Smart Cities and the Fourth Industrial Revolution

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Our mandate

CSIR MANDATE

"The objects of the CSIR are, through **directed** and **particularly multi-disciplinary research** and **technological innovation**, to foster, in the national interest and in fields which in its opinion should receive preference, **industrial** and **scientific development**, either by itself or in **co-operation with principals** from the **private** or **public sectors**, and thereby to contribute to the **improvement of the quality of life** of the people of the Republic, and to perform any other functions that may be assigned to the CSIR by or under this Act."

(Scientific Research Council Act 46 of 1988, amended by Act 71 of 1990)

CSIR
our future through science

CSIR mandate unpacked

Better utilisation of the resources of the Republic

Manpower training to improve productive capacity of its population

Improvement of technical processes and methods to improve industrial production

The promotion and expansion of existing, as well as the establishment of new industries

CSIR
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Vision and mission

VISION

We are accelerators of socio-economic prosperity in South Africa through leading innovation

MISSION

Collaboratively innovating and localising technologies while providing knowledge solutions for the inclusive and sustainable advancement of industry and society

CSIR
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Strategic objectives

- Conduct research, development and innovation, localise transformative technologies and accelerate their diffusion
- Collaboratively improve the competitiveness of high impact industries to support South Africa's re-industrialisation
- Drive the socioeconomic transformation through RD&I which supports the development of a capable state
- Build and leverage human capital and infrastructure
- Diversify income, maintain financial sustainability and good governance

CSIR research clusters

Priority industries | **Priority technologies**

Industry competitiveness | **R&D opportunities**

1
Future Production
Chemicals
Establish biochemical and pharmaceutical platforms to create a dynamic African chemical industry

2
Future Production
Manufacturing
Strengthen manufacturing value chain to support Industry 4.0

3
Future Production
Mining
Support the growth and revitalisation of the mining industry

4
Advanced Agri & Food
Innovate to strengthen agro-processing and rural agro-production sectors

5
NextGen Health
Develop interoperable Health Information Systems for patient-centric healthcare delivery

6
NextGen Enterprises & Institutions
Enable the transition of public institutions into a digitalised era to support public service delivery and business

7
SMART Logistics
Enable South Africa to be a global leader in the provision of a fully integrated logistics sector

8
SMART Places
Effect smarter infrastructure and service developments to enable competitive manufacturing environments and sustainable economic growth

9
Defence & Security
Build resilient defence and security capabilities for South Africa's borders, while fostering cybersecure platforms to conduct business

4IR Capability embedded in all clusters

Enabling capabilities

Global Urban Challenges

Top urban challenges facing cities around the world

North America
1. Climate change
2. Environment resource management
3. Social inclusion
4. Mobility
5. Water

South America
1. Economic development
2. Climate change
3. Mobility
4. Environment resource management
5. Urban planning

Europe
1. Social - Migration
2. Climate change
3. Economic development
4. Demographic change
5. Environment resource management

Middle East & North Africa
1. Water
2. Safety & Security
3. Innovation & Entrepreneurship
4. Migration
5. Environment resource management

Sub Sahara Africa
1. Water
2. Economic development
3. Innovation & Entrepreneurship
4. Safety & Security
5. Environment resource management

Asia
1. Urban Planning
2. Environment resource management
3. Climate change
4. Water
5. Mobility

Oceania
1. Climate change
2. Environment resource management
3. Economic development
4. Investment climate
5. Power/ Energy

Source: World Economic Forum, Shaping the Future of Urban Development & Services Initiative & PwC Research

Typical Stages of Development for a City

	Rudimentary	Functional	Integrated	Scalable
Urban Services	Basic survival needs met in terms of water, waste, sanitation, & shelter	Power, transportation, healthcare and education needs met	Scalable infrastructure for quality of life, green space, culture & elderly care	Mass transit, advanced education, etc. for economic competiveness
Sustainable Development	Access to basic services Urban poverty alleviation	Energy efficiency, Social cohesion, reuse and recycling	Social safety, prepare for climate change, address ageing	Renewables, green development, address climate change
Technology & Business Models	Limited adoption of technology and few PPPs	Adoption of technology for critical function & enterprise management; PPP frameworks adopted	Truly digital delivery, preemptive services, prescriptive analytics; PPP pipeline available & limited acceptance of disruptive business models for urban services	Process optimized, situation awareness, data-driven decisions; Smart regulations to accommodate disruptive business models
Planning	Unplanned development within administrative areas	Planned development, with siloed planning approach	Metropolitan plans in conjunction with adjoining areas	Integrated planning for administrative areas
Collaboration & Engagement	No/few linkages between people, processes & systems	Linkages between people, with few linkages in processes and systems	Digital collaboration (gov, citizens, private sector, NGOs, academia)	Extensive linkages (people, system, processes) and stakeholder collaboration
Organisation Structures	Structures exist, cites are not empowered or equipped	Structures exist, empowered (in silos) but not equipped	Agile governance structure, adaptive to new operating models	Integrated structures with adequate capacity

Future Characteristics of Cities

Sustainable

Demonstrates balanced accomplishment of social & economic development, environmental management & effective urban governance.

Citizen Centric

Focus on the physical, mental & social well-being of individuals & society, encompassing many factors (life satisfaction, physical health, psychological state, education, wealth, religious beliefs, local services & infrastructure, among others).

Economically Vibrant

Attracts investments, facilitates business, nurtures indispensable assets (its well-educated people), improves productivity, promotes growth and expands opportunities for all stakeholders.

Accessible

All sections of society in an accessible city can live independently and participate fully in all aspects of life. This city ensures that people with special abilities and the vulnerable section of society have equal access to all services provided.

Resilient

Enhances the capacity of individuals, communities, institutions, businesses and systems to survive and adapt while they experience chronic stress and acute shock across health, the economy, infrastructure and environment.

Well Governed

optimally utilizes resources to effectively realize the short- and long-term agenda of its development, while achieving greater transparency in public decision-making and establishing institutional accountability.

Responsive

To consume its available resources in the best way possible, such a city enables all stakeholders to use data collected by digital infrastructure to spot patterns, identify problems and make real-time decisions

Planned

strengthens its local economy by creating a master plan that integrates all urban domains, and offers enough flexibility to make amendments to the plan when external conditions change or when innovative solutions emerge.

Technical Innovations for Emerging Cities

Smart planning and construction

- Multifunctional buildings
- Optimised, high-quality building design, codes and standards
- Mixed-use communities, flexible and shared spaces
- Efficient residential and commercial building management
- Transparent land use planning, monitoring and management
- Integrated, digital planning processes

Sustainable transport and logistics

- Integrated, cost-efficient transport systems
- Shared, ambient and on-demand mobility services
- Low-carbon transport systems, including clean fuels and alternative materials
- Regional mobility and logistics
- Real-time traffic flow management
- Efficient logistics and supply chain monitoring

Clean energy and utilities

- Decentralised and peer-to-peer renewable energy systems
- Advanced energy storage networks
- Operations optimisation, asset monitoring and management
- Intelligent, sensor-based grid management
- Clean energy distribution and accessibility
- Pattern recognition, use modelling and forecasting

Urban health and resources

- Circular economy, resource and supply chain efficiency
- Integrated municipal and industrial waste management
- Waste reduction through sharing economy principles and intelligent packaging
- 'Living' buildings, green spaces and urban food production
- Water quality, management and re-use
- Air pollution sequestration and purifiers

Resilient urban systems

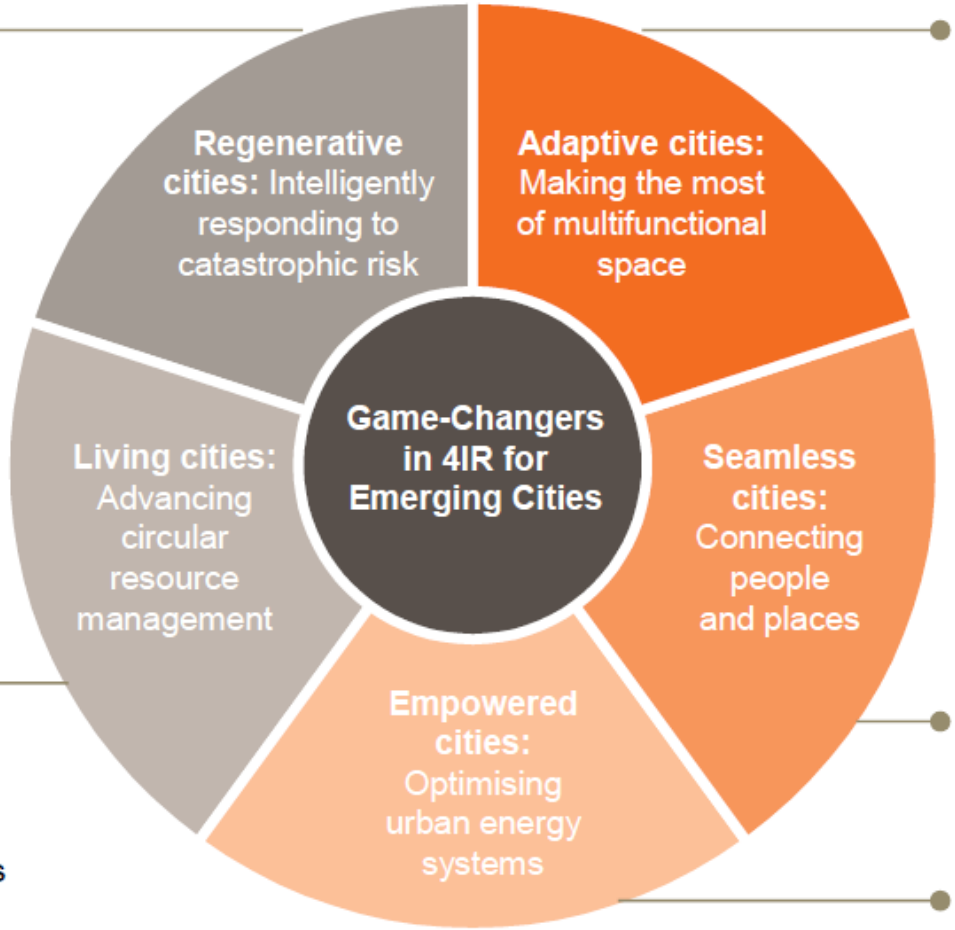
- Smart emergency response systems
- Vendor due diligence and enhanced risk management, monitoring and prediction
- Disaster-ready infrastructure and buildings
- Natural and man-made disaster mitigation, prevention and recovery
- Integrated financial, governance and procurement systems
- Real-time, integrated, adaptive urban management

4IR and emerging cities landscape overview

	Smart planning and construction	Sustainable transport and logistics	Clean energy and utilities	Urban health and resources	Resilient urban systems
3D Printing	• 3D printed buildings and rapid assembly components	• 3D printed cars • On-site and local 3D printing facilities	• 3D printed solar roof tiles • Small-scale wind turbines assembled from printed components	• Intelligent packaging for food and products • Printable sensors to monitor pollution	• Flood, heat, quake and storm-resistant 3D printed structures for shelters and homes
Advanced Materials (including nanomaterials)	• Smart, low carbon and no or low-cement concrete • Heat reducing, super insulating materials	• Advanced battery capability • Advanced carbon fibre composites for light-weight vehicles • Nanotech in fuel cells for cleaner urban air	• Graphene applications for energy generation and distribution • Solar sprays for PV building coatings • Next generation battery technologies	• Pollution absorbing or reducing films, coverings and construction materials	• Smart concrete to reinforce structures and vulnerable assets • Memory metals
Artificial Intelligence	• Machine-automated land-use change detection • Auditory-cue lighting / heating • Optimised sustainable building design	• Optimised transit routes based on traffic flow • Intelligent demand forecasting	• Intelligent energy demand forecasting • Energy usage optimisation	• Reduction in product waste by reviewing meta data on product use • Forecasting of resource intensive and polluting behaviours, patterns of consumption	• Machine-automated disaster risk prediction, monitoring and assessment • Proactive and reactive security intelligence • Traffic rerouting in emergencies
Robots	• Robots for efficient construction • Assisted assembly of pre-fabricated buildings	• Robots for repair of faulty parts and maintenance for optimal efficiency	• Assess health and explore or fix faults in pipes and on grids	• Waste collection and sorting	• Unmanned disaster response support into 'danger zones'
Drones & Autonomous Vehicles	• Drone imagery for land-use planning • Monitoring of human behaviour in the urban environment	• Autonomous vehicles for efficient networks • Drone deliveries	• Drones to monitor and maintain grids and infrastructure assets	• Drones to monitor the urban environment including air quality	• Drone deliveries for disaster response
Biotechnologies	• Living building facades and films • Biomimicry in urban design • Construction bio-materials and -processes	• Synthetic biofuels to ease land constraints • Carbon capture & use • Synthetic trees that clean the air	• Synthetic-based cleaner energy sources	• Bioplastics • Improved microbial waste management	• Biomimicry for flexible structures

	Smart planning and construction	Sustainable transport and logistics	Clean energy and utilities	Urban health and resources	Resilient urban systems
Energy Capture, Storage & Transmission	• Decentralised energy storage for building efficiency	• Advanced energy sources for urban electric vehicles • Next generation battery technologies	• Next generation energy storage • Decentralised grids	• Next generation energy storage for resource efficiency	• Adaptive energy distribution solutions • Mobile emergency power
Blockchain (and distributed ledger)	• Smart construction contracts • Automated planning assessments and approvals • Land registry	• Supply chain tracking and transparency • Automated payment of transport fees to reduce congestion	• Peer-to-peer and decentralised energy systems • Pay-as-you-go, smart meter payments • Net-metering through distributed generation	• Peer-to-peer sharing economy, material reuse and upcycling	• Relief payments
GeoEngineering		• Reducing air pollution		• Mitigating effects of climate change	• Changing weather patterns for disaster avoidance
Internet of Things	• Sensors in and on buildings to optimise construction pollution and operating performance for energy, water, waste and air quality	• Sensor-based traffic flow management • Smart fleet management	• Sensor-based grids and urban networks	• Sensors for pollution monitoring • Sensor-based waste monitoring and transparency	• Sensors to monitor natural hazards
New Computing Technologies	• Super high fidelity building information modelling (BIM)	• Quantum computing for optimal, ultra-efficient logistics and supply chains	• Quantum computing for efficient energy systems and utilities	• High-fidelity pollution tracking and monitoring	
Advanced Sensor Platforms	• Chemical sensors for building materials	• Real time optimisation of freight flow and rail system management	• Advanced sensors for grid management and monitoring	• Advanced nanosatellites to assess and monitor water resources • Biosensors for city-health monitoring and to sort waste for recycling	• Proactive and reactive security
Virtual, Augmented & Mixed Realities	• VR and AR for urban planning and citizen engagement • BIM user experiences	• AR journey experiences • VR meetings	• Virtual power plants • Virtual training for utilities and grid management	• VR/AR/MR experiences for behavioural change in resource use	• VR for disaster simulation • VR-based games for citizen emergency preparedness

4IR Game Changers for Cities



Internet of things
Artificial intelligence
Blockchain
Advanced materials
Advanced sensor platforms
3D printers
Virtual reality

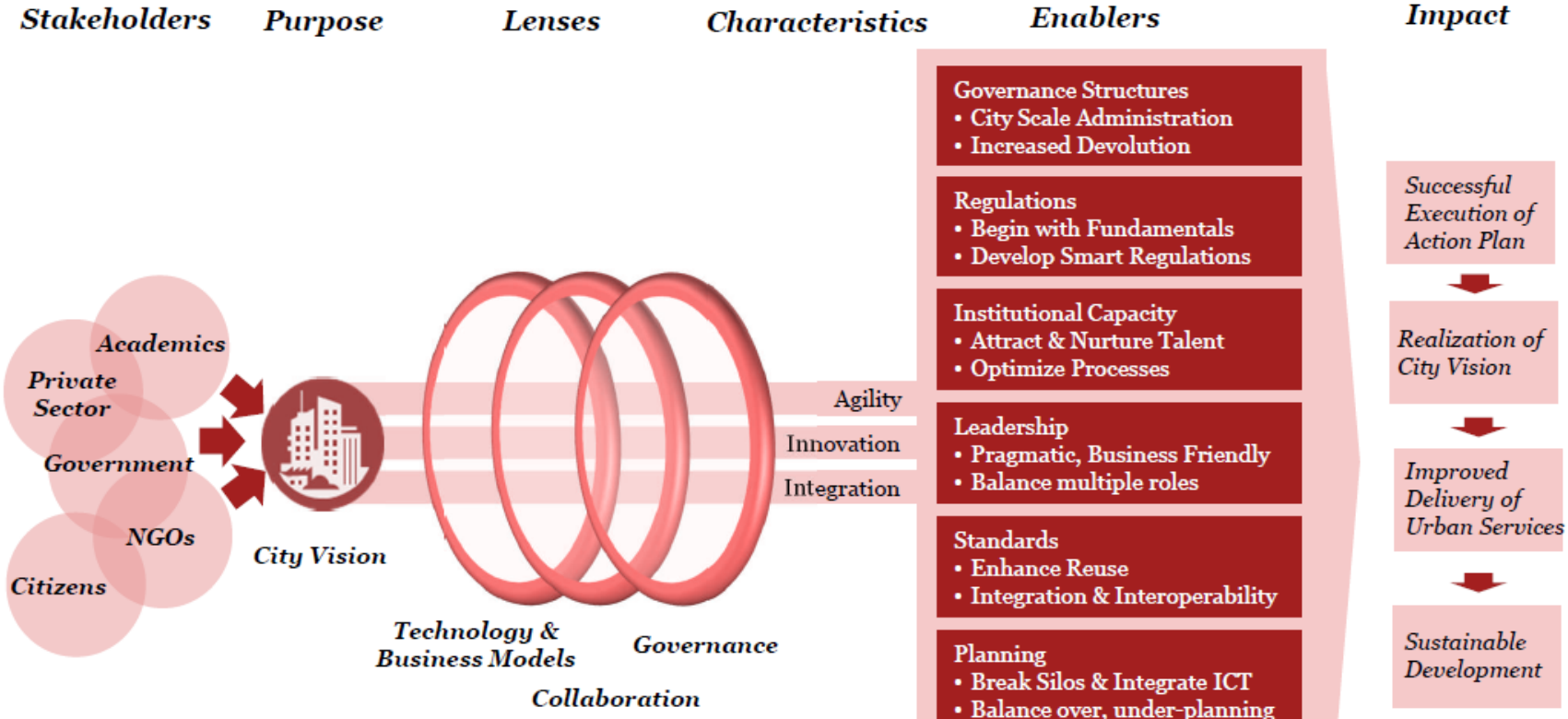
Internet of things
Artificial intelligence
Drones
Bioengineering
Blockchain
3D printers
Robots
Advanced materials
Mixed and augmented realities

Internet of things
Artificial intelligence
Blockchain
Bioengineering
Advanced materials
Advanced sensor platforms
3D printers
Robots

Internet of things
Artificial intelligence
Blockchain
Autonomous vehicles
Virtual, augmented and mixed realities

Internet of things
Artificial intelligence
Drones
Robots
Advanced materials
Blockchain

Achieving the Vision



Risks and challenges of the 4IR transition

Climate and environment

Energy intensity of 4IR technologies: 4IR technologies can help to increase energy efficiency, but their underlying use of energy is a cause for concern (e.g. the power required for Blockchain and autonomous vehicles (AV).

Increased rural-urban migration:

Efficiency and competitiveness gains from 4IR deployment may attract more people to cities for economic opportunities, placing the urban environment under greater pressure, and posing a risk to rural areas that are behind in development.

People and society

Jobs and inequality: The search for better livelihoods remains a driver of rapid urbanisation, but the world of work is changing and increased automation is inevitable as technology use rises. Governments need to ensure that the opportunities and benefits of the 4IR are widely shared within, and between cities, and that the vulnerable and marginalised are not left further behind.

Risks and challenges of the 4IR transition

Skills to implement and use new technologies:
4IR technologies and their applications often require specialist skills, beyond basic digital literacy. In an index of ten global cities' readiness to implement new technologies and current initiatives, Singapore came first, but according to research by PwC Russia, only 42% of its residents surveyed felt ready to use

Human-centred design: The opportunities for operational and environmental improvements through 4IR technologies are often clearly laid out, but endusers can be forgotten.

Cyber security and privacy: As more data on city operations, service providers, businesses and citizens are generated and shared digitally, balancing security and privacy concerns is already a key risk.

Terms of public-private partnerships: Greater data-sharing and collaborative solutions will be required between private-sector and governments to ensure new technologies in the likes of waste, water and transport, are piloted and adopted

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