect students to employment opportunities.

2.4.2.5 International Collaboration Programs

South African digital science researchers are well-integrated into global collaboration networks, through both African regional alliances and broader international partnerships:

African Research Universities Alliance (ARUA): South Africa is a key member of ARUA, a network of sixteen leading African universities. Through ARUA, universities like UCT, Wits, UP, and UKZN participate in Centres of Excellence and collaborative projects that often involve data science and ICT for development. For example, Wits leads ARUA's efforts in some areas of "big data" (Wits is the gateway for the IBM quantum initiative for all ARUA member universities) and UCT co-hosts initiatives on climate data and health informatics with other African partners. ARUA facilitates cross-border research, joint funding proposals (often to bodies like the EU or World Bank), and mobility of scholars. This means a South African research group might collaborate with peers in Nigeria, Kenya, Ghana, etc., on shared digital innovations (like using AI for climate resilience, or creating large African language datasets).

Bilateral and Multilateral Science Programs: South Africa's science agreements with countries like the United Kingdom, European Union, United States, India, China, and others have led to joint research programs. Under the SA-UK Newton Fund, for instance, there have been projects on data-driven healthcare and urban analytics involving South African universities and UK counterparts. The European Union's Horizon 2020/Horizon Europe framework has included South African partners in ICT projects (e.g., in fintech innovation, or in building high-performance computing capacity for the Square Kilometre Array's data). An example is the EU-South Africa ICT Dialogue that has supported exchanges and projects in areas such as cybersecurity and digital inclusion. South African universities also engage in staff/student exchange programs like Erasmus+ for ICT fields, and benefit from capacity-building grants aimed at curriculum development in data science.

SKA and Data Astronomy: While not purely "digital science," the Square Kilometre Array (SKA) radio telescope project (co-hosted by South Africa and Australia) has a massive data

science component. The need to process exabytes of data from SKA has driven investment in South African data infrastructure and skills. Local universities (UJ, UCT, UWC, North-West, Rhodes) formed the Inter-University Institute for Data Intensive Astronomy (IDIA), pooling expertise in machine learning for astronomy. This collaboration is both international (linked with global SKA partners) and cross-disciplinary, and has spin-off benefits for big data analytics techniques applicable in other domains. It exemplifies how international "big science" projects provide a training ground for advanced computing and data handling, boosting the national digital science competency.

Global Tech Companies and Training Partnerships: South African scholars often partner in international initiatives like Google's AI research programs, DeepMind scholarships (Google DeepMind has supported South African AI postgraduate students), and IBM's global University Programs. For example, Wits's role in the IBM Q Network means it connects with IBM's global quantum research community. Another notable collaboration is the UNESCO Chair in Data Science at UCT, which links to an international network of data science for social impact. These collaborations bring in global expertise and sometimes funding, and in return South Africa contributes unique perspectives or data (for instance, research on AI ethics in an African context, or using data science to address local challenges like education or wildlife conservation).

Pan-African and BRICS Initiatives: Regionally, South Africa is part of the Southern African Development Community (SADC) innovation programs and AU's digital strategy. It has hosted and helped form networks such as AfricAI and AI4D Africa (AI for Development, supported by Canada's IDRC) to unite African AI researchers. Within BRICS (Brazil, Russia, India, China, South Africa), there are collaborative forums on technology – for example, a BRICS Institute of Future Networks at Tshwane University of Technology focuses on 5G/6G research with international partners. These platforms increase opportunities for South African institutions to jointly develop technology and share knowledge on a global stage.

Overall, international collaboration is highly encouraged and commonplace – South African digital science teams engage via alliances, joint centres, student exchange, and co-authored research. Such collaborations provide access to international funding and expertise, while also showcasing South Africa's contributions (for instance, leadership in fields like AI for resource-constrained environments).

The following table summarizes the main institutions and communities in South Africa's digital sciences landscape, highlighting their focus areas and collaboration opportunities:

Table 4: Key South African institutions and communities in digital sciences, with their focus areas and collaboration opportunities. (Sources: as cited inline above)

Institution / Community	Type & Focus Areas	Collaboration Opportunities
Centre for AI Research (CAIR)	National academic network (nodes at 8 universities) focusing on Artificial Intelligence – machine learning, knowledge reasoning, AI ethics, etc. Funded by DSI and coordinated via CSIR.	Multi-university collaboration (research projects across campuses). Open to government and industry partnerships seeking AI R&D expertise. Trains Masters/PhDs in AI (potential studentships available).

Wits Institute of Data Science (WIDS)	University research institute at Wits focused on Data Science and machine intelligence. Interdisciplinary approach straddling academia & industry needs.	Partnerships with industry (e.g., NVIDIA for AI training). Collaborative projects across Wits faculties (health, finance, etc.). Offers training programs and data science challenges open to external partners.
Stellenbosch School for Data Science	Faculty-level school (launched 2019) dedicated to Data Science & Computational Thinking as an interdisciplinary field. Tackles African challenges via data-driven research.	Cross-faculty research programs – easy for other universities or companies to join on specific projects. Hosts public workshops and open online courses in data science. International researchers welcomed (e.g., recruited a leading quantum computing professor) for joint initiatives.
UJ Institute for Intelligent Systems (IIS)	University institute at UJ driving 4IR technologies: AI, robotics, IoT, big data, advanced telecoms. Emphasizes applied 4IR solutions (health, mining, smart cities).	Industry collaboration through sponsored research chairs (e.g., Nedbank Chair in AI). Opportunities for pilots and testbeds (IIS has cutting-edge tools like the Boston Dynamics "Spot" robot for research). Engages continent-wide on 4IR, so open to African partners and tech companies for solution development.
UJ Centre for Applied Data Science (CADS)	University centre (UJ, est. 2022) for Applied Data Science in business and economics contexts. Bridges computer science and domain disciplines for data-driven innovation.	Collaboration with industry verticals – invites companies to pose data problems for joint research. Provides postgraduate programs (MSc Applied DS) with industry project components. Connects with government on data-driven policy research.
Tshimologong Precinct (Wits)	Digital innovation hub & incubator in Johannesburg (university-linked). Focus on startups, entrepreneurship, and skills development in digital tech. Also site of corporate labs (IBM Research).	Startup incubation (accepts entrepreneurs from Wits and broader community). Corporate partnerships welcome (e.g., to run accelerator programmes or innovation challenges on-site). A gateway for international tech companies to engage African startups (IBM, etc., already present). Open for student interns, hackathons, and commercialization of university research.
The Innovation Hub (Gauteng)	Provincial science park in Pretoria supporting tech startups and industry clusters in ICT (smart industries), biotech, and green tech. Government-backed (Gauteng Growth & Dev Agency).	Incubation programs (e.g., Maxum Smart for ICT) that academics or recent graduates can join to launch spin-offs. Collaboration with universities on prototyping and product development (shared labs). Government-funded innovation programs (e.g., eHealth, mHealth apps) often channeled here – a chance for researchers to pilot solutions in a supported environment.

Cape Innovation & Tech Initiative (CiTi/UVU)	Non-profit tech incubator in Cape Town; Africa's oldest (Bandwidth Barn). Focus on inclusive digital economy growth – supports startups in fintech, edtech, creative tech, etc.	Public-private collaboration works with academic institutions (student entrepreneurship programs, research commercialization support) and corporates (accelerators, hackathons). Runs community coding and IT skills training (universities and NGOs can partner in these outreach initiatives). Also provides a platform for international partners (e.g., UK-SA Tech Hub, UNDP projects) to connect with local tech talent.
Artificial Intelligence Institute of SA	National institute (public-academic partnership: DCDT + UJ + TUT) for AI innovation. Targets strategic AI applications for industry and government (mining, agriculture, public services, etc.).	Large-scale collaborative projects – invites participation from other universities (as affiliates), private tech companies, and government departments to develop AI solutions. Likely funding opportunities for research aligned with its projects. Facilitates knowledge transfer and commercialization of AI research nationally.
Telkom Centres of Excellence (CoE) Program	Industry-academia network (Telkom + 15+ universities + govt) running since 1997. Each CoE is a research unit focusing on an ICT niche (telecommunications, networking, software engineering, etc.) at a host university.	Direct collaboration between academia and telecom industry. Postgraduate students can engage in industry-relevant research and often get internships or employment through Telkom and partners. Other companies can join as sponsors or utilize CoE research outputs. Annual SATNAC conference provides a forum to present CoE research to international audiences.
IBM–Wits Partnership (Quantum Computing)	International collaboration hub. IBM's Research Lab at Wits Tshimologong (opened 2016) and membership in the IBM Q Network make Wits a gateway for quantum computing research in Africa. Focus on quantum science, AI and big data in frontier research.	Access to IBM's global resources: local researchers and students can work with IBM scientists, use quantum cloud services, and contribute to publications. ARUA member universities can collaborate via Wits to utilize the quantum platform. Potential for co-supervised student projects and innovation grants from IBM. Illustrates a model for partnering with a multinational for technology transfer.

2.4.3 Catalogue of research infrastructures for Digital Sciences

2.4.3.1 Cross-Domain Research Infrastructures

2.4.3.1.1 National Integrated Cyberinfrastructure System (NICIS) (Cross-Domain)

Function: NICIS provides a national framework integrating high-performance computing (HPC), a high-speed network (SANReN), and a national research data infrastructure (DIRISA). It aims to equip researchers across all disciplines with advanced digital tools for cutting-edge research, fostering innovation, and global collaboration. NICIS supports data-intensive tasks, complex simulations, and collaborative projects requiring significant computational power, network bandwidth, and data management capabilities. It also focuses on human capital development in cyberinfrastructure and its diverse applications.

Implementation in South Africa: Implemented through collaboration between DSI, CSIR (managing CHPC), and TENET (managing SANReN). CHPC provides supercomputing resources. SANReN delivers high-speed connectivity. DIRISA coordinates research data management and services. This integrated approach creates a comprehensive national cyberinfrastructure ecosystem.

Target Groups: Researchers and postgraduate students across all scientific disciplines at universities and research institutions. Industry partners needing advanced computing and data analytics. Government initiatives relying on data-driven insights and technological advancements.

2.4.3.1.2 South African Research Infrastructure Roadmap (SARIR) (Cross-Domain)

Function: SARIR serves as a strategic framework by the DSI to guide the long-term planning, implementation, monitoring, and evaluation of essential research infrastructures across all scientific domains, including those crucial for digital sciences. It identifies and prioritizes RIs to ensure researchers have access to cutting-edge facilities. SARIR aligns RI investments with national research priorities and facilitates global science participation.

Implementation in South Africa: Developed through a bottom-up process involving the research community and aligned with national priorities by the DSI. It identified research needs across six domains and developed business plans for potential RIs. Prioritized RIs were selected for implementation, including NICIS components.

Target Groups: The broader South African research community across all public research institutions. Government for evidence-based policymaking. International research collaborations seeking strong infrastructure.

2.4.3.1.3 Tertiary Education and Research Network of South Africa (TENET) (Cross-Domain)

Function: TENET provides a high-speed, reliable, and secure network infrastructure connecting South African universities, research institutions, and related organizations. It enables seamless data transfer, collaboration, and access to national and international research resources. TENET underpins many digital science activities by providing the essential connectivity for HPC, data sharing, and remote access to facilities.

Implementation in South Africa: TENET is a non-profit company that manages and operates the SANReN network. It works in partnership with institutions to connect them to the national backbone and provides various network services tailored to the needs of research and education.

Target Groups: Universities, research institutions, science councils, libraries, museums, and other organizations involved in research and education across all disciplines.

2.4.3.2 Domain-Specific Research Infrastructures: Education & Social Sciences (3)

2.4.3.2.1 National e-Science Postgraduate Teaching and Training Platform (NePTT) (Domain: Education & Digital Sciences)

Function: NePTT is a national platform aimed at enhancing postgraduate training in e-Science and data science across various disciplines. It provides access to online learning resources, virtual research environments, and collaborative tools to equip students with the necessary digital skills for modern research.

Implementation in South Africa: NePTT operates as a virtual platform with contributions from various universities and research institutions. It offers online courses, workshops, and access to computational resources.

Target Groups: Postgraduate students and early-career researchers across all disciplines who need to develop skills in data science, high-performance computing, and other e-Science areas.

2.4.3.2.2 South African Social Attitudes Survey (SASAS) Data Archive (Domain: Social Sciences)

Function: The SASAS is a nationally representative survey conducted annually to track changes in the social attitudes and values of South Africans. The data archive provides researchers with access to this longitudinal data for studying social trends, public opinion, and the impact of social and political changes.

Implementation in South Africa: The Human Sciences Research Council (HSRC) conducts the SASAS and manages the data archive. Data is collected through face-to-face interviews and made available to researchers through application and data agreements.

Target Groups: Social scientists, political scientists, sociologists, psychologists, and other researchers interested in studying social attitudes and behaviour in South Africa. Policymakers and government agencies needing insights into public opinion.

2.4.3.2.3 National Income Dynamics Study (NIDS) Data Archive (Domain: Economics & Social Sciences)

Function: NIDS is a national longitudinal household survey that collects detailed information on the socio-economic circumstances of South African households and individuals over time. The data archive provides researchers with a rich resource for studying poverty, inequality, labour markets, and the impact of social policies.

Implementation in South Africa: Conducted by the Southern Africa Labour and Development Research Unit (SALDRU) at the University of Cape Town, 1 the NIDS data is made available to researchers through a data archive with clear access protocols.

Target Groups: Economists, sociologists, development researchers, and policymakers interested in understanding and addressing socio-economic issues in South Africa.

2.4.3.3 Domain-Specific Research Infrastructures: Humanities & Language Studies (1)

2.4.3.3.1 South African Centre for Digital Language Resources (SADiLaR) (Domain: Humanities & Language Studies)

Function: SADiLaR focuses on the development and promotion of digital resources and tools for all eleven official South African languages. It aims to support research, education, social transformation, and economic development related to these languages. SADiLaR creates and manages digital language resources (text, speech, multi-modal) and builds capacity in Digital Humanities.

Implementation in South Africa: A multi-partner entity hosted by North-West University with nodes at other institutions. It runs digitization programs to create language resources and Digital Humanities programs for capacity building.

Target Groups: Researchers and professionals in humanities, social sciences, language technologies, and computer science. Educators, businesses, and industries utilizing local languages.

2.4.3.4 Domain-Specific Research Infrastructures: Life Sciences & Health (8)

2.4.3.4.1 National Bioinformatics Network (NBN) (Domain: Life Sciences & Bioinformatics)

Function: The NBN aims to support bioinformatics research and development in South Africa. It provides access to bioinformatics tools, databases, training, and expertise. The network facilitates collaboration among bioinformaticians and life scientists to address biological questions using computational approaches.

Implementation in South Africa: A network of research groups and institutions involved in bioinformatics across South Africa. It often operates through collaborative projects, workshops, and shared resources.

Target Groups: Bioinformaticians, molecular biologists, geneticists, and other life scientists who use computational methods in their research.

2.4.3.4.2 South African Population Research Infrastructure Network (SAPRIN) (Domain: Health, Demography, Social Sciences)

Function: SAPRIN is a national research infrastructure that collects and maintains longitudinal health and socio-demographic data from selected population groups across South Africa. It provides a platform for researchers to study the health transitions, social changes, and the impact of policies and interventions on communities over time.

Implementation in South Africa: SAPRIN operates through a network of research sites in different provinces, each collecting data from defined population cohorts. Data is managed centrally and made available to researchers through an application process.

Target Groups: Researchers in public health, epidemiology, demography, social sciences, and related fields. Policymakers and government agencies needing population-level data for planning and evaluation.

2.4.3.4.3 National Collection of Fungi (PREM) (Domain: Life Sciences, Mycology)

Function: PREM is a national resource that houses a large collection of preserved fungal specimens, along with associated data. It serves as a vital infrastructure for taxonomic research, biodiversity studies, and understanding the role of fungi in ecosystems and agriculture. Digital records are increasingly important for accessing this collection's information.

Implementation in South Africa: Housed at the Agricultural Research Council (ARC), PREM maintains the physical collection and is actively involved in digitizing its records, including images and collection data.

Target Groups: Mycologists, plant pathologists, ecologists, and other researchers studying fungi. Bioprospectors and industries interested in fungal resources.

2.4.3.4.4 National Zoological Gardens of South Africa (NZG) Biological Records System (ZARS) (Domain: Life Sciences, Zoology, Biodiversity)

Function: ZARS is a database that contains detailed records of the animal collection at the NZG, including information on species, origin, life history, and health. This system supports research on animal behaviour, conservation, and captive breeding programs. Digital access to this data is crucial for research and management.

Implementation in South Africa: The NZG manages and maintains the ZARS database, which is used for the day-to-day management of the animal collection and for research purposes.

Target Groups: Zoologists, veterinarians, conservation biologists, and researchers interested in animal behaviour and captive management.

2.4.3.4.5 South African National Cancer Registry (NCR) (Domain: Health)

Function: The NCR collects and analyzes data on cancer incidence in South Africa. It provides essential information for monitoring cancer trends, planning cancer control programs, and supporting research on the burden and causes of cancer.

Implementation in South Africa: Managed by the National Institute for Occupational Health (NIOH), the NCR receives data from pathology laboratories and other healthcare providers across the country.

Target Groups: Cancer researchers, epidemiologists, public health professionals, oncologists, and policymakers involved in cancer control.

2.4.3.4.6 National Health Laboratory Service (NHLS) Data Repository (Domain: Health)

Function: The NHLS is the largest public health laboratory service in South Africa, and it generates vast amounts of diagnostic and surveillance data. While not always structured as a single research infrastructure, access to anonymized and aggregated NHLS data is crucial for epidemiological research, disease surveillance, and public health planning.

Implementation in South Africa: The NHLS operates a network of laboratories across the country, each generating data that is stored in their

Target Groups: Epidemiologists, public health researchers, infectious disease specialists, and other health researchers.

2.4.3.4.7 South African National Blood Service (SANBS) Data Repository (Domain: Health)

Function: SANBS collects and manages data related to blood donations, testing, and distribution across South Africa. Access to anonymized and aggregated data from this repository can be valuable for research on bloodborne diseases, transfusion medicine, and public health.

Implementation in South Africa: SANBS maintains its own data management systems. Access for research typically requires ethical approval and collaboration with SANBS researchers.

Target Groups: Medical researchers, public health specialists, transfusion medicine experts, and epidemiologists.

2.4.3.5 Domain-Specific Research Infrastructures: Environmental & Earth Sciences (7)

2.4.3.5.1 South African Earth Observation Network (SAEON) (Domain: Environmental Sciences, Earth Sciences)

Function: SAEON is a national network that monitors and researches long-term ecological changes in South Africa's diverse ecosystems. It collects and manages various environmental data, including remote sensing data, and provides a platform for researchers to study environmental processes and the impact of human activities.

Implementation in South Africa: SAEON operates through a network of research nodes across different biomes in South Africa, each focusing on specific environmental monitoring and research activities. It manages large environmental datasets.

Target Groups: Researchers in ecology, climate science, biodiversity, and environmental management. Government agencies responsible for environmental monitoring and policy.

2.4.3.5.2 South African National Space Agency (SANSA) Earth Observation Data Archive (Domain: Earth & Environmental Sciences, Space Science)

Function: SANSA manages a significant archive of Earth observation data acquired from various satellites. This data includes imagery and other remote sensing products that are valuable for environmental monitoring, disaster management, urban planning, and various scientific research applications.

Implementation in South Africa: SANSA receives, processes, archives, and distributes Earth observation data. They also develop value-added products and provide access to the data through their platforms.

Target Groups: Researchers in environmental science, geography, urban planning, and disaster management. Government agencies needing Earth observation data for monitoring and planning. Commercial users of satellite imagery.

2.4.3.5.3 South African National Antarctic Programme (SANAP) Data Centre (Domain: Polar & Environmental Science)

Function: The SANAP Data Centre archives and manages scientific data collected during South Africa's research activities in Antarctica and the Southern Ocean. This includes data on climate, oceanography, glaciology, and biology, which is crucial for understanding polar environments and their role in the global system.

Implementation in South Africa: Managed by the Department of Forestry, Fisheries and the Environment (DFFE) and collaborating research institutions, the data centre provides access to SANAP research data through defined protocols.

Target Groups: Polar scientists, climate researchers, oceanographers, biologists, and other researchers studying the Antarctic and Southern Ocean regions.

2.4.3.5.4 National Integrated Wildland Fire Information System (NIWFIS) (Domain: Environmental Science & Disaster Management)

Function: NIWFIS is a system that integrates data on wildland fires from various sources, including satellite imagery, ground reports, and weather information. It provides tools for fire monitoring, risk assessment, and management, supporting efforts to protect lives, property, and natural resources.

Implementation in South Africa: Managed by the Council for Scientific and Industrial Research (CSIR) in collaboration with other agencies involved in fire management. It provides online platforms and data services.

Target Groups: Fire managers, disaster management agencies, environmental conservation organizations, and researchers studying wildland fires.

2.4.3.5.5 South African National Biodiversity Institute (SANBI) Biodiversity Information Management and Reporting System (BIMS) (Domain: Environmental Sciences, Biodiversity)

Function: BIMS is a system developed by SANBI to manage and report on biodiversity data in South Africa. It integrates various datasets on species distribution, conservation status, and ecological information, providing a platform for research, conservation planning, and policy development.

Implementation in South Africa: SANBI manages and maintains the BIMS database and related tools. Data is contributed by various researchers, conservation organizations, and government agencies.

Target Groups: Biodiversity researchers, conservation practitioners, environmental managers, and policymakers.

2.4.3.5.6 Council for Geoscience National Data Repository (Domain: Earth Sciences, Geology)

Function: The repository is a national archive for geological data, including maps, borehole data, geophysical surveys, and mineral resource information. It provides essential data for mineral exploration, groundwater management, and geological research.

Implementation in South Africa: The Council for Geoscience manages and maintains the data repository, providing access to data and services to various stakeholders.

Target Groups: Geologists, mining companies, hydrogeologists, researchers in earth sciences, and government agencies involved in resource management.

2.4.4 Key challenges for RI development

Funding remains a problem for research projects and research infrastructure development in South Africa. Despite NRF South Africa providing initial funding for research projects, more can be done to unlock funding specifically for building and maintaining shared research infrastructure. We acknowledge the role played by SANReN in accessing global research networks; however, more collaborative efforts from the government and private sector to foster public and private investment in sustainable research facilities go a long way to improving research h capacity and research outcomes in the region.

Research Infrastructure has been developed in silos for different purposes serving different hubs spread across research institutions and universities. As management of these research infrastructures remains disaggregated, keeping them up to date with current software, hardware and other supporting digital technologies remains a challenge. Strategic planning and policy should ensure research infrastructure remains up to date and equally benefits from funding allocation to modernise and upgrade the existing infrastructure.

As much as the infrastructure is aging and outdated, upgrading and maintaining advanced research infrastructure requires upskilling the current workforce to contribute to the design and development stages of research infrastructure. This still proves to be a challenge in the South African context. Catching up with developed economies that run gigantic research infrastructure requires investment in higher education, professional development, and competitive remuneration to ensure that the population able to maintain and operate advanced research facilities and projects is incentivised to stay and contribute in their home countries.

Another approach that is lacking in the African context when approaching research, research facilities, and research outcomes is the lack of collaboration. First, this lack of collaboration is seen in the regional bloc space, which is then extended to the continental arena. This is mostly brought about by a lack of awareness of what is going on in the neighbouring states and barriers to access to what is available in the neighbouring states due to factors such as a lack of reliable and affordable internet connectivity. This also contributes to another challenge experienced in the South African context where, although much infrastructure is

available in different hubs, communities, and centres, there is inequality in the level of advancement and a lack of harmony towards a framework for deployment and collaboration.

Finally, administrative hurdles due to complex regulations and bureaucratic processes contribute to the lack of development of research and research infrastructure in South Africa. This also contributes to slowed collaboration with partners internally in the country and within the continent. Policies and frameworks are not streamlined and coordinated between government and research initiatives designed to expedite infrastructure development. This significantly slows down the adoption, collaboration, and establishment of new research infrastructure responding to the current research needs of Industry 4.0.

2.5 RI capacities in Kenya

2.5.1 Overview of national context

Based on the national policy and governance of the research infrastructures, Kenya's research agenda is guided by the Science, Technology, and Innovation (STI) Act of 2013. It established the National Commission for Science, Technology, and Innovation (NACOSTI) to regulate and promote research activities within the country[14]. NACOSTI's mandate includes accrediting research institutions, ensuring ethical standards, and aligning research with national priorities. Kenya has also established the National Research Fund (NRF)[15] that mobilises, allocates and manages financial resources required to facilitate an effective nation innovation system. Researchers at universities and other organisation can apply for NRF grants primarily by responding to calls. NRF also organises conferences where postgraduate (master's and doctoral) students can submit papers for peer review and presentation. In addition, Kenya established the Kenya Education Network Trust (KENET)[16]. KENET primarily builds and operates the National Research and Education Network (NREN), which provides Internet connectivity to education and research institutions. Under its research services, KENET provides the KENET Virtual Lab (VLAB)[17]. It is a virtual cloud environment where virtual machines are deployed on demand. KENET also funds projects and issues travel grants for students and researchers. Various universities in Kenya host centres of excellence in digital sciences, as well as innovation hubs. In addition, a few business incubation centres focusing on leveraging digital sciences are present in Kenya. Key examples are iHub[18] and iBiz Africa[19].

2.5.2 Identification of research and innovation communities in Digital Sciences

The few digital sciences research and innovation communities in Kenya mostly operate in isolation; there is little publicly available information on inter-community collaboration.

Strathmore University's Innovation Lab, @iLabAfrica is a Centre of Excellence in ICT innovation and development. The Internet of Things (IoT) and Wireless Networks[20] department conducts research on automation through smart solutions, and Low Power Wide Area Networks (LPWAN).

The University of Nairobi has established the Silicon Savannah Innovation Park (SSIP) that was co-funded by the government of Kenya and the government of France[21]. SSIP operates

[14] Website: https://www.nacosti.go.ke/mandate-functions/ (Accessed: 26/5/2025).
[15] Website: https://www.nrf.go.ke/ (Accessed: 26/5/2025).
[16] Website: https://www.kenet.or.ke/ (Accessed: 26/5/2025).
[17] Website: https://www.kenet.or.ke/content/kenet-virtual-lab (Accessed: 26/5/2025).
[18] Website: https://ihub.co.ke/ (Accessed: 26/5/2025).
[19] Website: https://ibizafrica.strathmore.edu/ (Accessed: 26/5/2025).
[20] Website: https://ilabafrica.strathmore.edu/internet-of-things-and-wireless-networks/ (Accessed: 26/5/2025).
[21] Website: https://www.uonbi.ac.ke/news/groundbreaking-silicon-savannah-innovation-park-new-engineering-and-science-complex-launched (Accessed: 26/5/2025).

as part of the Kenya's national technological ecosystem known as "Silicon Savannah" that will be headquartered at the Konza Technopolis, which will be Kenya's first technology and innovation city.

The African Advanced Level telecommunications Institute (AFRALTI) conducts research in digital sciences whose aim is to support its training and consulting services[22]. The focus areas include telecommunication engineering (5G, spectrum management), and Information Technology. In 2023 AFRALTI launched an initiative on Re-imagining a Better Connected and Innovative Africa[23], with focus on IoT, Data Science and AI.

Jomo Kenyatta University of Agriculture and Technology (JKUAT) launched JHUB Africa[24], which will have a key focus on Artificial Intelligence (AI)

2.5.3 Catalogue of research infrastructures for Digital Sciences

Research infrastructures for digital sciences in Kenya have been developed by government organisations and universities.

The Kenya Education Network Trust (KENET) has developed several research infrastructures. The KENET Virtual Lab (VLAB)[25] described earlier is a virtual cloud environment where customised virtual machines can be deployed. Users can select VM parameters such as size of RAM, number of CPUs and disk space required to create a VM. Each VM offers a pre-configured virtual appliance running various software tracks such as statistical analysis, Quantum Espresso, NumPy/Scikit which can be deployed on demand. VLAB is only accessible for use by approved users who are affiliated with KENET member Institutions.

KENET has also built an Open Access Data Repository (OADR) that meets the needs of open access journal requirement for researchers to publish their research data[26].

Jomo Kenyatta University of Agriculture and Technology (JKUAT) hosts JHub Africa, which provides prototyping labs where researchers can develop and test their products.

Strathmore University's iLab Africa has deployed and manages a Low Power Wide Area Network (LPWAN) infrastructure based on LoRaWAN[27]. The network facilitates conducting IoT-driven research. The network was developed through a collaboration by consortium partners in the Horizon 2020 project titled: WAZIHUB and was created to enable startups to develop sustainable business models.

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[22] Website: https://www.afralti.org/training/ (Accessed: 26/5/2025).
[23] Website: https://www.afralti.org/re-imagining-a-better-connected-and-innovative-africa/ (Accessed: 26/5/2025).
[24] Website: https://www.jkuat.ac.ke/jhub-africas-launch-sparks-a-new-era-of-data-driven-innovations/ (Accessed: 26/5/2025).
[25] Website: https://www.kenet.or.ke/content/kenet-virtual-lab (Accessed: 26/5/2025).
[26] Website: https://www.kenet.or.ke/content/kenet-research-infrastructures (Accessed: 26/5/2025).
[27] Website: https://ilabafrica.strathmore.edu/internet-of-things-and-wireless-networks/ (Accessed: 26/5/2025).

2.5.4 Key challenges for RI development

Challenges facing the development of research infrastructure in Kenya include inadequate funding, low inter-organisation collaboration, and inadequate documentation to support use of available infrastructure.

Collaboration among research institutions in Kenya is still low, compared to collaboration between Kenya researchers and international researchers. 80% of co-authored papers results from international collaborations[28]. This has impacted development of RI since despite organisations such as NRF encouraging through collaborative grants, there is no publicly available documentation on inter-linked RI among universities.

Inadequate documentation on RI and how to use it is evident from little information available about the KENET VLAB, and iLab Africa's LPWAN. There is no dedicated and updated documentation to enable researchers to leverage and integrate into the RI.

Inadequate funding for RI is a major challenge inhibiting its development[29]. The Kenyan government spends 0.8% of the GDP on research and development[30]; the exact proportion allocated to RI is not known but is much lower.

[28] Website: https://journals.sagepub.com/doi/full/10.1177/03400352241257668?mi=ehikzz (Accessed: 26/5/2025).
[29] Website: https://erepo.usiu.ac.ke/handle/11732/4314?show=full (Accessed: 26/5/2025).
[30] Mattia Fosci, Lucia Loffreda, Andrew Chamberlain, Nelisha Naidoo, "Assessing the needs of the research system in Kenya. Report for the SRIA programme.", Report commissioned by: The UK Department for International Development, October 2019. Website: https://assets.publishing.service.gov.uk/media/5ef4acb5d3bf7f7145b21a22/NA_report_Kenya__Dec_2019_Heart_.pdf (Accessed: 26/5/2025).

2.6 RI capacities in Cameroon

2.6.1 Overview of national context

Spanning 475,442 square kilometres and ranking as the 54th-largest nation globally, Cameroon, often dubbed "Africa in miniature" for its diverse geography and cultures, is home to approximately 29 million people speaking 270 native languages alongside English and French. Administratively divided into 10 regions, 58 departments, and 360 communes, the country's economy is characterized by a substantial population engaged in subsistence farming, with a per capita GDP estimated at US$ 1,736.86 in 2023[31].

The Ministry of Posts and Telecommunications (MINPOSTEL) is central to Cameroon's ICT sector, responsible for policy formulation and implementation. It supervises the Telecommunications Regulation Board (ART), which enforces telecom regulations, and the National Agency for ICT (ANTIC), tasked with promoting ICT development and regulating electronic security.

Cameroon's capacity for digital science research is closely linked to its overall national situation. While a young, increasingly urban population creates a demand for digital solutions, and government policies encourage the use of technology for economic growth, a significant digital divide hinders progress. High-speed internet, essential for advanced research, remains scarce and expensive [3]. Despite the efforts of the government connecting the countries to several submarine cables (SAT3/WACS, ACE, SAIL, and NCSCS) and deploying a national fiber optic backbone exceeding 25,000 km, the Internet penetration rate is 41.9% in 2023 according to the ITU[32]. In addition, the 2024 Network Readiness Index (NRI) ranked Cameroon 116th out of 133 economies[33]. However, Cameroon's 2020-2030 National Development Strategy (NDS30) projects a 6.4% growth in the digital sector by 2029[34].

Identification of research and innovation communities in Digital Sciences Cameroon's digital science research and innovation ecosystem features emerging expertise within several higher education institutions, including the Universities of Yaoundé I, Dschang, Douala, Ngaoundere, Buea, Bamenda, and Maroua, alongside engineering schools like ENSPY, ENSPD, and EGCIM. Individual researchers and developing research groups are actively engaged in areas such as Artificial Intelligence, with a focus on local language processing, Data Science applications across various sectors, Software Engineering tailored to regional needs, and foundational Cybersecurity research. Notably, Cameroon is also home to one of the five African Institutes for Mathematical Sciences (AIMS). While formal,

[31] Website: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=CM (Accessed: 26/5/2025).
[32] https://datahub.itu.int/data/?e=1&i=11624
[33] Portulans Institute, "Network Readiness Index (NRI) 2024", Website: https://download.networkreadinessindex.org/reports/countries/2024/cameroon.pdf (Accessed: 26/5/2025).
[34] Website: https://www.bmz-digital.global/en/initiatives/digital-transformation-center-cameroon/ (Accessed: 26/5/2025).

nationwide research networks dedicated specifically to digital sciences are still in their early stages, informal collaborations and individual efforts currently drive much of the output.

The country also hosts key organizations like the African Society in Digital Science (ASDS)[35], launched in 2023 and serving as an umbrella for the Conference on Research in Computer Science (CRI)[36]. Furthermore, the Cameroon Artificial Intelligence Society (CAIS) has been established to promote AI-related initiatives. In 2025, the University of Yaoundé II launched the first Multidisciplinary Lab on Responsible AI in Cameroon[37].

The growing startup scene presents a dynamic, though often under-resourced, front for innovation. Strengthening connections between these academic research centers and the expanding private sector, while also fostering more structured national research networks and increasing investment in collaborative projects, will be crucial for accelerating the growth and impact of digital science innovation in Cameroon.

2.6.2 Catalogue of research infrastructures for Digital Sciences

Cameroon faces a considerable developmental gap in its research infrastructure for digital sciences. Although some universities and engineering schools have basic IT resources, these are primarily designed for teaching, offering limited capacity for computationally demanding research in fields like advanced AI or large-scale data analytics. Despite government initiatives to establish University Digital Development Centers within the E-National Higher Education network for state universities, significant progress is still needed.

Access to dedicated High-Performance Computing (HPC) facilities remains a major barrier, potentially restricting Cameroonian researchers' involvement in cutting-edge digital science. Likewise, the infrastructure for managing and sharing research data is underdeveloped, lacking robust national repositories and standardized protocols. Network connectivity often suffers from bandwidth limitations, high costs, and reliability issues, even within major cities, hindering access to global research resources and collaborations. Furthermore, the concept of living labs and testbeds, vital for validating digital innovations in real-world settings, is still in its early stages.

2.6.3 Key challenges for RI development

The development of digital science research infrastructure in Cameroon is severely limited by a combination of factors: insufficient and inconsistent funding, inadequate internet connectivity (especially outside cities), a critical lack of skilled personnel to manage and use advanced infrastructure, the absence of a clear national strategy and coordination, challenges in ensuring long-term sustainability, and unequal access to resources,

[35] Website: https://asds.africa/ (Accessed: 26/5/2025).
[36] Website: http://cri-info.cm/ (Accessed: 26/5/2025).
[37] Website: https://www.linkedin.com/company/laboratoire-multidisciplinaire-d-ia-responsable-appliqu%C3%A9e-de-l-universit%C3%A9-de-yaound%C3%A9-ii/posts/?feedView=all (Accessed: 26/5/2025).

disadvantaging smaller institutions and startups. Overcoming these interconnected issues necessitates a comprehensive and sustained commitment from various stakeholders.

2.7 Lessons Learned from the EU RIs

The development and operation of large-scale Research Infrastructures (RIs) in Europe, within the SLICES and SoBigData RIs offer valuable insights and best practices that can inform the structuring and strategic planning of RIs in Africa, especially in the domain of Digital Sciences. Several key lessons emerge from these initiatives.

Successful RI projects begin with a clear alignment between infrastructure design and major scientific challenges. For example, SoBigData RI emphasizes ethical and responsible data science to address pressing societal challenges. This thematic focus ensures long-term relevance and political support. Similarly, SLICES has developed a long-term strategy (scientific and technical) vision, identifying main future research topics to provide adapted and suitable services to its users and stakeholders and set priorities. This makes the SLICES infrastructure versatile enough to support research in the long-term. In the African context, aligning RI goals with continental priorities such as those articulated in STISA-2024 and the AU Digital Transformation Strategy is essential for strategic coherence and stakeholder engagement.

Both SLICES and SoBigData RIs are structured as distributed research infrastructures, consisting of geographically distributed testbeds, facilities, and data services interconnected across multiple countries. This model supports scalability and cost-effective deployment. In the case of SLICES, the infrastructure includes a network of experimentation facilities for digital and networked systems (e.g., 5G/6G, edge/cloud computing, IoT), with nodes hosted in different European countries. These sites are interoperable through common APIs, virtualisation layers, and experimentation tools that support remote access, multi-site orchestration, and resource scheduling. In particular, SoBigData RI operates a virtual research environment (VRE) known as the SoBigData Gateway, which provides an integrated platform for access to: i) curated datasets related to social mining, human mobility, economy, and online behaviour; ii) analytical methods and algorithms, including reproducible workflows for data analysis, machine learning, and computational social science; and iii) distributed computing resources from participating institutions. For Africa, a distributed RI model would allow different regions or institutions to contribute specialized capabilities (e.g., AI, IoT, edge computing), while enabling integration into a continental framework

Early definition of governance models—incorporating scientific, technical, and financial management—is a key success factor in research infrastructure development. European RIs frequently adopt multi-level governance structures, which involve academic institutions, national authorities, infrastructure operators, and user communities. One widely used framework is the ERIC (European Research Infrastructure Consortium) model, which provides a legal structure recognized by the EU. The ERIC model facilitates transnational coordination, enables contributions in cash or in-kind from member states, and ensures accountability and sustainability through clear rules on governance, access, reporting, and financing.

In addition to governance, sustainability planning is embedded from the outset. This includes detailed analysis of capital and operational costs, income streams (including user fees and national contributions), and the development of a long-term business model that secures financial viability beyond the lifecycle of initial project funding. For African RI initiatives, adopting similar principles is critical. Defining governance frameworks that are transparent, inclusive, and adaptable to national and regional contexts—potentially inspired by the ERIC model—can foster multi-stakeholder participation, facilitate international collaboration, and ensure the long-term viability and scalability of digital science infrastructures across the continent.

European RIs strongly advocate for FAIR (Findable, Accessible, Interoperable, Reusable) data principles and open access to research tools. These principles enhance the discoverability, accessibility, and reusability of scientific outputs, fostering transparency and accelerating innovation. A key initiative supporting this vision is the European Open Science Cloud (EOSC)[38], which provides a federated framework of data services and research-enabling tools across Europe. EOSC supports the implementation of FAIR principles by offering shared digital environments for data storage, processing, and sharing, along with guidelines on governance, legal compliance, and technical standards. Adopting similar frameworks in the development of African RIs would promote interoperability, enable reuse of digital assets, and facilitate integration with international scientific infrastructures. Aligning with EOSC-inspired models could help African institutions benefit from shared services, cross-border collaboration, and capacity building in areas such as data stewardship and open science governance. This approach would also increase the visibility of African scientific contributions and foster stronger links with the global research community.

A recurring priority in European Research Infrastructures (RIs) is the establishment of structured and sustainable training programmes that equip a wide range of stakeholders—including researchers, data stewards, and technical personnel—with the knowledge and competencies required to effectively operate and benefit from the infrastructure. In this context, both SLICES RI and SoBigData RI have developed dedicated training platforms known as SLICES Academy[39] and SoBigData Academy[40], respectively. These academies serve as integral capacity-building pillars within their respective infrastructures. Their organisation is modular, offering a layered curriculum that addresses the needs of users with varying expertise levels—from beginners to advanced practitioners. Training formats include online courses, summer schools, hands-on workshops, hackathons, and thematic webinars. The structure of these academies encompasses: i) core training tracks, focused on foundational concepts and tools in digital sciences, experimentation, and data analytics; ii) advanced thematic modules; and iii) technical tutorials on the use of RI services and platforms, including experimentation workflows, data management practices, and software tools. The experience gained in organising and deploying these academies provides a

[38] Website: https://eosc.eu (Accessed: 26/5/2025).
[39] Website: https://www.slices-ri.eu/slices-academy (Accessed: 26/5/2025).
[40] Website: https://www.sobigdata.eu/training (Accessed: 26/5/2025).

replicable model for training initiatives in the African context, particularly in the framework of capacity building for emerging digital RIs.

Finally, successful RIs should be designed with strong community engagement, ensuring they serve the evolving needs of diverse users. For instance, SLICES RI includes early technology adopters in the design process to improve usability and impact. African initiatives can benefit from actively engaging local research communities, startups, and public sector users in the design and testing phases of infrastructure development.

3 Demand Analysis

This section presents the outcomes of the demand analysis conducted within the DIGITafrica project during the first six months of the project, aimed at identifying the research and innovation needs related to Digital Sciences in the African context. In this framework, demand analysis refers to the process of assessing the current and emerging requirements of the scientific and innovation communities for RIs, with a focus on experimental capabilities, computing and data services, and training.

The first action undertaken as part of this analysis was the inaugural consultation workshop, held on April 24–25, 2025, at the University of Cape Town (UCT). This workshop was organised by UCT and Sorbonne University, with support from the SLICES and SoBigData initiatives, and collected over 60 participants—both onsite and online—for two days of strategic discussions, collaborative dialogue, and technical demonstrations.

The workshop discussions provided a foundational understanding of the demand landscape, The results of this analysis will inform the subsequent identification of relevant research communities, the mapping of existing infrastructures, and the formulation of strategic recommendations for future RI development.

3.1 Organisation and timeline

The DIGITAfrica inaugural workshop, held at the University of Cape Town (UCT) Graduate School of Business Conference Centre, marked the first in-person consultation toward building a pan-African research infrastructure in digital sciences. The workshop brought together stakeholders from academia, government, industry, and international partners to explore collaborative frameworks, capacity development, and technical architectures for a federated research infrastructure tailored to African contexts.

The following table summarises the agenda of the first day, highlighting the objectives of each thematic session and the involved speakers.

Table 5: Schedule of Day 1 (24 April)

Time	Session Description	Speakers	Moderators
09:00 – 09:30	Welcome and Opening Keynote	Serge Fdida (Sorbonne University FR), Joyce Mwangama (University of Cape Town ZA)	
09:30 - 10:45	Session 1: Research Agendas and Technical Frameworks	Dr Scott Timcke (Research ICT Africa ZA), Leonard Mabele Mandry Ntshani	Joyce Mwangama (University of Cape Town ZA)
10:45 - 11:00	Coffee Break		
11:00 - 12:00	Building the DIGITAfrica Network	Dr Partson Chikudza (Research Council of Zimbabwe, ZW)	

		Dr Michelle Smith Mark Johnson	
12:00 - 13:00	Panel: Research Priorities		Prof. Serge Fdida (Sorbonne University FR)
13:00 - 14:00	Lunch		
14:00 - 15:00	The Capacity Building		
15:00 - 16:00	Panel: The Economic Sustainability		
10:45 - 11:00	Coffee Break		
16:15 - 17:00	Blueprint and Proof of Concept		
17:00 - 17:30	Finalization and Action Plan		

Day 1 (24 April) began with opening remarks by Prof Serge Fdida and Prof Joyce Mwangama, emphasising the importance of sustainable, co-designed digital research infrastructures that reflect African priorities while leveraging European expertise through platforms like SLICES and SoBigData. They also emphasized the importance of cross-continental collaboration and the need to address fragmentation in digital research capabilities through coordinated RI development. Then, each session and panel focused on a specific thematic area — ranging from technical frameworks and research priorities to capacity building and sustainability — offering participants the opportunity to share insights, identify challenges, and propose strategies for advancing digital science RIs across the continent. The following summary outlines the main themes and contributions from each session.

Session 1 – Research Agendas & Technical Frameworks

The opening session explored the current landscape of African research infrastructures in the context of the AU-EU collaboration agenda. Speakers included Dr. Scott Timcke, Leonard Mabele, and Mandry Ntshani, who discussed the importance of inclusive policy-making and effective data governance to support the development of robust and equitable research ecosystems across the continent. Discussions also underscored the need for differentiated technical frameworks that account for regional disparities and sector-specific demands.

Session 2 – Building the DIGITAfrica Network

This session focused on the establishment of the DIGITAfrica network through multi-sector partnerships and regional engagement. Presentations by Dr. Partson Chikudza, Dr. Michelle Smith, and Mark Johnson emphasized the strategic role of regional nodes and thematic centres in supporting collaboration and capacity building across African countries. The discussion highlighted the value of inter-institutional collaboration and the potential for leveraging existing national and regional initiatives.

Panel Discussion – Research Priorities

Moderated by Prof. Serge Fdida, this panel brought together experts such as Prof. Thomas Magedanz, Prof. Bamba Gueye, Dr. Henda Ghazel, and others to identify common research themes of continental relevance. Key areas highlighted included federated artificial intelligence, dynamic spectrum management, and policies for local data sovereignty. The importance of mapping these priorities to actionable blueprints and use cases was emphasized.

Session 4 – Capacity Building

This session examined strategies to address the skills gap in digital sciences, focusing on the role of micro-credentialing and digital academies. Contributions from Prof. Ahmed Biyabani, Dr. Winston Ojenge, and other speakers stressed the importance of accessible, modular training programs tailored to evolving technological and research needs, and to diverse user profiles, from researchers to technicians. Emphasis was also placed on the need of replicating successful models such as SANReN and KENET.

Panel Discussion – Economic Sustainability

Moderated by Prof. Albert Lysko, the sustainability panel explored financial models for supporting long-term viability of research infrastructures. Discussions highlighted the need for diverse funding sources, improved public-private partnerships, and policy mechanisms to ensure infrastructure assets are efficiently utilized and maintained. Sustainability was framed not just in financial terms but also in terms of long-term institutional engagement and human resource retention.

Session 5 – Blueprint and Proof of Concept

The final session presented concrete technical demonstrations and outlined the design of modular, federated testbeds developed within the SLICES initiative. Led by Dr. Damien Saucez and Dr. Nikos Makris, the discussion introduced a practical roadmap for implementing federated 5G experimentation environments and integrating machine learning frameworks tailored for distributed digital infrastructures, emphasizing how these models can be adapted for African research contexts.

Finalisation and Action Plan

The final session summarised insights from the day and proposed a roadmap for developing a distributed, federated RI aligned with African research and innovation priorities. A strong call was made for coordinated follow-up activities, including pilot deployments and governance definition, with DIGITAfrica playing a facilitation role.

Figure 10: Day 1 of the DIGITAfrica Workshop (technical sessions).

Day 2 (25 April) was dedicated to a hands-on training session, where participants explored the SLICES infrastructure. Led by Dr Saucez and Dr Makris, attendees deployed and managed virtualised 5G and Open RAN environments using Kubernetes clusters and SDR hardware, troubleshooting performance, synchronisation, and compute resource allocation challenges. The session also emphasised reproducibility, sustainability, and experimentation ethics.

Figure 11: Day 2 of the DIGITAfrica Workshop (hands-on sessions).

The workshop concluded with a strong consensus on moving from consultation to co-development, with each region contributing to the evolving DIGITAfrica blueprint and federated infrastructure model.

3.2 Outcomes

The inaugural DIGITAfrica stakeholder workshop served as a key consultative forum to identify regional priorities, gaps, and user needs relating to the establishment of a pan-African research infrastructure (RI) in digital sciences, also pointing to strategic priorities and actionable recommendations. The event brought together diverse stakeholders from across academia, government, and industry, representing all five African partner countries, alongside representative of the SLICES and SoBigData RIs.

The key findings are summarised below, reflecting the shared priorities and lessons identified throughout the event.

- **Digital Infrastructure Gaps and Fragmentation:** Participants underscored widespread disparities in digital research infrastructure across the continent. These gaps were not only geographic (urban vs. rural) but also institutional, with historically disadvantaged universities often lacking access to high-performance

computing, experimental networks, and data-intensive platforms.

- **Connectivity and Power Supply Constraints:** Limited bandwidth, inconsistent connectivity, and unreliable power supply were identified as critical bottlenecks for digital research. These constraints impede both participation in global research and the establishment of locally sustained experimentation platforms.

- **Skills and Human Capital:** The demand for targeted training was echoed across sessions. Capacity building must address different user tiers, from advanced researchers to technicians, while also responding to local linguistic and educational contexts. The role of micro-credentialing and modular learning paths was emphasized.

- **Need for Localised, Use-Case Driven Infrastructure:** Stakeholders called for infrastructure that reflects local priorities such as agriculture, health (e.g., telemedicine), climate resilience, and education. The ability to test and co-design services in real-world, African contexts was seen as vital to ensure impact.

- **Sovereignty and Data Governance:** A strong demand was voiced for sovereign African participation in data governance and AI model development. Participants stressed the importance of building capabilities not just for consuming external tools, but for developing locally relevant technologies and open platforms.

- **Blueprint and Technical Reference Requirements:** There was strong interest in lightweight, modular blueprints that can be deployed incrementally. Demonstrations of Open RAN, federated learning, and cloud-native 5G architectures during the workshop illustrated the appetite for open, standards-aligned testbeds capable of being adapted to diverse environments.

- **Governance and Funding Models:** Sustainability emerged as a major concern, with participants calling for funding models that go beyond project-based cycles. Public-private partnerships, alignment with national research agendas, and regional co-investment schemes were proposed as potential enablers.

The workshop highlighted the importance of designing a flexible, scalable infrastructure that responds to layered demands, ranging from experimentation and training to service validation and community outreach. A clear recommendation was the need to anchor the infrastructure in real-world African challenges while supporting cross-country interoperability. Local deployment scenarios, user-specific training resources, and inclusive governance structures must be integral to the blueprint development in subsequent work packages.

4 Conclusions and Recommendations

The work presented in this deliverable provides an initial yet comprehensive overview of the state of digital science RIs across five African partner countries. It identifies common trends, structural gaps, and emerging opportunities, while also laying the ground for a federated pan-African RI landscape that is both sustainable and aligned with continental priorities such as those defined in the AU Digital Transformation Strategy and STISA-2024.

The key conclusions from the capacity and demand analyses highlight the following:

- *Fragmentation*: Digital RIs are unevenly distributed across regions and institutions, with historical disparities limiting access for less-resourced communities.
- *Infrastructure bottlenecks*: Persistent challenges in connectivity, power supply, and data infrastructure critically undermine research capacity.
- *Human capital deficits*: There is a shortage of skilled personnel for developing, managing, and using digital RIs. Tailored training and capacity building must be prioritized.
- *Sustainability issues*: Most RIs rely on ad hoc, project-based funding models that are not scalable. Long-term investment strategies and diversified funding mechanisms are needed.
- *Limited coordination*: There is a lack of shared governance frameworks and federated models that can enable cooperation and interoperability across countries and sectors.

To address these issues, the following recommendations are proposed for the development of a pan-African Research Infrastructure in Digital Science:

1. *Adopt a distributed and modular RI architecture*: Emulate successful European models from SLICES and SoBigData initiatives, by implementing federated, interoperable testbeds and platforms. This enables each country to contribute and benefit according to its capacities while ensuring continent-wide coverage and alignment.
2. *Design with use-case and impact in mind*: Ensure infrastructures address locally relevant challenges, such as health, agriculture, and climate adaptation, and support experimental validation in real-world African contexts.
3. *Strengthen governance and legal frameworks*: Develop governance models inspired by ERIC-type structures that support transparency, multi-stakeholder engagement, and scalability. These must be adapted to the African political, legal, and institutional contexts.
4. *Ensure sustainability*: Incorporate detailed sustainability planning, including funding models that combine national budgets, international cooperation, and public-private partnerships. Explore user-based revenue streams for service access.
5. *Develop capacity building*: Establish training academies and curricula based on layered, modular models tailored to different user groups, from early-career researchers to technicians and policymakers.

6. *Community engagement*: Develop strong engagement with local research communities and the private sector to facilitate infrastructure development. To involve relevant research communities in the co-design of the research infrastructure. Organise consultation workshops and forums to facilitate the exchange of ideas and needs.
7. *Promote Open Science*: Align the African RI with FAIR principles and open science policies, fostering transparent, inclusive, and ethically responsible research.
8. *Develop lightweight blueprints and deployment templates*: Provide adaptable technical references that can guide the progressive deployment of local infrastructures, especially in low-resource or high-need contexts. This lowers entry barriers and accelerates implementation.
9. *Enable cross-country coordination and interoperability*: Promote the standardization of interfaces, data formats, and access protocols to support collaborative experimentation and cross-border innovation.

The implementation of these recommendations will be critical in shaping the next steps of DIGITAfrica and the broader objective of establishing a pan-African digital science RIs.

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