هيئة تنمية البحث
والتطوير والابتكار
Research Development
and Innovation Authority

Research, Development and Innovation (RDI) in Economies of the Future

INNOVATION OUTLOOK

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EXECUTIVE SUMMARY

The Kingdom of Saudi Arabia is advancing a transformative vision to establish itself as a global leader in Research, Development, and Innovation (RDI), driving economic diversification and building a sustainable knowledge-based economy. Anchored in Vision 2030, KSA's RDI agenda aims to unlock KSA's economic potential, strengthen its global position, and address critical national priorities through cutting-edge science, technology, and innovation.

At the heart of Economies of the Future are three key focus areas: AI and digital technologies, cognitive urban living, and new physical frontiers, such as space exploration and deep-sea research. These focus areas are designed to foster sustainable, diversified growth, redefine urban living, and expand human potential into uncharted domains. By investing in these areas, the KSA is positioning itself at the forefront of global innovation and development.

KSA's strategy aligns with emerging global trends, including advancements in AI, robotics, immersive technologies, and quantum computing. These transformative technologies are reshaping industries and global economies, creating new opportunities for countries prepared to invest in RDI. KSA is proactively leveraging these trends to tackle grand challenges, enhance productivity, and drive long-term economic resilience.

A mission-oriented approach underpins KSA's RDI framework, ensuring focused, measurable outcomes. By addressing grand challenges, rallying ecosystems, breaking down silos, and fostering innovation, this approach unites public and private stakeholders around bold goals. Key missions include developing cognitive cities, achieving net-zero aviation, deploying 6G technologies, and establishing self-sustaining deep-sea and space exploration initiatives.

Functional enablers play a critical role in delivering RDI success in KSA. These include robust funding and investment mechanisms, workforce development initiatives, regulatory reforms, infrastructure enhancement, and fostering linkages across sectors. Grants program have been initiated, and a performance-based institutional funding model will help to enhance the efficiency of fund utilization and maximize impact. By prioritizing these areas, KSA is creating the ideal ecosystem for research and innovation to thrive. KSA's progress in RDI is supported by groundbreaking initiatives and partnerships. Collaborations with global leaders as well as landmark projects exemplify the growing momentum within its innovation ecosystem. These efforts underscore KSA's ambition to lead in transformative industries and secure a competitive edge on the global stage.

Through substantial investments and efforts directed towards future-oriented sectors, KSA is demonstrating its commitment to fostering a thriving innovation ecosystem. Initiatives like the KSA Space Strategy and the development of cognitive cities reflect the KSA's focus on long-term sustainability, enhanced quality of life, and global collaboration. Strategic partnerships between government, academia, and private enterprises are further accelerating this progress. KSA's bold vision for RDI is reshaping its economic landscape and positioning the country as a global leader in the economies of the future. By fostering innovation, leveraging cutting-edge technologies, and investing in transformative projects, KSA is ensuring its long-term prosperity, technological prominence, and leadership in shaping the future global economy.

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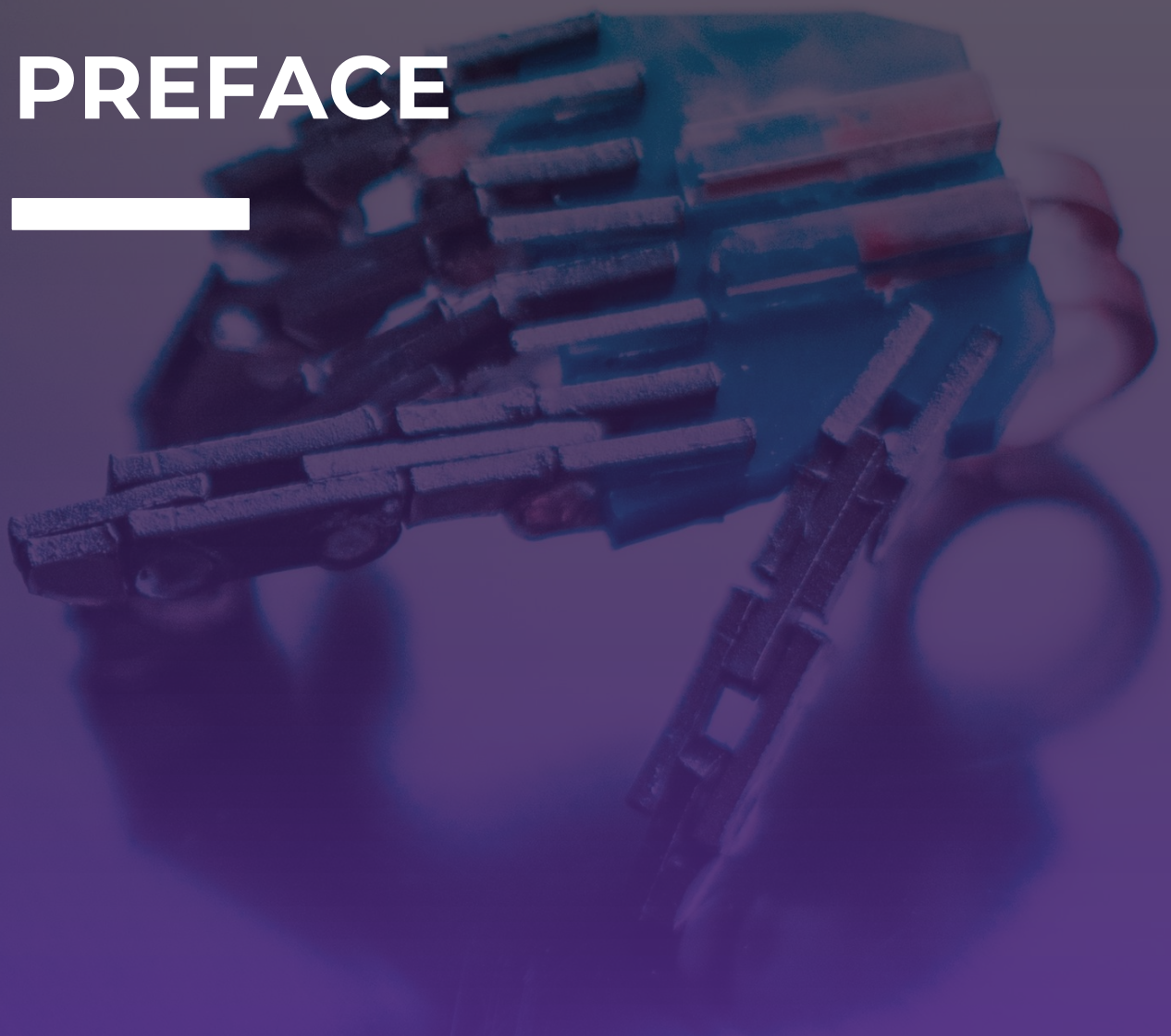
PREFACE



THE URGENCY OF NOW

The Kingdom of Saudi Arabia (KSA) is at a defining moment in its pursuit of innovation, harnessing advanced technologies to shape the future of its economy. Across domains like artificial intelligence (AI), robotics, cognitive cities, deep-sea exploration, space, aviation, and advanced computing, KSA is taking bold steps to lead on the global stage. In a world of rapid technological advancements, this journey reflects KSA's commitment to staying competitive and unlocking transformative opportunities.

The progress is already visible in groundbreaking projects. KSA is setting global benchmarks with its futuristic, sustainable infrastructure, becoming a global model for smart and cognitive cities. Jeddah and Medina are advancing innovative urban projects that blend technology and sustainability, while Riyadh's AI-powered traffic management system is enhancing urban mobility and reducing environmental impacts. The Red Sea project is globally recognized for its leadership in sustainable tourism and marine ecosystem preservation, showcasing how innovation drives economic and ecological harmony.

This momentum extends beyond individual projects. KSA is building an innovation ecosystem that fosters collaboration across industries and sectors. By leveraging cutting-edge technologies and developing pioneering solutions, KSA is positioning itself as a global hub for research, development, and transformative change. Its ability to integrate sustainability, advanced infrastructure, and groundbreaking ideas is setting a new standard for economic and technological progress. KSA's focus on emerging technologies and visionary projects underscores its determination to lead the global economy into a more innovative and sustainable future.

As this journey continues, it is critical for ecosystem stakeholders—research institutions, private sector leaders, and innovators—to join hands in driving impact. These collaborations will amplify progress, align with global advancements, and create opportunities that propel the Kingdom's leadership in emerging industries. With clear ambitions and a proven ability to execute, KSA is charting a path of unparalleled growth and progress.

OUR GUIDING PRINCIPLES

The global landscape for RDI in the Economies of the Future is evolving at an unprecedented pace. There is a relentless emphasis on connectivity, supported by resilience and redundancy, across all sectors. AI and robotics are rapidly transforming every area of the economy. In urban environments, political leaders, the private sector, and academia are collaborating to discover new technologies and practices that can enhance urban living. Furthermore, there is growing recognition that testing and refining technologies in the most challenging environments—such as deep-sea and space exploration—drives innovation to the cutting edge.

The RDI agenda in KSA is guided by a comprehensive set of policy directives that provide a clear roadmap for the future. These policies emphasize stable and increased funding, active participation from the private sector, and the efficient utilization of resources. KSA has already established a robust framework for RDI, exemplified by the creation of the Research, Development and Innovation Authority (RDIA), which plays a central role in coordinating efforts across the public and private sectors, academia, and international partners. These initiatives align with a broader mission-oriented approach that KSA has adopted, focusing on high-impact goals in computing, robotics, urban innovation, and exploration in the sea, air, and space. The guiding principles outlined in this outlook offer a structured and collaborative framework for steering KSA's RDI efforts in the Economies of the Future. The country is not only addressing its own needs but also tackling global challenges. The technologies and solutions developed and deployed in KSA will contribute to the economies of countries around the world. This collaborative approach is not only beneficial for global progress but also aligns with KSA's ambitions to become a global leader in RDI.

RDI ACTION PLAN OF THE KINGDOM OF SAUDI ARABIA

KSA has adopted a mission-oriented approach for RDI. This approach is designed to set clear, achievable goals supported by strong collaboration between the public and private sectors. The mission-oriented plan provides the necessary framework to ensure that all efforts align with the broader strategic objectives of Vision 2030 and beyond, enabling KSA to tackle its most pressing challenges through focused, coordinated, and impactful actions. We have selected ten specific missions that address the Economies of the Future. They revolve around dramatically more computational, robotic, and AI power; employing technologies throughout the urban fabric, and deploying these technologies in frontier environments like the ocean depths and deep space.

These missions will be predominantly executed using technologies that are invented, refined, and commercialized within KSA. The development process will involve knowledge workers from both KSA and around the world, working at laboratories, institutions, startups, and large companies based in KSA. This is the essence of the Kingdom's mission-oriented approach: building a powerful foundation for innovation that drives transformative progress and unlocks new opportunities. This innovation "muscle" will enable KSA to continually tackle emerging challenges with greater efficiency, positioning the country as an even more attractive destination for entrepreneurs globally to build their visionary companies. Additionally, KSA will become an even stronger partner for foreign companies and research institutions seeking collaboration on groundbreaking initiatives.

KSA's focus on Research, Development, and Innovation (RDI) is now being directed towards shaping the economies of the future. **By leveraging targeted interventions across key RDI enablers, KSA is positioning itself to drive economic diversification and technological transformation.** This approach emphasizes the development of emerging sectors such as digital technologies, advanced manufacturing, and renewable energy, ensuring that KSA is at the forefront of global economic shifts. Through these efforts, KSA is not only preparing for the future but actively shaping it.

Central to this plan is a robust framework for RDI funding, specifically designed to accelerate breakthroughs in future-focused industries. Comprehensive talent development programs are also being deployed to build a workforce equipped to lead in cutting-edge fields. Additionally, policies are being crafted to facilitate open collaboration, allowing for the free exchange of ideas and expertise. By fostering an RDI ecosystem that prioritizes innovation in forward-looking sectors, the Kingdom of Saudi Arabia is paving the way for a resilient, diversified economy capable of leading in the next era of global growth.

1. Funding for innovation: Recognizing that funding is critical to a thriving RDI economy, KSA has already established a national research grants program with substantial financial resources to support research projects, primarily at academic institutions. Looking ahead, KSA plans to implement performance-based institutional funding models to improve the efficiency and effectiveness of fund utilization, ensuring that resources are directed toward impactful and high-performing projects.

2. Human capital and talent development: Significant investments are being made to improving STEM education across all student levels. This is complemented by a range of programs aimed at training Saudi engineers and researchers, while also attracting foreign talent to study and work, fostering a diverse and dynamic workforce that aligns with its ambitious vision for a thriving RDI ecosystem and a knowledge-based economy.

3. National regulatory reform: RDI focused economy is also supported and shaped by national policies and regulations. KSA has introduced bold and comprehensive reforms that create a more dynamic and fluid RDI focused economy, facilitating the efficient movement of ideas, capital and talent in KSA, and from the globe into KSA, while enhancing its engagement with global innovators.

4. Infrastructure for innovation: To support innovation, KSA is establishing a strong infrastructure, both in terms of physical spaces and the collaboration platforms needed to sustain it. New programs are creating workspaces, laboratories, and supportive facilities to drive R&D and commercialization efforts aligned with KSA's future economic missions. In parallel, these programs address the supply chain elements across "discover, develop and deploy" areas, necessary to foster innovation.

5. Connectivity and collaboration: A successful RDI economy is a "linked" economy. The people, researchers, institutions, and companies involved must have efficient ways to connect, collaborate, and work together. Often, innovation strategies overlook the "soft" elements of collaboration and connectivity, but KSA has prioritized these linkages.

This comprehensive approach sets KSA on a bold path to establishing a world-class RDI focused economy. By leveraging its unique strengths and developing innovative solutions, KSA is securing a better future for its citizens and setting a global standard in deploying technology for the greater good. This report serves as a testament to the strides KSA is making toward becoming a leader in these critical areas.

02

INTRODUCTION

2.1 The RDI Agenda in the Kingdom of Saudi Arabia

For the Kingdom of Saudi Arabia (KSA), investing in research, development, and innovation (RDI) is essential to driving economic growth, fostering global competitiveness, and stimulating innovation. Nations with robust RDI ecosystems consistently outperform others in GDP growth and economic resilience, underscoring the strong correlation between innovation and prosperity. Moreover, countries that prioritize R&D achieve greater global influence and recognition, further enhancing their international standing. By advancing its RDI initiatives, KSA aims to unlock its economic potential, strengthen its global position and fulfill its long-term strategic objectives.

RDI investments also provide KSA with the tools to address critical national priorities while advancing technology, science, and innovation. These initiatives play a vital role in fostering new industries, supporting economic diversification, and creating high-value job opportunities. Breakthroughs in artificial intelligence, mobility, and digital tech. offer KSA a unique chance to position itself as a global leader in innovation. By leveraging RDI as a catalyst for progress, KSA can unlock untapped opportunities, improve productivity, and transition toward a knowledge-based, sustainable economy.

The present moment marks a pivotal juncture for KSA's RDI journey. Globally, rapid advancements in transformative technologies—such as artificial intelligence, robotics, and clean energy—are revolutionizing industries and shaping the future economy. Leading nations are intensifying their RDI investments to dominate emerging sectors. For instance, the global AI market is projected to grow at a more than 20% CAGR, while sectors like smart cities and space exploration are creating trillion-dollar opportunities. For KSA, acting now is critical to remaining competitive, accelerating Vision 2030 goals, and establishing leadership in the global innovation ecosystem. Timely action will enable KSA to leverage these global trends and secure its long-term economic and technological prominence.

Illustration 1: Pressure is rising to compete at the global stage

Nations are doubling down their RDI plays
Leading economies invest in national RDI programs

17 G20 countries launched RDI strategies

2.4x gap increase in avg. GDP per capita[3]

Pressure on KSA to position itself as a leader in this rapidly expanding global market

20% CAGR of AI market between 2022 and 2029 to reach $1.4Tn+ by 2029[4]

15% CAGR of global smart cities market to reach $870Bn+ by 2026[5]

$1 Tn projected size of Global space economy by 2040[6]

1. Global Innovation Index Report; 2. Soft Power Index and GII; 3. In developed vs. developing nations in 50 years - UNCTAD "Technology and Innovation report 2021"; 4. Fortune Business Insights; 5. MarketsandMarkets; 6. Morgan Stanley

2.2 KSA's national RDI focus areas

2.2.1 Defining KSA's national RDI focus areas

For the realization of the RDI agenda in KSA, as laid out in the previous section, it is essential to introduce focus areas to provide clear direction for RDI efforts. They ensure that resources are effectively allocated, collaborations fostered, and impactful outcomes achieved in alignment with Vision 2030. By defining specific focus areas, KSA can streamline its efforts and avoid fragmentation. Besides enhancing efficiency, this targeted approach amplifies the impact of RDI initiatives, driving comprehensive advancements in key sectors, and ensuring that they contribute meaningfully to national development goals.

Globally, RDI paradigms are shifting towards multi-disciplinary priorities to address pressing challenges. This shift is driven by several key factors. First, it involves mobilizing cross-sectoral and multi-disciplinary capabilities from idea to market, ensuring that diverse expertise and resources are harnessed to tackle complex problems. Second, concentrating and coordinating RDI investments towards measurable goals enables performance management and ensures that funds are used effectively. Creating accountability to facilitate the achievement of RDI priorities is another critical driver, as it ensures that all stakeholders are committed to delivering results.

This targeted, multi-disciplinary approach also enables the realization of national ambitions by synchronizing non-RDI policy and regulatory measures, accelerating the uptake of innovations through demand signaling, and boosting private sector engagement. Improving the communication of goals and impacts ensures that the benefits of RDI efforts are clearly understood and appreciated by all stakeholders.

Illustration 2: 3-step approach was adopted to derive KSA's emerging RDI focus areas

Identified long-list of RDI-relevant national objectives

Cluster RDI-relevant national objectives into priority clusters based on:

- Common cross-disciplinary capabilities
- Cross-sectoral linkages and impact
- Common policy instruments measures

Priorities validated through extensive stakeholder and expert engagement

Illustration 3: Four RDI focus areas for the Kingdom of Saudi Arabia were identified

01

Health and Wellness

- Solve KSA's prevalent medical and behavioral **health challenges**
- Achieve early prevention of diseases **through personalized wellness and healthcare services**
- Disrupt **digital healthcare** to ensure health equity across KSA (based on AI use cases)

02

Sustainability and Essential Needs

- **Sustainably secure supply of water, food and power** to the population and industry (localized food supply)
- Become a global exporter of **advanced water and food techs (e.g., water desalination)**
- Establish KSA as a global paradigm on **environmental conservation** (e.g., coral reefs)

03

Energy and Industrials

- Maintain and extend KSA's **global leadership position in energy** supply
- Establish KSA as a regional hub for **specialty chemical** derivatives
- Ensure hydrocarbon demand sustainability through **advanced non-metallic products and blue hydrogen**

04

Economies of the Future

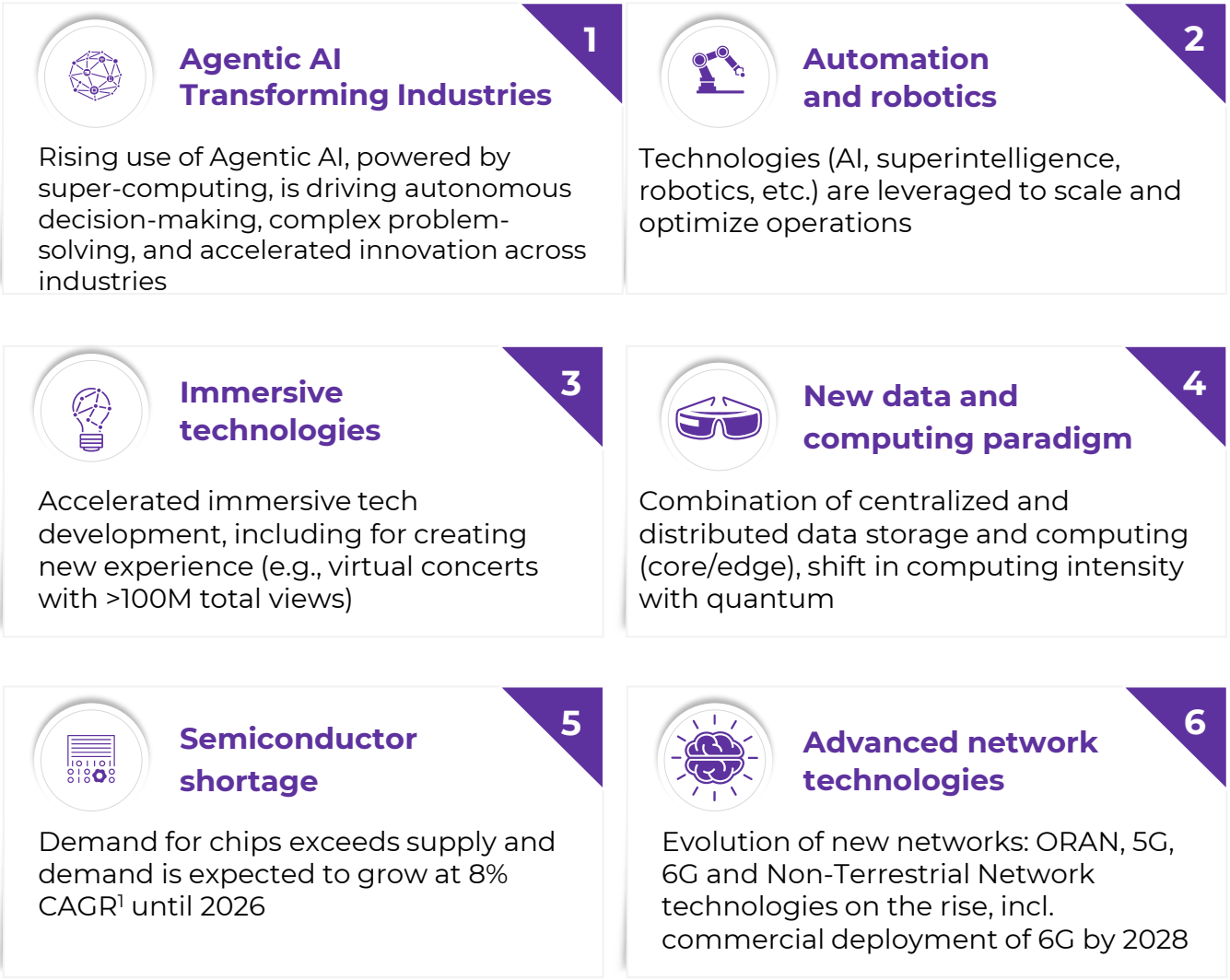
- Foster **digital technology and AI frontiers** in priority sectors to build a regional/ global edge (e.g., AI applications incl. genAI/AGI or semiconductors)
- Reimagine the future of **cognitive urban living** through hyper-connected cognitive cities
- Become a global champion of **new physical frontiers** including space/deep sea exploration

2.2.2 Global trends and the RDI imperative

Research, Development, and Innovation (RDI) are the driving forces behind advancements in digital technologies, which are rapidly transforming global industries. As AI, computing, robotics, and other cutting-edge technologies reshape the world, **RDI plays a crucial role in exploring their potential and overcoming challenges.**

The **convergence of digital technologies,** such as AI, IoT, and immersive realities, **is creating new opportunities and challenges that RDI must address.** The ongoing commitment to RDI in these areas will be essential in shaping the future, as it drives the creation of solutions that can tackle complex problems, enhance human capabilities, and improve quality of life on a global scale.

Illustration 4: Key trends in AI and digital



The rising trend of Agentic AI is revolutionizing automation by enabling AI systems to autonomously plan, execute, and adapt to complex tasks with minimal human intervention. Powered by AI supercomputing, these intelligent agents are accelerating decision-making, problem-solving, and innovation across industries, reshaping the future of work and technology.

These technologies are essential for supporting AI-driven applications, smart cities, and autonomous systems. With the global 6G market projected to reach $340 billion[1] by 2040, KSA's investments in advanced network technologies position the country to lead the way in next-generation connectivity.

Source: 1. Precedence Research

Building upon the network infrastructure, automation and robotics are leveraging these advancements to scale and optimize operations across industries. AI-powered robotics are enhancing efficiency, precision, and productivity, transforming manufacturing, logistics, healthcare, and more. In smart factories, industrial robots are driving automation, while robotic-assisted surgeries in healthcare are improving patient outcomes. As KSA works to localize its robotics value chain and expand robotics adoption, these technologies will become integral to the nation's long-term competitiveness and productivity across sectors.

Another key component in this interconnected landscape is the rise of immersive technologies. With the development of AR, VR, and MR, immersive experiences are reshaping the way individuals interact with digital content. Whether it's virtual concerts that attract over 100 million views or advanced VR training solutions in the workplace, these technologies are becoming essential in creating more engaging and realistic user experiences. The global AR/VR/MR market is forecasted to grow from ~$100 billion in 2024 to $600+ billion[2] by 2029, driven by increasing demand across entertainment, healthcare, real estate, and retail sectors. KSA's focus on fostering immersive technologies presents a major opportunity to create innovative digital experiences and establish itself as a hub for alternative reality and related innovations.

As the complexity of digital systems grows, new data and computing paradigms are emerging to address the increasing demand for data processing and storage. The shift towards a combination of centralized and distributed data systems, including edge computing and quantum technologies, is crucial to enabling the real-time processing and analytics required by AI applications and autonomous systems. Edge computing reduces latency and enhances real-time decision-making by processing data closer to its source, while quantum computing, expected to generate up to $850 billion[3] in economic value by 2040, offers unprecedented computational power that will revolutionize industries like cryptography and materials science. KSA's investment in both edge and quantum computing technologies will enable the country to be at the forefront of data-driven innovation, paving the way for breakthroughs in multiple sectors.

However, the rapid development of these technologies is also being shaped by external factors, such as the global semiconductor shortage. Semiconductors are the building blocks of modern digital systems, underpinning everything from smartphones and vehicles to AI-powered systems and IoT devices. The shortage, driven by supply chain disruptions and increasing demand for consumer electronics, highlights the importance of securing a stable supply of semiconductors to sustain digital transformation efforts.

The evolution of network technologies serves as the backbone of this transformation, providing the infrastructure required to support other emerging technologies. With Open Radio Access Networks (ORAN), 5G, and the commercial deployment of 6G by 2028, KSA is at the cusp of a new digital era. Non-terrestrial networks (NTNs) such as Low Earth Orbit (LEO) satellites and High-Altitude Platform Systems (HAPS) further complement terrestrial broadband, enabling more robust, scalable, and ubiquitous network access.

Source: 1. Market Research Future; 2. Mordor Intelligence; 3. BCG Quantum computing perspective (2024)

The semiconductor market is projected to grow at 9-11% CAGR (2025-2029)[1], offering a significant opportunity for KSA to build resilience by investing in semiconductor manufacturing capabilities and strengthening partnerships with global chipmakers. By doing so, KSA can safeguard the continuity of its AI and digital transformation strategies, ensuring that the critical infrastructure required remains accessible.

Finally, next-generation connectivity, such as 5G and the forthcoming 6G, is set to revolutionize global communication networks by providing ultra-fast, low-latency connections. These advanced networks support a wide range of applications, from autonomous vehicles to smart cities, ensuring seamless global connectivity. Global 5G subscriptions are expected to reach nearly 5 billion+[2] by 2029, accounting for 60% of all mobile subscriptions at that time. Additionally, 6G is expected to deliver speeds up to 50 times faster than 5G[3], with key advancements such as AI-driven network optimization and terahertz frequency utilization. 6G will enable unprecedented real-time interaction between humans and machines, making it critical for applications such as immersive extended reality (XR), holographic communication, and space-based internet infrastructure. The 6G era will usher in a new wave of hyper-connected devices, with applications in sectors such as advanced healthcare, autonomous transportation, and beyond.

Illustration 5: Key trends in cognitive urban living

1 AI-driven urban innovation

RDI in AI and machine learning is enabling smarter, more efficient urban management through predictive and adaptive technologies.

2 Sustainable and green urban technologies

Research in sustainability is driving the development of green technologies, renewable energy systems, and eco-friendly infrastructure for climate-resilient cities.

3 Smart mobility research

RDI is advancing autonomous vehicles, AI-driven traffic systems, and green transport solutions to improve urban mobility and reduce emissions.

4 Digital twins and urban simulation technologies

Digital twin technology is transforming urban planning by allowing real-time simulations and data-driven decisions to optimize city development and operations.

5 Urban health tech and biotechnology integration

RDI in biotechnology and health tech is enhancing urban healthcare systems with innovations like AI-powered diagnostics, biosensors, and biophilic designs that promote well-being.

Source: 1. Statista market forecast on Semiconductors; 2. Ericsson 5G Market report; 3. Financial Times

AI-driven urban innovation is revolutionizing how cities manage resources, infrastructure, and services, through breakthroughs in artificial intelligence and machine learning. Innovative AI applications are empowering cities to implement predictive and adaptive technologies that optimize urban planning, manage traffic, enhance energy distribution, and ensure public safety. These advancements allow cities to become more responsive and agile, with real-time decision-making driving greater efficiency and resilience. As cities adopt more AI-driven solutions, they open doors to continuous innovation, from autonomous city operations to more personalized urban services, marking a transformative step in future urban living.

But AI innovation alone cannot create the cities of the future. As AI-driven systems enhance urban intelligence, sustainable and green urban technologies are innovating to ensure these advancements are environmentally responsible. Sustainable urban innovation is reshaping cities as urban green spaces, climate-resilient infrastructure and green buildings are on the rise. Global green buildings market expected to reach $1.1 trillion[1] by 2029. The need for investing in climate-resilient infrastructure is significant, as climate change is estimated to cause global average annual loss (AAL) in infrastructure, including buildings, of around $700-$800 billion[2]. Ambitious net-zero emissions targets are being set to address climate change, with implementation of green regulations at municipal level, supported by efficient recycling programs to manage urban waste.

Innovation in smart mobility solutions is also essential to the future of cities, as populations grow, and mobility demands increase. The integration of smart infrastructure and services is revolutionizing urban environments by leveraging advanced technologies to enhance connectivity, efficiency, and sustainability. Innovations like intelligent traffic management, smart parking, and energy-efficient grids are driving this change. The global smart infrastructure market is projected to reach $1.4 trillion by 2030 at a CAGR of ~20% from 2024 to 2030[3], driven by the increasing demand for smart city solutions that are designed to optimize resource use, lower operational costs, and enhance the quality of life for city residents.

As these innovations take hold, the future of urban planning is being shaped by digital twin and urban simulation technologies. Innovation in digital twin technology is allowing cities to create advanced virtual models of their infrastructure and services, enabling real-time simulations that optimize development, resource management, and urban resilience. Cities can now simulate the impact of new projects, predict infrastructure wear and tear, and improve the efficiency of resource distribution. This innovation-driven approach ensures cities can plan smarter, adapt faster, and thrive in a future defined by continuous change.

Lastly, future cities will merge biotechnology and health-tech innovations into urban life, with AI-driven diagnostics and smart healthcare systems embedded in public spaces for real-time health monitoring. Autonomous health services, such as drone-based medical deliveries, will improve emergency response, making cities healthier and more resilient environments.

Source: 1. Mordor Intelligence; 2. Biennial Digital Report CDRI; 3. Grand View Research

Illustration 6: Key trends in new physical frontiers

1 Agile spacecraft designs

Increasing use of SmallSats, advanced systems, and innovative engineering and production methods to enhance efficiency

2 Launch system advancements

Diverse range of launchers, including new micro and super-heavy models, with innovations like serial production and reusable technologies, are revolutionizing space access

3 Privatizing space investment

The influx of risk capital, aimed at high returns, is driving the privatization of space financing. New public policies are fostering private sector innovation, accelerating growth in the space industry

4 Deep sea mining

Utilizing advanced technologies to extract critical minerals, meeting resource demands while addressing environmental concerns

5 Data explosion of AI/ML innovations

The rapid growth of data, AI/ML technologies, and emerging space services is driving a surge in new opportunities. Ambitious exploration initiatives are further fueling this boom in space-based services

The adoption of agile spacecraft designs, particularly through the use of SmallSat alternatives, is reshaping the space industry. SmallSat, which include miniaturized satellites like CubeSats, offer cost-effective, flexible solutions for a variety of missions. Combined with advanced systems and innovative engineering practices such as 3D printing and modular construction, these designs allow for faster development and mission adaptability. This trend is driving down costs and enabling more frequent launches to meet the rising demand for space-based services. Global small satellite market estimated at ~$5 billion in 2024, projected to reach $11 billion+[1] by 2029 at a CAGR of 16-18% from 2024-2029[2]. The diversification of launch systems, including the development of small launchers and super heavy-lift launchers, is significantly enhancing access to space.

Source: 1. Markets and Markets; 2. Mordor Intelligence

Micro-launchers, designed for smaller payloads, provide more flexibility, while super-heavy launch vehicles enable ambitious missions, such as deep space exploration. Additionally, serial production and reusable technologies are reducing the cost of space access and increasing the frequency of launches, making space more affordable for a wide range of missions. Global reusable launch vehicles market estimated to reach $5 billion+ by 2029, up from $3 billion+[1] in 2024.

The commercialization of space reflects a growing interest in space as a domain for business and innovation. Companies are increasingly investing in space ventures, from satellite technology to space tourism, driven by the potential for new markets and revenue streams. Private markets firms invested $12.5 billion into space companies[2] in 2023, a 30% jump from the prior year. The global space economy is expanding due to increased availability of space-based technologies like satellite communications, GPS, and Earth observation services. These advancements are driving growth as more sectors and industries can access and benefit from these capabilities.

Deep sea mining involves the extraction of valuable minerals and metals from the ocean floor, often at depths of several hundred to thousands of meters. These resources include critical materials and rare earth elements, which are essential for industries such as electronics, renewable energy, and battery production. As terrestrial sources of these materials become increasingly scarce, deep-sea mining presents a potential alternative. Advancements in mining technologies, coupled with the rising demand for critical minerals, is fueling the push for deep-sea mining. The market for marine mining is growing rapidly, with global deep-sea mining expected to reach $15 billion+[3] by 2030, up from ~$650 million in 2020.

Disruptive technologies like AI/ML are transforming industries such as space and deep-sea exploration by introducing groundbreaking innovations that redefine operational possibilities. The rapid expansion of services is being fueled by the explosion of data and advancements in AI/ML technologies, creating new opportunities in space and other sectors. AI/ML is transforming vast data into actionable insights, driving innovation and growth. This convergence supports ambitious exploration efforts and unlocks new commercial possibilities in the space industry. Real-time data analysis is enabling more efficient operations and cutting-edge solutions. By 2033, the global space technology market* is expected to reach $900 billion+ from ~$440 billion[4] in 2023 growing at a CAGR of 7-9%.

The exploration of new physical frontiers, such as space and the deep sea, is increasingly driven by global collaboration and sustainability initiatives. International partnerships between space agencies, private companies, and research institutions are accelerating progress by pooling resources, expertise, and technologies. In deep-sea exploration, sustainable practices are gaining prominence, with a growing emphasis on minimizing environmental impact. Meanwhile, breakthroughs in autonomous underwater vehicles (AUVs) and space rovers are expanding the capabilities of exploration missions, enabling access to previously unreachable environments. These trends reflect a shared global vision to unlock the immense potential of these uncharted territories while addressing the challenges associated with their exploration and utilization.

Note:*This market includes satellite communications, weather forecasting by satellites, earth atmospheric observation, navigation systems, space tourism, and space exploration
Source: 1. Mordor Intelligence; 2. Space Capital; 3. Global Mining Review; 4. Expert Market Research

The global significance of RDI in Economies of the Future is underscored by substantial investments and groundbreaking initiatives worldwide. Countries and international organizations are increasingly recognizing the critical role of RDI in exploring space and deep-sea, transforming urban living, and enabling digital and AI adoption. These efforts are crucial for driving innovation and achieving long-term sustainability goals.

By 2030, market size of 17 frontier technologies* such as artificial intelligence, Internet of Things is expected to reach over $9.5 trillion. According to UNCTAD readiness index ranking of 166 countries based on five building blocks**, US tops the index followed by Sweden and Switzerland. China, the most-ready developing country, ranked 35, followed by Brazil (40), India (46) and South Africa (56).

Cities are evolving into smart and cognitive environments that can adapt and respond in real-time to residents' needs, driving sustainability and resilience. The World Bank invests an average of $5-6 billion in planning and implementing lending projects on sustainable cities and communities every year to help cities meet the critical demands of urbanization.[1]

In 2023, global government expenditure for space programs hit a record of ~$117 billion. US Government spent around $73 billion on its space programs in 2023, making it the country with the highest space expenditure in the world. The US was followed by China, with government expenditure on space programs of over $14 billion. Space technology will help in monitoring the effects of climate change, warn of impending natural disasters and improve humanitarian response when they strike. In 2022, global research and development spending on aerospace and defense was € 21 billion+ (~US$23 billion***) with US being the highest spender followed by EU.

Illustration 7: Countries around the world are focusing on RDI initiatives in Economies of the Future

South Korea K-Network 2030 strategy[4]	Released in February 2023, aims at building state-of-the-art communication networks and making South Korea an ICT and Internet superpower. South Korea plans to launch the commercial service of 6G network in 2028 (two years earlier); feasibility study for R&D worth ~$480 million under way
EU Quantum Technologies Flagship[3]	The Quantum Technologies Flagship, launched in 2018, is a long-term research and innovation initiative that aims to support the work of hundreds of quantum researchers over 10 years, with an expected budget of €1 billion from the EU
UK National AI strategy[1]	Launched in 2021, UK's National AI Strategy sets out a 10-year vision for the UK and AI. It aims to invest in long-term needs of the AI ecosystem, support the transition to an AI-enabled economy ensuring AI benefits all sectors and regions and ensure effective AI governance to foster innovation
Singapore Smart Nation[5]	Led by the Ministry of Digital Development and Information (MDDI), the Smart Nation initiative, launched in 2014, introduced a wide range of smart technologies in both its public and private sectors. It aims to create a city powered by digital innovation and technology that responds to citizens' ever-changing needs
France Deep Sea project[8]	France has announced the allocation of €25 million in funding for its Deep Sea Project, a multi-faceted research mission, it will cover areas such as the development of innovative deep-sea equipment – underwater drones, autonomous submersibles, robotic systems and sensors

Note * 17 frontier technologies: Artificial intelligence, Internet of Things, Big Data, Blockchain, 5G, 3D printing, Robotics and Drone technology, Gene Editing, Nanotechnology, Solar photovoltaic, Concentrated Solar Power, Biofuels, Biogas and Biomass, Wind energy, Green hydrogen, Electric vehicles; ** five building blocks : ICT deployment, skills, research and development (R&D) activity, industry activity and access to finance, UNCTAD 2023; *** Converted from Euro to USD using exchange rate as of 30 dec 2022 from Oanda

1. Sourced from Digitimes Asia, July 2023 and The Korea Times 2023; 2. Sourced from European Commission; 3. Sourced from Gov.uk; 4. Sourced from Thales, Feb 2023; 5. Sourced from The Deep Sea Project: France to invest €25 million in seabed exploration, Apr 2024

2.2.3 Key challenges in Economies of the Future

The Kingdom of Saudi Arabia is actively pursuing advancements in its digital and AI space, future of urban living, and new physical frontiers, yet it still faces challenges across these domains. In the digital and AI sector, KSA must continue to advance infrastructure at scale, as well as investment, and talent development to enhance its global competitiveness. Nascent space and deep-sea exploration sectors still have a reliance on foreign technology and limited domestic capabilities. Similarly, in the realm of future of urban living the need for more robust technology deployment must be overcome to fully realize the potential of smart urban living in KSA. These challenges reflect both the complexities of developing new industries and the need for strategic coordination and investment to achieve KSA's ambitious goals.

KSA is currently navigating several important challenges

KSA is making remarkable progress in its journey toward becoming a global leader in the digital and AI economy. While there are still areas of opportunity, such as digital infrastructure, technology, artificial intelligence (AI), and data management, KSA is well-positioned to address these challenges and capitalize on emerging growth prospects.

KSA was facing challenges related to the growth of digital infrastructure, but in recent years, KSA's digital infrastructure has advanced significantly and continues to evolve rapidly. KSA is poised for significant data center expansion, with plans to exceed 1,000 megawatts (MW) over the next five years. The current capacity in 2024 stands at approximately 250-300 MW, with ~40% located in Riyadh[1]. By increasing investment in large-scale data centers (1GW+) and distributed computing power, KSA can better meet the growing demand for scalable digital services and further enhance its position in the global digital landscape. Additionally, there is an opportunity to boost content localization and strengthen digital infrastructure. The country's 5G adoption, though growing, still lags leading nations, highlighting the need for faster network expansion and improved connectivity.

In the technology sector, the Kingdom is building a strong foundation for an innovation-driven ecosystem. Current investment in venture capital (VC) and growth private equity (PE) is lower as compared to that in top global players. However, this reflects a significant opportunity for growth as KSA continues to foster innovation and expand its tech workforce. KSA's technology exports, particularly in hardware, present another area of growth. The technology trade deficit also indicates potential for expanding tech exports. Significant efforts are being taken to increase the increase the technology exports.

KSA is currently navigating several important challenges as it continues to strengthen its position in the global digital and AI economy. While the country has made impressive strides in expanding digital infrastructure, fostering innovation, and advancing AI capabilities, there are still areas that require further development. Ensuring greater adoption of emerging technologies, increasing the integration of AI across industries, and expanding the digital economy's contribution to national growth are key areas of focus.

At the same time, enhancing the local technology ecosystem, strengthening knowledge transfer, and fostering a more robust startup and entrepreneurship culture will be critical for long-term success. Efforts are already underway to accelerate AI-driven research, support digital transformation across sectors, and create a strong pipeline of skilled talent. With these ongoing initiatives and a commitment to innovation, KSA is well-positioned to capitalize on future opportunities and establish itself as a leader in the global digital landscape.

Source: 1. GAIN Summit report on "State of AI in Saudi Arabia", Argaam;

In the field of AI, KSA has demonstrated impressive momentum and a clear strategic direction, although there are areas where further development is needed to fully align with global leaders. Saudi Arabia's AI landscape continues to evolve, with notable advancements in infrastructure, policy frameworks, and industry adoption. While efforts have accelerated in areas like high-performance computing (HPC) expansion, AI governance, and research funding, further integration across sectors remains a key priority. Ensuring a cohesive AI adoption strategy, fostering stronger public-private partnerships, and expanding domain-specific AI applications will be instrumental in scaling AI's impact across industries.

Additionally, the Kingdom's investment climate for AI startups and enterprises is strengthening, but there remains room for expanding funding mechanisms, increasing access to R&D grants, and enhancing investor confidence in AI-driven ventures. RDIA is actively supporting AI-focused and AI-integrated projects through targeted R&D grants, fostering innovation, accelerating commercialization, and strengthening the broader AI ecosystem in alignment with national strategic priorities.

By creating a more supportive ecosystem for AI commercialization, talent attraction, and industry collaborations, Saudi Arabia is reinforcing its position as a regional leader in AI innovation and digital transformation. The establishment of the Saudi National Company for AI as a national AI champion and AI-enabling policies are strong steps in this direction, and further efforts will help solidify KSA's position as a global leader in AI. While KSA's data privacy regulations are among the strictest globally, creating a solid foundation for data governance, the development of a comprehensive economic value framework for data could help harness data as an economic asset. Data quality and accessibility remain areas of focus, with the National Data Catalog seeing initial adoption of more than 30 entities, strong progress is being made, with multiple datasets published as part of KSA's open data policy.

KSA is making strides towards the development of cognitive urban living, with few areas of development to fully realize its vision. While there have been significant efforts in laying the groundwork for cognitive urban living initiatives, these efforts have the potential to be further harmonized and integrated at the national level.

KSA has made impressive strides in smart city development and continues to build on its successes. The country's strong digital infrastructure is a key enabler of smart city initiatives, ranking #14 on the Mobile Speedtest Index[1]. Cities like Riyadh and Medina have also gained global recognition, ranking #30 and #73 respectively on the IMD Smart City Index, reflecting the potential of KSA's cities to become leaders in smart urban living. There are opportunities to further enhance smart city development, particularly in the areas of funding mechanisms and private sector engagement.

KSA has made substantial progress across digital infrastructure, technology, AI, and data management, positioning itself as a rising leader in the digital economy. While challenges remain, particularly in areas such as infrastructure, investment, talent development, and data governance, these challenges represent significant opportunities for growth. With continued strategic efforts, KSA is well on its way to enhancing its global competitiveness in these crucial sectors.

Saudi Arabia has made significant progress in expanding its digital infrastructure to support its ambitions in AI, cloud computing, and smart technologies. However, as digital transformation accelerates, the demand for scalable, high-performance infrastructure continues to grow. Ensuring widespread access to fast and reliable connectivity, expanding cloud computing capabilities, and strengthening data storage networks remain areas of focus. The country is already addressing these challenges by investing in next-generation digital hubs, fostering collaborations with global technology leaders, and streamlining policies to enhance digital readiness. With these ongoing efforts, Saudi Arabia is steadily reinforcing its position as a regional powerhouse in digital connectivity and innovation.

Source: 1. Speedtest index

While efforts are being made to encourage collaboration within the smart city ecosystem, clarifying funding allocation and increasing private sector participation will be critical for scaling smart city projects sustainably. The rollout of key technologies such as Closed-Circuit Television (CCTV) systems and sufficient computing power to support advanced smart city use cases also presents an area for further development.

National and sectoral platforms like Smart C, Sawaher, and Balady are emerging, and there is potential to develop more robust city-level platforms for effective integration and management of smart city services. KSA is also seeing progress in smart municipal services, such as the Balady app, designed to address challenges like visual pollution. However, the effectiveness of these services varies across different cities, signaling an opportunity for a more unified approach.

Overall, KSA has laid a strong foundation for cognitive urban living. By building on its successes and addressing opportunities in technology deployment and collaboration, the country is well-positioned to close the gap with leading nations and fully leverage the potential of smart cities to enhance urban living.

The pursuit of new physical frontiers represents some of the most ambitious and cutting-edge initiatives within the Economies of the Future. For KSA, these areas are relatively nascent, not only within the Kingdom but on a global scale. The challenges faced in pushing these physical boundaries are inherently tied to the early stages of development in these fields. This focus on emerging activities means that KSA is dealing with challenges that are less about fixing existing problems and more about building capabilities from the ground up. As KSA ventures into these domains, several challenges have emerged that require strategic attention. The challenges faced are tied to two primary issues: human capabilities and foreign reliance. One of the major challenges is the limited availability of skilled professionals. KSA's space workforce needs to grow to match the ambition of being on par with leading nations in the field of space. Additionally, there are emerging academic programs and scholarships available for students in space-related disciplines. More investments are needed in education, such as creating specialized degree programs and providing scholarships to encourage more students to pursue careers in space and marine sciences.

KSA also currently relies on international partnerships for activities such as satellite manufacturing and launch operations. For example, KSA partnered with Lockheed Martin to manufacture and launch its geostationary communications satellite, SaudiGeoSat-1, and with Arianespace for other satellite launches. While these partnerships are vital, KSA plans to develop more domestic capabilities to reduce its reliance on foreign expertise and infrastructure. This includes fostering a local ecosystem of space technology manufacturers and service providers. In the context of deep-sea exploration, partnerships with international marine research institutions have been crucial, but domestic initiatives and local expertise need to be expanded to maintain long-term growth and self-sufficiency in these sectors.

These challenges are not insurmountable. They reflect the growing needs of a nation that is boldly stepping into new realms of exploration and innovation. As KSA continues to invest in these sectors, overcoming these challenges will be crucial to establishing itself as a global leader in space and deep-sea exploration.

As the digital economy grows, ensuring cybersecurity, regulatory alignment, and data governance is crucial to sustaining momentum. Strengthening digital security frameworks, optimizing cloud infrastructure, and developing regulatory sandboxes are critical steps toward achieving a secure and well-regulated digital landscape. Efforts are already underway to align policies with global best practices, establish digital trust frameworks, and enable seamless data exchange, ensuring that businesses and individuals can operate with confidence in a digitally driven environment. With these proactive measures, Saudi Arabia is well-positioned to lead in the digital and AI-driven economy, fostering an ecosystem that is both innovative and resilient.

2.2.4 Strong momentum and key opportunities

The Kingdom of Saudi Arabia in developing its Economies of the Future and holds a unique value proposition and is building strong momentum, making it well-positioned to overcome challenges and advance RDI-driven solutions.

KSA is accelerating its efforts across AI and digital technologies, supported by substantial investments and strategic initiatives as part of Vision 2030. KSA's digital infrastructure is being enhanced with a focus on increasing mobile broadband (MBB) coverage, where it currently ranks 14th globally[1] on the Mobile Speedtest Index with download speeds of 129 Mbps. The expansion of digital infrastructure not only improves connectivity but also provides a robust platform for RDI in emerging technologies, enabling researchers, businesses, and innovators to leverage high-speed internet for testing and deploying new digital applications. By boosting data center capacity from the current 250-300 MW to 1,000 MW+ by 2030 and achieving 90% 5G coverage and 76% fiber[2] coverage across the nation, KSA is positioning itself as a global digital hub, fostering innovation ecosystems where new ideas and technologies can flourish.

$14.9 billion investment in AI and technology have also been announced, reinforcing KSA's position as a regional hub for innovation[3]. This includes major initiatives such as Groq's AI inference node, Google Cloud's digital infrastructure, and Lenovo's advanced manufacturing center. Strategic partnerships with Alibaba Cloud, Qualcomm, and SambaNova will further accelerate AI development, while 300MW of new data center capacity strengthens Saudi Arabia's digital ecosystem. These investments align with the Kingdom's vision to drive AI leadership, regional competitiveness, and next-generation technology advancements.

In the AI domain, KSA is aiming to significantly boost its presence on the global stage. The AI market, which currently represents only 1% of the total ICT market in KSA, is targeted to grow to 6% by 2030[4]. This expansion is supported by initiatives to increase the number of AI companies, attract AI-related foreign direct investment (FDI), and elevate KSA's ranking to the top 17 globally in AI governance and readiness. A critical component of this initiative is the development of Arabic language technologies, with the goal of making KSA a world leader in this niche. By focusing on AI-specific RDI, KSA aims to drive innovation in natural language processing, AI ethics, and machine learning, creating unique solutions tailored to the Arabic-speaking world. Additionally, the plan to increase the number of AI-skilled professionals and data scientists by 2030 will contribute to a research-driven AI ecosystem, where homegrown talent can push the boundaries of what AI technologies can achieve, fostering breakthrough innovations across sectors.

KSA's technology sector is also set for rapid expansion, with the objective to double the tech sector's size and achieve a significant increase in market size by 2030. As KSA continues to attract global tech companies and develop its local technology landscape, RDI in emerging technologies such as cloud computing, blockchain, and cybersecurity will be critical to this expansion. KSA's efforts to build a culture of innovation, combined with investments in cutting-edge technologies, will enable the creation of next-generation solutions that can compete on a global scale, driving research collaborations and further enhancing KSA's reputation as a technological leader.

In the robotics sector, KSA is pushing for greater integration of robotics across industries, with a particular emphasis on manufacturing. The plan involves creating smart factories and achieving a 50% automation rate in water resource management. By 2030, KSA plans to have 15 manufacturing lighthouses, which are factories that have fully integrated Industry 4.0 technologies and demonstrate significant operational and financial benefits. These initiatives will drive RDI in robotics and automation, where innovations in robotic process automation, AI-driven machinery, and IoT-enabled production systems can create breakthroughs in efficiency and productivity.

Source: 1. Speedtest index; 2. Arab News; 3. MCIT; 4. IDC Worldwide Black Book for technology

By nurturing an innovation ecosystem around robotics, KSA is setting the stage for a new era of advanced manufacturing, with R&D centers developing customized robotic solutions for local and global industries. KSA is rapidly advancing its digital infrastructure, AI capabilities, and technology-driven economy, with ongoing investments in cloud computing, connectivity expansion, and AI-driven automation. Strategic initiatives are fostering innovation hubs, research collaborations, and advanced training programs. With a clear vision and sustained efforts, the Kingdom is positioning itself as a leader in digital transformation and AI-powered innovation.

Data plan is another critical pillar, with the goal of enhancing the Kingdom of Saudi Arabia's data management capabilities and maximizing the economic value of data. KSA's current data creation rate is 4x lower than leading countries, but efforts are underway to close this gap by improving data literacy, enhancing data privacy compliance, and increasing the percentage of data management practices in line with global standards. This focus on improving data practices is directly linked to driving data-driven innovation and RDI, as better data quality and accessibility will fuel new discoveries, product development, and services across industries. By 2030, KSA aims to achieve a top 17 ranking on global data indices, reflecting its commitment to becoming a leader in data-driven research and innovation. This enhanced focus on data governance will empower researchers, innovators, and businesses with the tools to unlock the full potential of data as a transformative asset in the digital economy.

KSA is advancing its cognitive urban living initiatives by leveraging existing strategies and actively engaging with international smart city organizations. KSA has made significant progress with city-level plans, such as the Riyadh City plan, and sectoral strategies. Efforts are underway to develop crucial policies, including the IoT regulatory framework and CCTV laws, which are essential for creating a more integrated smart city approach. Pilot projects, such as AI-powered car theft identification in Riyadh and the Smart Riyadh Operation Center for real-time traffic management, highlight the practical steps being taken. Supporting these efforts, KSA has developed a Smart City Sub-Strategy as part of the broader national digital economy strategy. This sub-strategy focuses on creating a comprehensive smart city platform and application ecosystem that facilitates citizen engagement and enhances urban services and operations. A key objective is to build a robust and scalable infrastructure capable of enabling nationwide integration and interoperability of smart city applications. By 2030, KSA aims to have one Saudi city ranked in the global top 10 for smart city deployment, with strong use case adoption across major urban sectors.

KSA is rapidly establishing itself as a key player in the global space exploration arena. This initiative is part of a broader effort to diversify its economy under Vision 2030, recognizing new physical frontiers as a critical sector for economic, strategic, and technological growth. The Kingdom’s "right to win" in space exploration is rooted in its unique geographic advantages, significant investments, and a well-structured national space strategy. KSA’s geographical location provides distinct advantages that are pivotal for space activities. The country's proximity to the equator, coupled with its clear skies (85% of the year), low humidity, and minimal cloud coverage, make it an ideal site for launching satellites into various orbits, including Sun-synchronous and Geostationary. Furthermore, KSA’s sparsely populated areas offer vast expanses suitable for the development of spaceports, which are essential for both national and international satellite launches. Additionally, KSA's abundant solar resources and ongoing investments in hydrogen production align perfectly with the development of green rocket fuels. This synergy not only supports the Kingdom's space ambitions but also reinforces its commitment to sustainability as part of the Saudi Green Initiative.

KSA’s National Space Strategy is designed to position the country as a global leader in space innovation by 2030, with a long-term vision extending to 2050. The strategy focuses on fostering an innovative space ecosystem that includes manufacturing, launch capabilities, satellite operations, and cutting-edge value-added services.

Source: 1. KSA space market investment opportunities

KSA aims to spearhead emerging space activities such as in-orbit servicing, space tourism, and the development of innovative lunar and Martian habitats. By embracing RDI, KSA is positioning itself at the forefront of space exploration, harnessing breakthrough technologies that will drive the next wave of global space advancements. The economic potential of the space sector is immense, with the global space market projected to grow at a 5% CAGR, reaching approximately SAR 3.5 trillion by 2040[1], presenting KSA with a substantial opportunity to shape the future of space exploration and commercialization through innovative solutions.

The Kingdom is making substantial investments in space infrastructure. KSA is also exploring partnerships with global space leaders to acquire and localize key technologies, ensuring that KSA can rapidly build its space capabilities. Significant momentum is being generated through initiatives such as the OneWeb joint venture, which focuses on satellite communications, and plans to establish a spaceport for launching small and micro satellites. These initiatives are critical for positioning KSA as a regional leader in satellite services.

The strategic importance of space exploration for KSA lies in its potential to drive innovation and transformative growth. As space becomes an expanding frontier for innovation, the Kingdom is focused on developing cutting-edge space capabilities that not only ensure national security but also position KSA as a leader in the global space economy. The advancement of space-based intelligence, surveillance, and reconnaissance (ISR) systems, alongside next-generation missile detection technologies, will enhance KSA's ability to protect its borders while fostering technological breakthroughs. Moreover, KSA views its space initiatives as an innovation engine to enhance its standing in international space governance.

KSA's right to win in space exploration is anchored in its strategic geographical advantages, a well-defined national plan, and significant investments in infrastructure and technology. KSA is rapidly building momentum, with a clear focus on leveraging its unique strengths to become a leading player in the global space industry. By pursuing these strategic objectives, KSA is not only positioning itself for success in space exploration but also laying the foundation for long-term economic growth and technological leadership on the world stage.

2.3 Guiding principles for RDI in Economies of the Future

The Kingdom of Saudi Arabia is on a transformative journey in the realm of Economies of the Future, leveraging RDI to drive significant advancements. The following three themes collectively represent the critical areas where KSA is focusing its RDI efforts to build a sustainable, diversified, and future-ready economy.

The first theme of the Economies of the Future centers on AI and digital technologies. These innovations are revolutionizing industries, driving new business models, and reshaping the global economy. KSA is making significant investments in AI and digital solutions to build a globally competitive digital economy. From AI-driven automation to the development of intelligent systems across various sectors, KSA is positioning itself as a leader in the digital era. This focus aligns with the broader Vision 2030 objectives, ensuring KSA remains at the forefront of technological innovation and digital transformation.

The second theme within the economies of the future is cognitive urban living, which encompasses cognitive cities, advanced transportation systems, and sustainable infrastructure. As the world moves towards urbanization, there is a critical need to rethink how cities are designed, operated, and integrated with the natural environment. KSA is at the forefront of this transformation with initiatives that aim to create hyper-connected, zero-carbon cities that are not only smart but also livable. These cognitive cities will serve as models for urban development, leveraging technologies such as IoT, AI, and sustainable energy solutions to enhance the quality of life while reducing environmental impact.

The third theme focuses on the **new physical frontiers which include space and deep-sea exploration. These sectors represent the frontiers of human ambition and technological innovation.** KSA's investment in these areas is not only about exploring new territories but also about establishing leadership in cutting-edge industries that promise significant economic and strategic benefits. Space exploration, with its potential for resource utilization and scientific discovery, is complemented by advances in aviation technology and the untapped potential of deep-sea resources. Together, these domains are set to redefine what is possible, driving both economic growth and national prestige.

To accelerate this journey, certain guiding principles are essential. These principles ensure cohesive efforts and provide guidance for all stakeholders in the RDI ecosystem of the Kingdom of Saudi Arabia.

1. Establish flexible and adaptive regulatory frameworks that can keep pace with rapidly evolving technologies to promote continuous innovation: As emerging technologies evolve at an unprecedented rate; it is essential that policy frameworks remain agile to foster innovation without stifling progress. KSA continues to develop adaptable regulations that allow for experimentation and growth in cutting-edge fields such as AI, autonomous vehicles, and space technologies. This approach will ensure that regulatory policies keep pace with advancements, creating an environment where innovators can thrive. By prioritizing flexibility and rapid response in governance, KSA will nurture the next generation of technological breakthroughs while safeguarding societal and economic interests.

2. Encourage systemic integration of technological convergence to drive cross-industry collaboration and innovation: The convergence of diverse technological domains—such as AI for space exploration or biotechnology for ocean conservation—is crucial for accelerating innovation and solving complex challenges. By promoting collaboration between different industries and research sectors, KSA can catalyze breakthroughs that occur at the intersections of multiple disciplines. This approach not only amplifies innovation but also fosters a more resilient and dynamic RDI ecosystem. Encouraging convergence will enable KSA to unlock synergies across sectors, boosting its competitive advantage and paving the way for pioneering advancements in emerging technologies.

3. Focus on human-centered innovation that enhances well-being, equality, and inclusivity: KSA's RDI initiatives should prioritize innovations that directly improve quality of life. By focusing on technologies that serve human needs, KSA can ensure that the benefits of innovation are accessible and inclusive, driving progress across sectors.

4. Cultivate global collaboration and multilateralism in R&D to address global and local challenges: KSA must prioritize international collaboration to tackle global issues. By engaging in joint ventures and shared research initiatives, KSA can accelerate innovation while contributing to global solutions. Global cooperation will enhance KSA's influence and bolster its RDI capabilities.

5. Advance technological sovereignty by cultivating domestic expertise in critical sectors, ensuring self-reliance and enhancing national security: Building technological sovereignty is crucial for shaping the economies of the future. By focusing on in-house development in fields such as AI, cybersecurity, space exploration, and digital infrastructure, KSA can reduce dependency on external technologies. This approach not only strengthens local expertise and fosters innovation but also secures the Kingdom's strategic industries against global uncertainties. As KSA enhances the technological capabilities, this can bolster national security and create a resilient and self-sufficient foundation for future growth and stability in the digital and space domains.

6. Build a future-ready workforce through education and training: Invest in comprehensive education and training programs to ensure KSA's workforce is equipped with skills in emerging sectors such as quantum computing, AI, robotics, and space technologies. By creating a dynamic and adaptive workforce, KSA will ensure it has the talent required to sustain its leadership in future economies. These programs will need to align closely with RDI objectives, ensuring that the workforce is ready to meet the demands of cutting-edge industries.

7. Ensure ethical development and deployment of future technologies: As KSA leads in technologies like AI, space exploration, and autonomous systems, it must maintain the highest ethical standards, ensuring that these innovations prioritize transparency, safety, and societal well-being. This principle emphasizes the need for robust regulatory frameworks to manage risks and ensure the responsible use of emerging technologies. By upholding ethical considerations, KSA will build public trust and reinforce its reputation as a global leader in responsible innovation.

03

KSA'S APPROACH TO RDI IN ECONOMIES OF THE FUTURE

3.1 Overview of RDI missions

To drive the Kingdom of Saudi Arabia's vision for future economic growth, address emerging challenges, and harness opportunities for cutting-edge innovation, a mission-oriented approach has been adopted in the Economies of the Future sector. Each mission is designed with clear, achievable goals supported by robust public and private sector collaboration. This systemic approach to advancing future-focused economic initiatives ensures that efforts are strategic, coordinated, and impactful. By targeting specific missions, RDIA plans to unite the ecosystem and nation around bold, forward-looking goals, breaking down silos and promoting cross-disciplinary innovation.

3.2 Mission-oriented approach

KSA's emerging Economies of the Future sector faces critical challenges, including the need for diversification, the rapid evolution of global markets, and the necessity for advanced technological infrastructure. These challenges require a robust RDI plan that not only addresses these immediate needs but also fosters innovation and long-term economic resilience. The mission-oriented approach is crucial for turning these challenges into opportunities and positioning the nation as a leader in the global economy of tomorrow.

Illustration 8: Key Elements of the Mission-Oriented Approach

Addressing Grand Challenges:

Missions are designed to address significant challenges in the evolving Economies of the Future, ensuring the Kingdom is prepared to tackle current and emerging economic transformations

Rallying the Ecosystem

The approach involves mobilizing various stakeholders, including government agencies, private sector entities, and research institutions, to work together towards shared goals in driving future economic growth

Breaking Down Silos

By promoting multi-disciplinary efforts, the mission-oriented approach ensures that different sectors collaborate, leading to innovative solutions that address complex economic and technological challenges

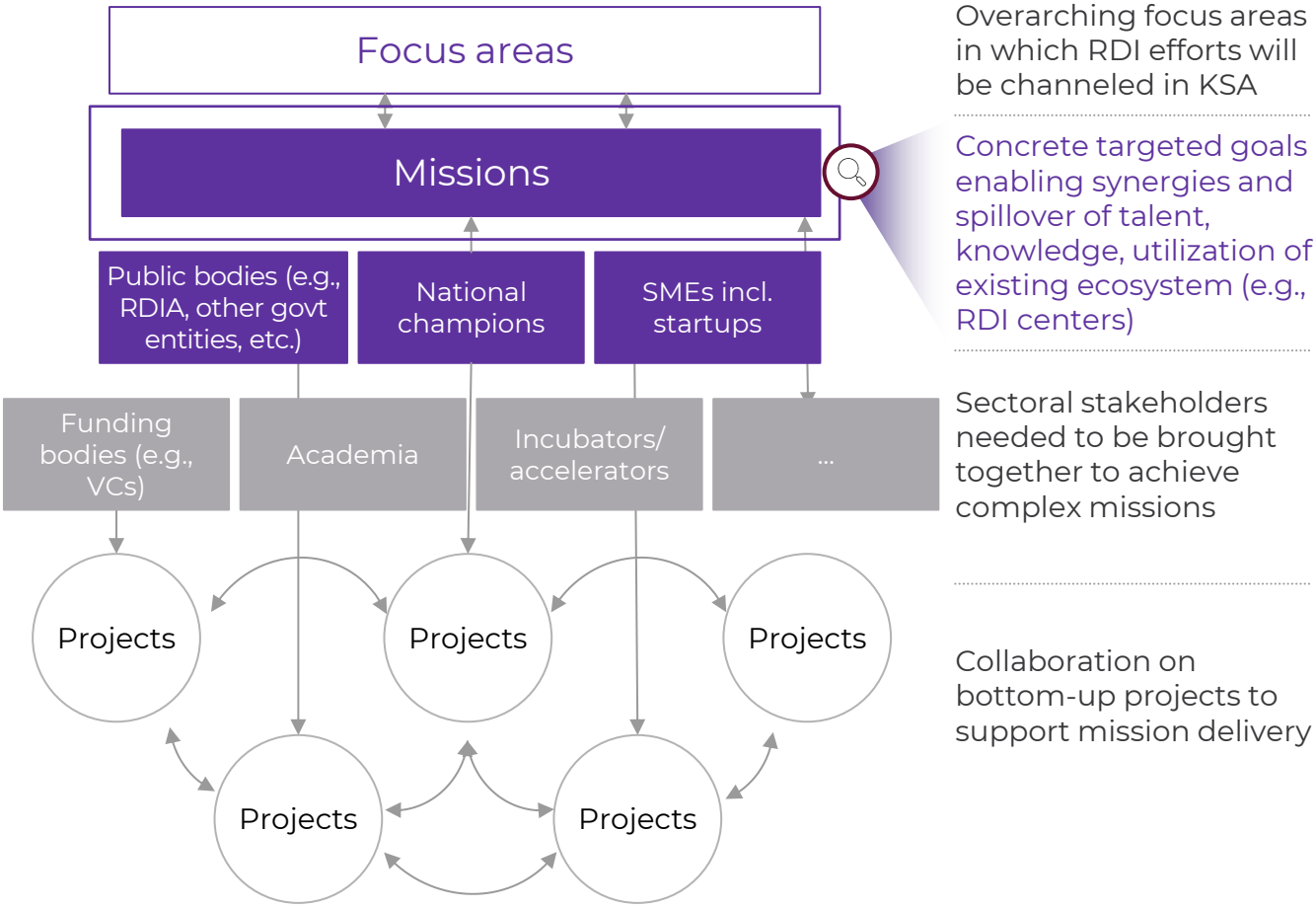
Fostering Innovation

Clear and ambitious missions drive focused innovation, enabling the development of new technologies and strategies that can significantly advance KSA's position in the global economy of the future

The mission-oriented approach ensures effective achievement of ambitious targets by addressing grand challenges, mobilizing diverse stakeholders, promoting multi-disciplinary collaboration, and fostering focused innovation.

It also emphasizes the importance of integrating global best practices and local expertise to address the challenges of future economic development comprehensively. Through international collaborations and knowledge exchange, KSA can harness innovative ideas and advanced technologies to drive economic transformation. This approach ensures that KSA remains adaptable to emerging global trends and resilient in the face of economic and technological challenges.

Illustration 9: Missions act as the glue connecting stakeholders in the ecosystem



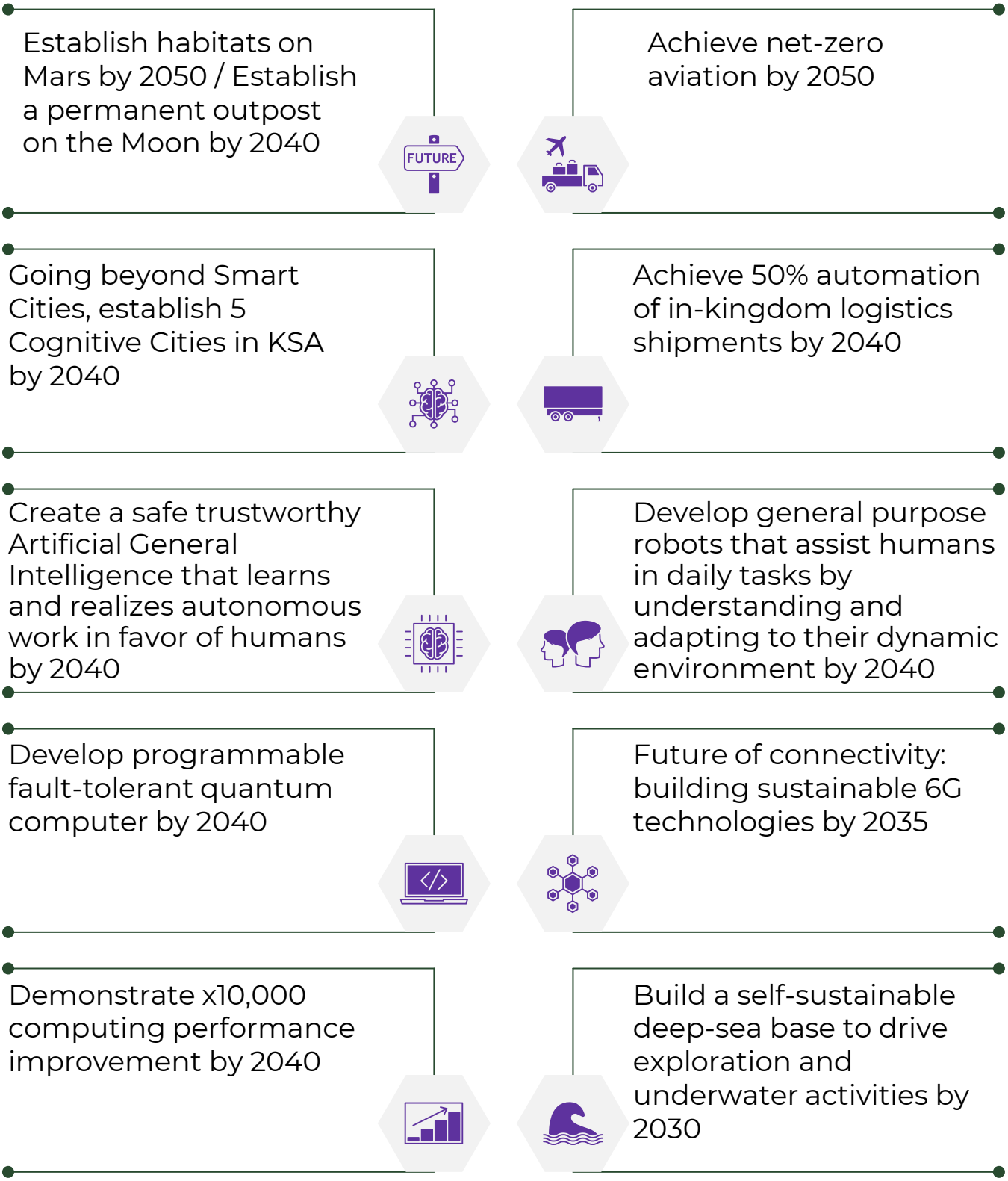
The mission-oriented approach is designed to address grand challenges to secure the present and win the future. It focuses on rallying the ecosystem and nation behind bold and ambitious targets, ensuring that all stakeholders are aligned and motivated. By breaking the silos of sectoral priorities and catalyzing multi-disciplinary efforts, this approach fosters collaboration across various sectors, enhancing the collective impact.

These guidelines are essential for driving significant advancements, ensuring that resources are effectively utilized, and creating a cohesive and dynamic innovation landscape. This strategic approach not only targets immediate goals but also sets the foundation for long-term success. It leverages the collective strength of diverse sectors, integrating expertise and resources to tackle pressing issues and unlock new opportunities. By fostering a culture of collaboration and shared purpose, this initiative accelerates progress and amplifies the impact of each initiative. It ensures that every stakeholder—from government bodies to private sector leaders—contributes to and benefits from a unified vision, setting the stage for transformative breakthroughs and sustained growth. This cohesive framework is not only geared towards achieving immediate milestones but also creating a resilient and adaptable innovation ecosystem poised for future success.

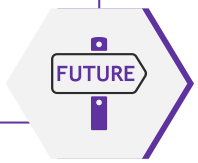
3.3 Economies of the Future RDI missions

RDIA has identified 10 Economies of the Future missions to address critical challenges and leverage opportunities for innovation. These missions are designed to position KSA as a regional and global leader of space and sea exploration, future of urban living, and advanced digital and AI applications. The mission-oriented approach ensures that these goals are ambitious, achievable, and backed by significant public and private sector collaboration.

Illustration 10: Missions focused on the Economies of the Future



Establish habitats on Mars by **2050** / Establish a permanent outpost on the Moon by **2040**



Mission motivation

As many countries and private actors compete to conquer space exploration, the Moon and Mars are considered as the new frontier. KSA has been rapidly increasing its space investments in recent years, and it was the first country to send an Arab, Prince Sultan bin Salman, into space in 1985. KSA is the latest Middle Eastern country to sign the US-led Artemis Accords, which outline peaceful exploration of the Moon and beyond. Spatial exploration would allow KSA to further diversify its economy while establishing its sovereignty outside of Earth. Space-related tech could be applied to other sectors to strengthen the economy.

Potential research areas (non-exhaustive, may be modified in the future as required)

Normalize interplanetary logistics	• Propulsion systems capable of frequent interplanetary travel • Geospatial Intelligence/Earth Monitoring/Satellite Imagery • Commercial Space Launch: Hardware and Service	• Building a vertical spaceport • Space crafts and Components • Space Refueling service • Human landing system • …
Enable surface exploration of the planet	• Space-based solar power • Lunar energy storage • Autonomous planetary rovers to navigate on the planet • Design and deploy a network of AI-enabled robotic mining, manufact. and construction	operations • Lunar research center • Samples retrieval • AI-based remote manage. Of lunar facility operations • …
Manage interplanetary communications	• Laser communication • Satellite communication • Micro/nano-satellites • Reliable ground command and ground control communication with robots and spaceships • Orbital logistics	• On-orbit servicing • Developing a Lunar constellation for PNT and comms services • Debris tracking and retrieval • Space traffic management • …
Build planet specific infrastructure	• Structures, materials and thermal control • Asteroid mining for raw materials • Microgravity materials • In orbit and off earth manufacturing	• Reusable launch vehicles • Environmental Control and Life Support System (ECLSS) • In-situ resources utilized for infrastructure construction • …
Ensure human life can survive on the planet	• Radiation and other health issues • Spaceflight training • Commercial space stations • Governance and societal topics	• Space Food and Proteins • Water extraction and conditioning for human use • Underground Habitat to ensure thermal stability • …

Going beyond Smart Cities, establish **5** Cognitive Cities in KSA by **2040**

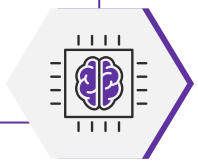
Mission motivation

Cognitive cities go beyond smart cities and leverage data even more to offer ever improving services to residents and businesses. The Line in KSA is one of the best examples worldwide and already has commitments of $1.5 billion from Google and Alibaba to help build the technology infrastructure—the largest digital economy investment in the MENA region. Cognitive cities will enable citizens to live in a city where the quality of life and usage of resources is optimally harmonized. This mission would leverage quantum computing, robotics and other new tech while contributing to water stress management and digital healthcare.

Potential research areas (non-exhaustive, may be modified in the future as required)

Smart 5 Environment technologies	• Circular Economy / Waste to Products • Climate Intelligence • Urban environment monitoring through AI (air, trees, radiation, water pollution..)	• Smart beaches • Smart sustainable buildings • Smart road networks • Urban air mobility (UAM) Parking • ...
Cognitive city urban mgmt.	• Predictive analytics incl. AI / ML • Modular constructions • Crowd analytics for better crowd management • Collective intelligence through	smart infrastructure and advanced data fusion (e.g. AGI) • High-fidelity simulation models for UAM operations • ...
Fast and secure connectivity	• Quantum computing • Secure and encrypted cloud • Low latency connectivity through 6G • Dynamic networking	• Integration of different technologies • Satellite internet constellation • ...
Breakthrough technologies	• Metaverse XVRS • Blockchain for data collection and exchange in real time • Digital twins • Synthetic intelligent operating system	• General purpose humanoid robots • Robots with cluttered and dynamic environments navigation • ...
IoT and IT architecture	• Enhanced sensor connectivity • Standardized open protocols • Edge computing • Smart infrastructures (benches,	kiosks, robots etc.) • IoT Air Quality and Noise Pollution Monitoring • ...
Public safety technologies	• AI enabled real time detection and auto quarantine of technology • Identification and monitoring Applications powered by AI • Gunshot Detection • Smart disaster management	• Drones for risk management • 5G-enabled augmented reality (AR) training simulations for trainings • 5G technology for crowd management • ...

Create a safe trustworthy Artificial General Intelligence that learns and realizes autonomous work in favor of humans by **2040**



Mission motivation

Many countries such as China are investing billions in AI startups, with endless applications as it enters the realm of every industry and aspect of society. However normal AIs still are unable to adapt to different kinds of situations and interact with one another. General AI would be able to comprehend, learn and do tasks like a human brain would, in any kind of situation. This would enable AI to make the most of today's connected societies and further reduce work for humans. This is perfectly in line with KSA's vision to build a knowledge-based economy with many highly qualified people in the future.

Potential research areas (non-exhaustive, may be modified in the future as required)

Human like capabilities	• NLP based automated conversation with speaker recognition and communication systems • Fast and Robust Self supervised learning for faster training times • Competencies that exceed human comprehension	through technologies such as quantum computing, increasing data processing speed • Robots with audio-visual cues for information processing and haptic sensing/perception • ...
Working protocols	• Working protocol integrating different systems in a unified manner instead of standalone systems • Seamless data sharing between AI systems with Inter machine learning models enabling faster trainings and decision making	• Human machine interface in order to be able to modify protocols at whichever depth and whichever speed required • Personalization of virtual assistants for improved social and emotional engagement • ...
Universality	• Dialect language detection and adaptation (especially for semantically complex languages such as Arabic and Mandarin) • Low-code and no-code AI for nontechnical experts in	different domains to tailor AGI to their own needs • Low data AI able to start in any environment with reduced pre acquired data • ...
Tangibility	• Centralized decisions with decentralized actions across cities • Improved building techniques for increasingly complex bodies (laser sintering, 3D printing..) • Improved locomotion (holonomic, centaur, humanoid..)	• Spatial Artificial Intelligence , Semantic SLAM, Semantic Navigation • Stronger and more flexible actuators for movement (hydraulics, silent pneumatic with optimized air compressors..) • ...

Develop programmable fault-tolerant quantum computer by **2040**

Mission motivation

Quantum computing could answer the increasing demand for information processing, yet it is still imperfect. Quantum computers are inherently much more susceptible to disturbances and thus require error correction mechanisms, to avoid errors propagating uncontrolled in the system and losing information. Having fault tolerant quantum computing would enable to exploit the potential of quantum computing. This technology could enable strategic projects for KSA such as oil exploration and aerodynamics, reducing carbon emissions.

Potential research areas (non-exhaustive, may be modified in the future as required)

Quantum computing and simulation	• NISQ • Quantum annealing machine • Superconducting qubit • Ion trap	• Photonic qubit • Cooled atom • Quantum Walk • …
Quantum measurement and sensing	• Diamond color center • Quantum entangled light sensor • Optical lattice clock	• Atomic interferometer • Distributed Quantum sensing • …
Quantum cryptography and communications	• Quantum key distribution • Quantum repeater • Quantum memory • Quantum teleportation	• Structured Light • Continuous Variable Systems • …
Quantum materials	• Topological quantum matters • Spintronic materials • Energy conversion materials	• Photonics material • …
Supporting science	• Condensed matter physics • Photonics • Electronics • Spintronics • Ultrafast electronics • Quantum beam technology	• Cryogenic engineering • Quantum error correction theory • Middleware compiler • Quantum interface technology • …

Demonstrate **x10,000** computing performance improvement by **2040**

Mission motivation

Processing power is growing quickly as a result of the emergence of artificial intelligence and machine learning, which has increased demand for increasingly powerful computers. As a result, the development of AI and the increase in processing power of these powerful gadgets are intrinsically related. KSA will be able to develop its cognitive cities, multi-purpose robots, secure AI, and many other inspirational missions by reaching x10,000 computing performance improvement.

Potential research areas (non-exhaustive, may be modified in the future as required)

New more efficient transistors	• 3D transistors able to support higher temperatures • 3D transistors able to cool down faster and spread temperature to maintain functioning longer	• Scale mass production, some designs cannot be mass produced in a cost-effective way • ...
Special technologies	• Neuromorphic computing • Integrated electronics • Neutral atoms • Reduce errors performed by lack of machine precision and stochasticity in the output • Special purpose-interface to	integrate the special tech developments • Connecting special port machines to the general computing network • Optical devices • ...
High performance materials	• Better performance materials: Germanium, diamond... • Mining at scale • Integrating new materials to manufacturing process	• Gallium arcenyde • Graphene • Alternatives to silicon • ...
Quantum Computing	• Fault tolerant quantum computing • Build assembly line and grow to scale • Standardization of quantum computers • Running protocols to solve errors, with approaches and tradeoffs, no consensus • Race from vendors to show they	are ahead in building fault tolerant computers • Manage energy efficiency of existing laptops with technologies prior to quantum computing • Backward integration of technology • ...

Achieve net-zero aviation by **2050**

Mission motivation

Aviation significantly contributes to global warming and many countries are doing efforts to reduce its impact on the environment. As KSA aspires and strives to become a touristic hub and meet its target of 100 million tourist per year by 2030 the demand for aviation is expected to grow significantly, but so will the environmental. Decarbonizing aviation would enable KSA to welcome more tourists while staying aligned to its net zero objectives.

Potential research areas (non-exhaustive, may be modified in the future as required)

Sustainable aviation fuel	• Fully/Hybrid electric aircraft concepts • e-SAF using electrolysis by thermo-chemical conversion of organic matter • Distinctive aircraft design to accommodate liquid hydrogen storage (e.g. including cryogenic pipes to store	hydrogen during long distance flights) • Lipids recovery from waste streams Hydrogen and ammonia based SAF to replace kerosene as jet fuel energy source • …
Decarbonized aircraft construction materials	• Sustainable composites and composite structures • Alloy compatibility with hydrogen to include renewable energy sources in aircraft energy mix • Standardization of types of composites for reduced production intensity and	optimized emissions • Increased reuse of aluminum aircraft fuselage rather than recycling • Open-source data from OEMs to facilitate material identification and processing for re utilization • …
Efficient and sustainable aircraft technologies	• New propulsion technologies such as geared turbofan reducing fuel consumption, emissions and noise • Wing morphing and MDO • Waste heat utilization for aerodynamic performance • Advanced Lightweight Aircraft Design (e.g. double bubble	design) • Automatic pilot aids helping pilots save fuel during flight through real time fuel usage analytics and virtual simulations • AI predictive maintenance to improve aircraft efficiency • …
Efficient and sustainable aircraft design	• Sustainable cabin design optimizing weight and passenger comfort • High lift and movables design to increase amount of lift produced and reduce fuel needs • Advanced design (canard wings, blended wings, strut or truss	braced wings) to further increase energy efficiency and reduce fuel needs • Lightweight, Flexible Solar Power Solutions for aircraft • Liquid hydrogen-fueled long endurance drone for cargo • …

Achieve **50%** automation of in-kingdom logistics shipments by **2040**

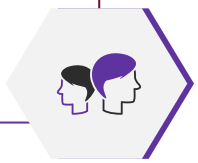
Mission motivation

Automation in the logistics industry is essential for saving money, improving services, reducing inventory, and making reliable decisions. Logistics automation helps in reducing costly errors, coping with the ever-increasing transport costs, improving customer service, gaining access to data and analyzing freight traffic in real-time. According to KSA's plans, the logistics and transportation sector will be encouraged to grow by 4% by 2030, contributing to 10% of the country's GDP which is in compliance with the most recent plan.

Potential research areas (non-exhaustive, may be modified in the future as required)

Automated product handling	• Adoption of AI enabled robot manipulators for easy and efficient picking, sorting, and packing/palletizing • Fully automated generalized bin-picking systems in robots	• Simultaneous localization and mapping (SLAM) technique for mobile robots navigation • Collaborative robots cobots) integrating human behavior prediction into planning
Smart logistics infrastructure	• Smart Ports Solutions including IOT, telematics devices, and remote monitoring • Drone docking stations for pickup and delivery services	• 3D Printing enabling nearshoring of production • Fully robotic ship offloading processes • ...
Automated inventory tracking system	• Radio frequency identification (RFID) technology for logistics and inventory systems • Smart wearable technology including glasses using Augmented Reality • Deploying APIs (application	programming interface) for greater supply intelligence • Warehouse drones to check inventory • Automated storage and retrieval systems • ...
Optimized last mile delivery	• Utilizing unmanned aircraft systems-delivery drones and driverless cars • Leveraging machine learning for forecasting congestions and planning optimal routes • Use of AI for vehicle-cargo	matching, vehicle routing • Vehicle-to-Infrastructure (V2I) testing with smart traffic lights • UAV Traffic Management (UTM) for delivery applications • ...
Smart monitoring and quality checks	• Monitoring failure patterns and anomalies to plan future failures using predictive AI algorithms • Leveraging predictive shipping analytics to reduce parcel shipping costs	• Facilitating transactions using blockchain technology for efficient and secure invoicing and payment systems • ...

Develop general purpose robots that assist humans in daily tasks by understanding and adapting to their dynamic environment by **2040**



Mission motivation

Today's robots are very limited in their use to the complexity of their setup and also inability to adapt to new and changing environments, restricting them to simple or very specialized tasks. However, with decreasing costs and an increase in training capabilities, robot could become multifunctional. Such robots would be key to missions such as autonomous mines which would greatly benefit from polyvalent robots and be enabled by the growing number of Saudi scientist in the new knowledge economy.

Potential research areas (non-exhaustive, may be modified in the future as required)

Robot construction	• 3D printing due to produce highly complex bodies • Lithium iron phosphate batteries that do not explode • Silent pneumatic actuators,	with optimized air compressors • Hydraulic compressors for increased mobility • Laser sintering of titanium • ...
Locomotion	• Legged locomotion “brute force” (control command approach) or intuitive biomimicry approach • Smart Chairs: Personal mobility omni-directional robots (E.g. Centaur Robotics, UniCub)	• Real time balance management and control • Improving Robot Learning to adapt in real world varied conditions. (Online Learning, Reinforcement Learning ...) • ...
Sensory	• Sensor Fusion to merge data from multiple sources • Natural language processing to understand words • Multiple technology combination interface • Semantics understanding • Real-time object detection	models (e.g., YOLO: You Only Look Once) • AI / Machine learning (agnostic robot decision making) • Real time robot decision making system leveraging AI • ...
Human robot interaction	• Humanoid embodiment for humans to relate • Robot Aesthetics: Crossing the Uncanny Valley • Facial expressions (nodding,	visual cues, empathy) • Information processing visual cues via AI (blinking, LED light) • ...
Safety	• Thermal management and control(internal and external) with heat distribution • Force sensors to avoid accidents due to exceedingly strong force	• Impedance controls (change level of force to achieve task without being dangerous) • ...

Future of connectivity: building sustainable **6G** technologies by **2035**

Mission motivation

As the world becomes increasingly technological, there is increasing demand for data transfer advanced contemporary information and communication technologies. 6G will provide for the shortcomings of the current generation, help enable higher data rates, greater overall capacity, and lower latency levels. As KSA is looking more in depth into autonomous systems, digitalized economies, digital healthcare, and sustainable systems, it must develop 6G to enable and support these technologies.

Potential research areas (non-exhaustive, may be modified in the future as required)

6G network architecture	• Massive scale of IoT networks • Machine learning to meet machine reasoning processing demands • Digital twinning for simulations and decision making	• Software-defined networking • Network function virtualization • Fully-decoupled radio access network (FD-RAN) • …
Combined sensing and communication	• Spectral efficiency • Connected intelligence • Environmental sensing networks • Ultra-Reliable and Low-Latency Communications • Ambient backscatter communication	• Quantum communication • Holoportation (high quality reconstructed 3D models of people) and holographic communication • Reconfigurable intelligent surfaces • ……
Space, Air, and Extreme Ground Connectivity	• Non terrestrial networks • Vehicular Cloud Computing • Multi-Access Edge Computing • Unmanned Aerial Vehicle/Satellite communication	• Usage of low earth orbit (LEO), medium earth orbit MEO), and geostationary earth orbit (GEO) satellites • …
Privacy and security controls	• Pairs of deep neural networks • Distributed ledger technologies • Post quantum cryptography • Distributed ledger technologies and blockchain • Electronic and IT security • Adversarial machine learning	• Differential privacy, disinformation, and randomization • Zero-trust architectures • Homomorphic encryption • …

Build a self-sustainable deep-sea base to drive exploration and underwater activities by **2030**

Mission motivation

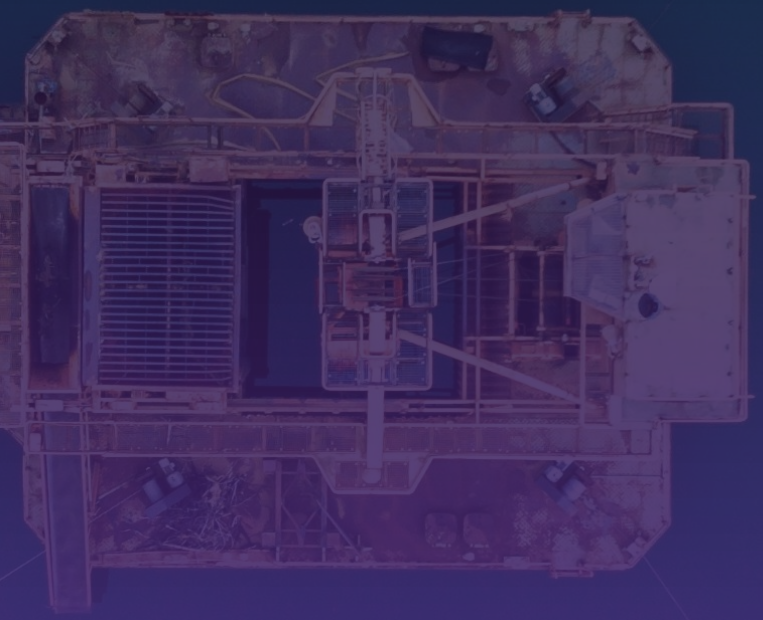
Despite covering over 70% of the planet, very little of the ocean floor has been explored. There are only a handful of short-term research stations underwater, so that a self-sustainable deep-sea base would be a first in the world and would enable KSA to take the leadership on the topic. The base would also facilitate research in climate change and sustainable mining tests, as well as assist in better monitoring and evaluation of underwater infrastructures such as oil rigs or communication cables. This also opens a lot of multi-disciplinary opportunities in the areas of robotics, AI, and material sciences.

Potential research areas (non-exhaustive, may be modified in the future as required)

Durable underwater construction	• Use of 3D printed parts able to sustain deep-sea pressure • High yield steel alternatives (aluminum, titanium composites) with a minimum yield strength of 100 ksi to	provide toughness and endurance • Acrylic sheets that offer double the impact resistance • …
Sustainable energy supply	• Use of ocean thermal energy by harnessing temperature differences between ocean surface waters and deep ocean waters	• Renewable energy supply generated by green hydrogen electrolysis • …
Communications and transportation	• Optical wireless communications (UOWCs) able to support higher data rates at low latency levels • 3D benthic mapping of the sea to identify a place conducive to research and suitable engineering-wise	• Underwater acoustic communication network to support quick transmission • Remotely operated vehicles to carry cumbersome equipment like video cameras • …
Durable freight equipment	• Use of suitable diving bell to transport material from the surface to depth and back in open water • Autonomous AI-powered	research freight vessels to transport and deploy equipment to the sea base • …
Sustainable deep-sea exploration	• Aquatic drones to explore high-pressure depths • Solar-powered uncrewed surface vehicle (USV) to collect data under water • High-tech tagging to transmit	data about movements and interactions between wildlife • Smart sea robots able to use the ocean's endless supply of energy as propulsion to collect data • …

04

FUNCTIONAL INTERVENTIONS FOR RDI IN ECONOMIES OF THE FUTURE



In the Kingdom of Saudi Arabia, the advancement of RDI is driven by 5 crucial enablers that are essential for creating a robust and dynamic RDI ecosystem tailored to Economies of the Future. The RDI policy in KSA provides cohesive direction to improve these enablers in tandem, ensuring that the overall RDI posture of the KSA can advance effectively and sustainably. By addressing each enabler comprehensively, KSA aims to foster innovation, drive economic diversification, and establish itself as a global leader in future-oriented industries. **Funding and Investments** ensure that adequate financial resources are available to support groundbreaking research and development projects in emerging economic sectors. **Human Capital** focuses on developing a skilled workforce capable of driving advancements in cutting-edge technologies and future industries. **Regulatory landscape** creates a conducive environment for innovation by establishing clear guidelines and standards that support the growth of next-generation industries. **Ecosystem Infrastructure and Supply Chain** facilitate the efficient delivery of advanced services and the commercialization of new technologies. **Linkages and Cultural Promotion** emphasize the importance of collaboration and engagement across sectors to drive innovation and improve outcomes in evolving markets.

Illustration 11: Key enablers for fostering and supporting RDI in the Economies of the Future

Funding and investments

Adequate funding and strategic investments are essential for driving RDI success in the emerging Economies of the Future. By ensuring that financial resources are aligned with groundbreaking research and development projects, KSA can accelerate its leadership in innovative industries.

Human capital

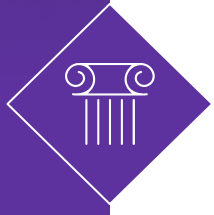
Developing a skilled workforce is crucial for RDI success in the Economies of the Future. Equipping the workforce with the necessary skills to drive advancements in next-generation technologies and industries will position KSA as a global leader in these fields.

Regulatory landscape

Effective policies and regulations create a conducive environment for RDI in the Economies of the Future. Establishing clear guidelines and standards will support innovation and growth in future-oriented sectors.

Ecosystem, infrastructure and supply chain

Well-developed infrastructure and an efficient supply chain are critical for supporting RDI activities in the Economies of the Future. Ensuring that advanced services and new technologies can be quickly and efficiently brought to market will be key to driving economic transformation.



Linkages and cultural promotion

Building strong connections between various stakeholders and promoting a culture of innovation are vital for RDI success. By fostering collaboration and engagement across sectors, KSA can drive significant advancements in future industries and contribute to its Vision 2030 goals.

4.1 Funding and Investments

Status quo and current efforts

In recent years, the Kingdom of Saudi Arabia has made substantial investments in the field of Data and AI, positioning itself as a leader in the emerging global tech economy. USD 100 billion+ have been committed over the next decade to fuel the growth of AI, underpinning this ambition with significant capital aimed at building a comprehensive AI ecosystem. This funding supports not only the development of infrastructure, such as the Dammam 7 supercomputer[1] and the planned 200-qubit quantum computer, but also fosters innovation through venture capital and startup accelerators. Multiple venture capital funds in the Middle East, have been actively investing in AI and tech startups in KSA, contributing to the rapid growth of the local tech ecosystem. KSA has also established multiple AI-focused Centers of Excellence (CoEs) in collaboration with leading universities and global tech giants, supported by significant government funding aimed at driving R&D in advanced technologies. Moreover, through initiatives like the National Semiconductor Hub, KSA is investing in the development of fabless chip design capabilities, essential for advancing its semiconductor industry. Significant efforts and funds are also being channeled into the development of cognitive technologies, further enhancing KSA's capabilities in AI and robotics.

$14.9 billion investment in AI and technology have also been announced, boosting KSA's role as a regional innovation hub. This includes AI infrastructure, cloud computing, and advanced manufacturing, driving digital transformation and global competitiveness.

Illustration 12: Success story – Deep Tech venture studio established in KSA

Concept

Creation of a deep tech venture studio that focuses on artificial intelligence and other advanced technologies

This venture was formed through a collaboration that leverages KSA's commitment to fostering innovation and economic diversification, and Hashgraph's expertise in distributed ledger technology (DLT)

Contribution to RDI funding and investments

The venture studio helps in funding and investments for RDI in AI and the digital space by:

1. **Providing access to capital:** offering seed and early-stage funding to startups, enabling them to invest in RDI activities without the financial constraints typically faced by early-stage companies
2. **Structured support for RDI:** allocating resources, such as access to research grants, advanced AI tools, and infrastructure, essential for developing innovative tech
3. **Attracting investors:** by fostering high-potential startups and creating a strong pipeline of innovative products, the venture studio attracts both regional and global investors, further boosting funding opportunities
4. **Mentorship and commercialization support:** assisting startups in refining their innovations and guiding them through the commercialization process, which increases the likelihood of attracting investment and achieving market success

Source: 1. New York Times;

The Kingdom of Saudi Arabia is at the forefront of funding initiatives aimed at transforming its urban environments into smart and cognitive cities, which are integral to its vision of the future. KSA has allocated significant investments for the development of a national smart city platform, which are designed to unify and enhance urban service delivery across the nation. KSA has attracted significant investment as a model of cognitive urban living, where advanced technologies are integrated into every aspect of city life. KSA is driving the digital infrastructure with a $1 billion[1] investment in cognitive technologies, including cloud computing and AI, which are crucial for the development and management of these smart cities. Private sector investment has also been substantial, with venture capital firms participating in funding rounds for startups developing smart city technologies. For instance, investments have been made in digital marketplace that improves the efficiency of supply chains in urban environments, highlighting the role of private equity in supporting innovation. Universities are also leading RDI efforts. 4 new Centers of Excellence have been established, including Centers of Excellence (CoE) on Generative AI and Smart Health.

Grants offer benefits that extend beyond the scientific community in KSA. RDIA driven grant programs like the Basic Science Grant (BSG) initiative and Technology Development Grant (TDG) support fundamental scientific research and applied technology development activities. The Technology Development Grant awards funds of up to $2.6M (SAR 10M)[1] over a period of 5 years. These initiatives are aimed at expanding the pool of talented researchers and enhancing their participation in areas leading to the next generation of breakthroughs. Additionally, the Academia-Industry Innovation Grant (AIIG), Innovation Flagship Grant (IFG) and Accelerator Flagship Grant (AFG) provide grants for RDI ecosystem development.

It is crucial to ensure sufficient funding for the foundational building blocks, including sensing technologies such as quantum sensing, printed and environmentally friendly sensors, and high-precision sensing, as well as the entire computing spectrum and their interconnections. Key areas requiring additional attention include quantum computing, GPUs/FPGAs, integrated platforms, research on 6G networks, and the application of Artificial Intelligence (AI) for real-time control and autonomous systems. The seamless integration from sensing to computing, AI, and autonomous responses should be a central focus for driving innovation in this domain.

KSA's funding and investment landscape in new physical frontiers has also seen significant growth, driven by strategic initiatives from both the government and private sector. The National Space Strategy outlines a clear roadmap for KSA to become a major player in space exploration, supported by substantial government funding. This includes investments in satellite technology, where KSA has committed to significant spending on the development and deployment of satellites to enhance both scientific research and commercial applications. For instance, KSA through its strategic investments, is supporting projects like the OneWeb joint venture, which aims to develop a network of low earth orbit (LEO) satellites, an initiative that has seen hundreds of millions of dollars in investment.

Private sector involvement is also notable for exploring opportunities in deep-sea mining and space resource extraction. These investments in space exploration technologies reflect the growing interest of private equity in the untapped potential of space and deep-sea resources. KSA's strategic focus on enhancing RDI in Economies of the Future has led to significant advancements. With robust government support, substantial private sector investments, and a thriving entrepreneurial ecosystem, KSA is well-positioned to continue its progress in Economies of the Future research and innovation. The collaborative approach between government agencies, academic institutions, and the private sector is fostering a dynamic RDI landscape, contributing to the overall well-being of KSA.

Source: 1. Technology Development Grant Guideline document

Illustration 13: Examples of successful KSA-based start-ups and programs pioneering innovation in Economies of the Future

	Mozn	Sary	FalconViz
Description	Leading KSA AI startup that specializes in developing advanced machine learning, natural language processing, and big data analytics solutions. Mozn provides AI-driven products that cater to various sectors, including finance, security, and government, helping organizations make data-driven decisions with greater accuracy and efficiency	Saudi startup that operates a digital marketplace connecting small and medium-sized businesses (SMBs) with wholesalers and suppliers. The platform streamlines the supply chain process, allowing businesses to procure goods more efficiently, which is crucial for urban commerce in a rapidly developing market like KSA	Saudi startup specializing in 3D surveying and mapping using drones and advanced data processing technologies. FalconViz provides high-precision 3D models and mapping services that are essential for urban planning, construction, and heritage preservation, making it a critical player in the development of smart cities in KSA
Funding received	Mozn has raised a Series A funding round of $10 million led by reputed venture funds and other investors. The funding is being used to scale its operations and enhance its AI capabilities	Sary has raised a total of $112 million in funding across multiple rounds, including a $75 million Series C round led by reputed venture funds and other investors. This funding supports Sary's expansion across the region and the enhancement of its digital platform	FalconViz has also received Venture funding, including investors which support startups in their early stages. FalconViz has benefited from several rounds of investment aimed at scaling its operations and expanding its technological capabilities

Outlook for funding and investments

The Kingdom of Saudi Arabia is poised to significantly increase its funding and investments in RDI across the key themes of Economies of the Future.

The future of AI and digital in KSA is underpinned by ambitious funding strategies aimed at positioning KSA as a global hub for innovation. Plans have been announced to attract over $20 billion[1] in foreign and domestic investments in AI by 2030. This investment will be channeled into developing AI infrastructure, supporting AI startups, and fostering international partnerships with leading tech companies. Additionally, KSA is expected to play a critical role by increasing its stakes in AI-related ventures globally, thus facilitating technology transfer and localization. KSA also plans to launch new AI-focused funds that will support local startups and research institutions, providing them with the necessary capital to scale their operations and drive innovation.

For grants, future initiatives will focus on potential research topics highlighted under the missions specified for Economies of the Future. These targeted grants will drive innovation in key areas, ensuring that funding is directed towards projects with the highest potential for impact. Additionally, the grants will continue to support startups and SMEs, fostering a dynamic and innovative ecosystem. The reactivation and rebuilding grants for existing labs across the country will also ensure that these facilities remain at the cutting edge of research and development.

KSA is committed to establishing a dynamic and flexible RDI funding ecosystem. Central to this vision is the implementation of a performance-based institutional funding model, designed to provide sustained financial support for foundational research activities while driving efficiency and accountability. RDIA's efforts will ensure the provision of institutional funding to maintain the foundational activities of research entities, fostering an environment conducive to discovery and innovation.

Additionally, this model introduces a transition from traditional funding approaches to more competitive mechanisms that prioritize high-impact and transformative RDI initiatives. By channeling resources towards the most promising projects, KSA aims to maximize the efficiency of its investment while promoting advancements across key sectors such as AI, modern mobility, space exploration, etc. This balanced and strategic approach ensures a robust RDI lifecycle—from discovery to market deployment—anchored in the Kingdom's long-term vision for economic growth and global leadership.

Moreover, KSA's commitment to developing cognitive urban spaces is reflected in its future investment plans, particularly in the context of the mega projects and other megacities like the Red Sea Project and Qiddiya. KSA has allocated significant funds towards the development of these futuristic cities, which will serve as living laboratories for smart city technologies. These projects will receive up to $500 billion in investments, with a significant portion earmarked for the development of digital infrastructure, IoT ecosystems, and sustainable urban solutions. Furthermore, the government is expected to introduce new financing mechanisms, such as green bonds and public-private partnerships, to attract global investors to its smart city projects.

KSA's ambitions in space and deep-sea exploration are set to expand dramatically, with plans to increase investments in space research and development. KSA has announced a roadmap to invest $2.1 billion in its space program over the next decade. This funding will be directed towards building the necessary infrastructure for satellite development, launching space missions, and fostering international collaborations. The King Salman Space Center will be established, which will serve as a hub for space research, satellite assembly, and international cooperation. KSA is also exploring opportunities to attract private investments in its space sector, particularly in satellite communications and space tourism. These efforts are aligned with KSA's broader goal of becoming a leader in the global space economy, leveraging its strategic location and growing technological capabilities.

Source: 1. The Economic Times

4.2 Human Capital

Status quo and current efforts

The Kingdom of Saudi Arabia is actively investing in human capital to meet the demands of its rapidly expanding AI and digital sectors. The establishment of Centers of efforts to ensure that the workforce can meet the growing demands of KSA's ambitioExcellence (CoEs) at prominent institutions is central to these efforts. For example, some universities have launched the AI Initiative, focusing on training researchers and professionals in advanced AI techniques and applications. These initiatives are supported by partnerships with global tech leaders such as IBM and Google, who provide access to cutting-edge AI tools and resources. Additionally, AI focused academies have been set up, which offer intensive training bootcamps in AI and data science, aiming to produce over 5,000[1] skilled professionals annually. Furthermore, targeted educational programs like the GenAI Academy, in partnership with NVIDIA, focus on upskilling individuals in AI and related technologies, offering courses on AI fundamentals, machine learning, and AI ethics, with a target to train 20,000[2] individuals by 2030. Despite these initiatives, challenges persist, particularly in attracting and retaining top AI talent. The percentage of advanced data analytics and machine learning graduates remains significantly lower than in leading AI nations, and KSA faces a projected shortage of 45,000[3] digital professionals by 2030, underscoring the need for continued and expanded human capital development.

In the realm of cognitive urban living, KSA is making strategic investments to ensure that its human capital can support the development and management of these advanced urban environments. There is a strong emphasis on building a skilled workforce to drive smart city initiatives, particularly in areas like data analytics, IoT, and urban planning. The Smart City Operations Center in Riyadh is a key project aimed at building these capabilities, serving as a hub for managing city operations through real-time data while also functioning as a training ground for city managers and technicians. Equipped with advanced tools like AI-powered traffic management systems and smart surveillance, it provides hands-on experience in cutting-edge urban technologies. Moreover, KSA is leveraging international expertise to enhance its smart city workforce. Partnerships with organizations such as the International Telecommunication Union (ITU) and the World Economic Forum (WEF) have been instrumental in providing training programs and certifications for Saudi professionals in smart city management and digital infrastructure. Additionally, specific human capability development initiatives include programs aimed at increasing the number of certified smart city professionals by 50%[4] by 2025. However, there is still a need to scale these us smart city projects.

In space segment, several key programs have been initiated to develop local expertise in space technology. The "Custodian of The Two Holy Mosques Space Scholarship" Program offers scholarships to Saudi students for advanced degrees in space-related fields at top universities worldwide. This program is part of a broader plan to cultivate a new generation of Saudi space scientists and engineers who can lead national space missions. In addition, satellite development programs have incorporated extensive training modules for Saudi engineers, involving hands-on experience in satellite design, development, and launch operations. These programs, conducted in collaboration with international partners such as Lockheed Martin and Airbus, ensure that Saudi professionals are trained to international standards. Another significant initiative is the establishment of the "Madar" training program, which focuses on providing specialized training in satellite communications, space mission planning, and remote sensing, with the goal of training over 1,000[5] professionals by 2025.

Source: 1. Saudi Gazette; 2. Arab News; 3. Accenture; 4. Vision 2030, KSA; 5. Al Arabiya report

Despite these efforts, the Kingdom of Saudi Arabia still faces challenges in building a sufficiently large and skilled workforce in space sciences, particularly as it aims to expand its activities in satellite technology and deep-sea exploration. Moreover, a variety of space training programs have been developed which aim to equip the national talent to adapt to the rapid developments in this field, explore investment opportunities, and benefit from various international experiences. These training programs are offered to three targeted audiences and implemented by three related courses covering the management of space operations, the most widely used sciences and technologies, and an overview of the space sector and its opportunities.

Illustration 14: KSA has shown significant progress across multiple RDI metrics

Outlook for human capital

As Economies of the Future evolve, KSA is laying down comprehensive plans to enhance its workforce by equipping individuals with the skills, knowledge, and expertise necessary to lead in these future-oriented fields.

The outlook for human capital in AI and digital is characterized by large-scale initiatives aimed at training and upskilling the Saudi workforce. KSA plans to expand its educational offerings in AI and related fields through the establishment of new programs and partnerships with leading global institutions. Efforts are underway to launch specialized training programs, such as AI-specific degree programs in collaboration with top universities. The focus will be on developing a workforce proficient in AI applications across various sectors, from healthcare to finance, to ensure that KSA remains competitive in the global AI market. KSA also aims to attract top global AI talent through initiatives like the planned establishment of AI Centers of Excellence (CoEs) that offer world-class research opportunities and facilities.

In the area of cognitive urban living, KSA's human capital plan involves a significant investment in building a skilled workforce capable of designing, implementing, and managing smart city technologies. KSA will develop hubs for training the next generation of urban planners, architects, and engineers who specialize in smart technologies. KSA plans to introduce new educational programs at universities focusing on urban innovation, sustainability, and digital infrastructure. Moreover, through partnerships with international experts and technology firms, KSA aims to establish training centers within these cities to provide hands-on experience with the latest smart city technologies.

Source: 1, 2, 3: RDIA report on "Insights into Saudi Arabia's Research and Innovation Ecosystem" (2025);

The government also intends to launch initiatives that encourage women and youth to pursue careers in smart city development, addressing both gender diversity and youth engagement in these emerging fields.

Universities are undertaking efforts to equip the next generation with the skills required to thrive in these industries. Human Capital Initiative aligns education and training programs with Vision 2030's goals, fostering a culture of lifelong learning and collaboration between academia and industry. Similarly, interdisciplinary research centers have been established that focus on robotics, and intelligent manufacturing, providing hands-on opportunities to students and researchers, while bridging the gap between academic output and market needs.

Private sector initiatives also play a pivotal role in aligning workforce development with market demands. They foster collaboration between academia and industry, providing infrastructure for research and commercialization in cutting-edge fields. Meanwhile, partnerships with private companies and international organizations have resulted in non-profit technical institutes offering world-class training in digital technologies and modern mobility. Together, these efforts underscore Saudi Arabia's commitment to building a robust and future-ready workforce, ensuring the Kingdom remains a global leader in innovation and economic diversification.

When it comes to new physical frontiers, the nation is preparing to significantly enhance its workforce through targeted educational and training programs. These programs will be integrated into KSA's educational system, from primary education to university levels, to foster a strong interest in space among young Saudis. Additionally, KSA plans to offer scholarships for advanced degrees in space-related fields at top international universities, aiming to create a new generation of Saudi space scientists and engineers. The establishment of the space focused center will further support these efforts by providing state-of-the-art facilities for research, training, and international collaboration. KSA also intends to create exchange programs that allow Saudi students and professionals to gain experience at leading global space institutions, ensuring that they are equipped with the skills necessary to lead future space missions.

4.3 Regulatory landscape

Status quo and current efforts

The Kingdom of Saudi Arabia has undertaken significant regulatory and policy reforms to support its ambitions in becoming a global leader in Economies of the Future. These reforms are essential in creating a conducive environment that facilitates innovation, investment, and growth across these sectors.

The regulation of Economies of the Future in KSA involves multiple stakeholders and entities, across various sectors, each contributing to advancements in AI, digital transformation, space, transportation, and smart cities. To ensure national alignment, cohesive efforts, and strategic direction, RDIA will coordinate with all relevant entities, fostering collaboration and driving innovation in line with Saudi Arabia's Vision 2030 goals.

KSA has developed and implemented several key policies, including ethical guidelines, data protection standards, and AI governance frameworks. One of the significant achievements under these efforts is the establishment of the AI Ethics Framework, which provides guidelines for the responsible development and deployment of AI technologies. This framework ensures that AI applications align with global ethical standards, focusing on issues such as fairness, transparency, and accountability. Moreover, KSA has also launched regulatory sandboxes that allow companies to test and develop AI solutions in a controlled environment before full-scale deployment. To further streamline AI innovation, KSA has collaborated with international partners, including UNESCO, to set up the International Center for AI Research and Ethics (ICAIRE). This center aims to advance global AI policies, making KSA a key player in the international AI regulatory space.

For the theme of cognitive urban living, KSA has recognized the need for a robust regulatory framework to manage the complexities of smart city technologies and ensure their safe and effective deployment. KSA is currently developing national standards for smart city infrastructure, which include regulations on data governance, cybersecurity, and IoT device management. These standards are part of a broader effort to create a unified regulatory approach that prevents fragmentation and ensures interoperability across various smart city platforms and applications. The regulatory efforts in smart cities are complemented by the development of specific laws and frameworks aimed at enhancing digital infrastructure. For example, the government has introduced new regulations for the deployment of 5G networks, focusing on spectrum management, network security, and the facilitation of public-private partnerships to accelerate the rollout of smart city technologies.

KSA is also establishing a comprehensive regulatory framework to support its growing ambitions in the fields of space and deep sea exploration. KSA is focusing on the development of space laws and regulations that align with international standards. These regulations are intended to govern activities such as satellite launches, space exploration, and the commercialization of space technologies. For instance, the ecosystem has been working on regulations that facilitate the development and launch of small satellites. This includes specific guidelines on satellite registration, frequency allocation, and orbital debris management to ensure that all space activities are conducted safely and sustainably. Additionally, the focus is on ensuring that KSA adheres to international space treaties and agreements. One significant effort in this area is KSA's commitment to the Outer Space Treaty and its involvement in the formulation of the Artemis Accords, which govern international cooperation in lunar exploration and the use of space resources.

Moreover, the Kingdom of Saudi Arabia is actively developing specific regulations for satellite communications, with an emphasis on spectrum management to support the growing demand for satellite-based services. KSA is also advancing efforts to regulate emerging space activities, such as space mining and in-orbit servicing. For example, the KSA has engaged with global leaders like NASA and ESA to co-develop policies that ensure the sustainability of space operations, particularly in managing space debris and ensuring the long-term usability of key orbits. Frameworks are also being developed that will facilitate private sector investment in space activities, including the development of spaceports and the establishment of a domestic space industry. This includes regulations that encourage foreign direct investment in Saudi space ventures, ensuring that KSA becomes a hub for space-related innovation in the region.

Outlook for regulatory landscape

The regulatory landscape for Economies of the Future is set to undergo significant transformations. KSA recognizes that a forward-looking, adaptable regulatory framework is essential to fostering innovation, ensuring safety, and maintaining ethical standards across these rapidly evolving sectors.

In the realm of AI and digital, KSA is expected to further refine its regulatory framework to keep pace with technological advancements and global standards. KSA plans to introduce comprehensive AI laws that cover aspects such as data privacy, AI ethics, and accountability in AI decision-making processes. These regulations will likely be designed to ensure that AI applications are used responsibly and transparently, aligning with international best practices while also addressing the unique needs of Saudi society. Additionally, KSA is expected to implement a robust AI governance framework that includes continuous monitoring and updating of AI regulations as the technology evolves. This may involve the creation of specialized regulatory bodies or advisory councils that include experts from academia, industry, and government to guide policy-making in AI.

For cognitive urban living, KSA is poised to establish a regulatory environment that facilitates the deployment of cutting-edge urban technologies while safeguarding public interests. KSA plans to introduce new laws that govern the use of data generated by smart city infrastructure, ensuring that data privacy and security are prioritized. This includes regulations for the management of IoT devices, data sharing between public and private entities, and the use of AI in public services. As part of these efforts, the government is expected to develop standards for interoperability and cybersecurity across smart city platforms, ensuring that different systems can work together seamlessly and securely. Moreover, regulatory frameworks will likely be adapted to encourage the adoption of green and sustainable technologies in urban planning, aligning with KSA's broader environmental goals. Public engagement will also be a key focus, with the government anticipated to introduce policies that promote citizen participation in smart city governance, ensuring that the benefits of smart cities are widely shared and that residents have a say in how these technologies are implemented.

KSA's regulatory landscape is also expected to expand significantly as KSA ramps up its space and deep sea activities. KSA is set to lead the development of comprehensive space laws that align with international treaties and standards, such as the Outer Space Treaty and the Artemis Accords. These regulations will cover areas such as satellite launches, space mining, and the commercialization of space technologies. KSA is likely to focus on establishing clear guidelines for the use of space resources, ensuring that any activities conducted in space are sustainable and environmentally responsible. Additionally, regulations will be introduced that support the growth of a domestic space industry, including incentives for private sector investment in space-related RDI. This may involve the creation of space-specific regulatory zones or innovation hubs that offer a more flexible regulatory environment to encourage experimentation and innovation in space technologies.

4.4 Ecosystem Infrastructure and Supply Chain

Status quo and current efforts

The Kingdom of Saudi Arabia is making substantial investments in building a robust ecosystem, advanced infrastructure, and resilient supply chains to support its ambitions in Economies of the Future. These efforts are crucial for creating an environment where innovation can thrive and where the necessary resources are available to sustain long-term growth across these strategic sectors.

In fact, **KSA is heavily investing in digital infrastructure to support the growing demands of AI and data-intensive applications.** A cornerstone of this initiative is the development of hyper-scale data centers, such as those being established in collaboration with global technology giants like Google and Oracle. These cloud regions within KSA are designed to provide the high-performance computing resources necessary for AI research and applications, ensuring that local companies and institutions have access to the latest in cloud computing technology. A prime example of these efforts is the recent launch of the Dammam 7 supercomputer[1] in collaboration with IBM. Dammam 7 is one of the most powerful supercomputers globally and is aimed at enhancing KSA's capabilities in areas such as energy, healthcare, and environmental modeling. In addition to digital infrastructure, KSA is also building a robust AI ecosystem through the establishment of innovation hubs, research centers, and startup accelerators. National Center for Artificial Intelligence has been launched, which provides a collaborative platform for research and development in AI. This center supports the creation and growth of AI startups by offering resources such as access to computing power, research funding, and partnerships with global tech firms. Furthermore, KSA is developing specialized technology parks, like the Riyadh Techno Valley, which are designed to foster collaboration between research institutions, startups, and industry leaders, thus driving innovation in AI and robotics.

KSA's infrastructure plan is also focused on creating interconnected urban systems that leverage IoT, AI, and big data. KSA is developing fully integrated, technologically advanced city that incorporates smart infrastructure from the ground up. KSA is leading the development of cognitive solutions that will drive the city's operations, including a city-wide cloud infrastructure that supports real-time data processing and decision-making. This infrastructure is critical for enabling the kind of responsive, data-driven urban management that is central to the concept of a cognitive city. KSA is also addressing the supply chain needs for smart cities through the development of local manufacturing capabilities for key technologies. KSA has initiated projects to localize the production of IoT devices, sensors, and other critical components required for smart city infrastructure. For instance, efforts are focused on developing and local manufacturing of IoT solutions within KSA. This venture aims to ensure that KSA can meet its own demand for these technologies while also positioning itself as a regional supplier.

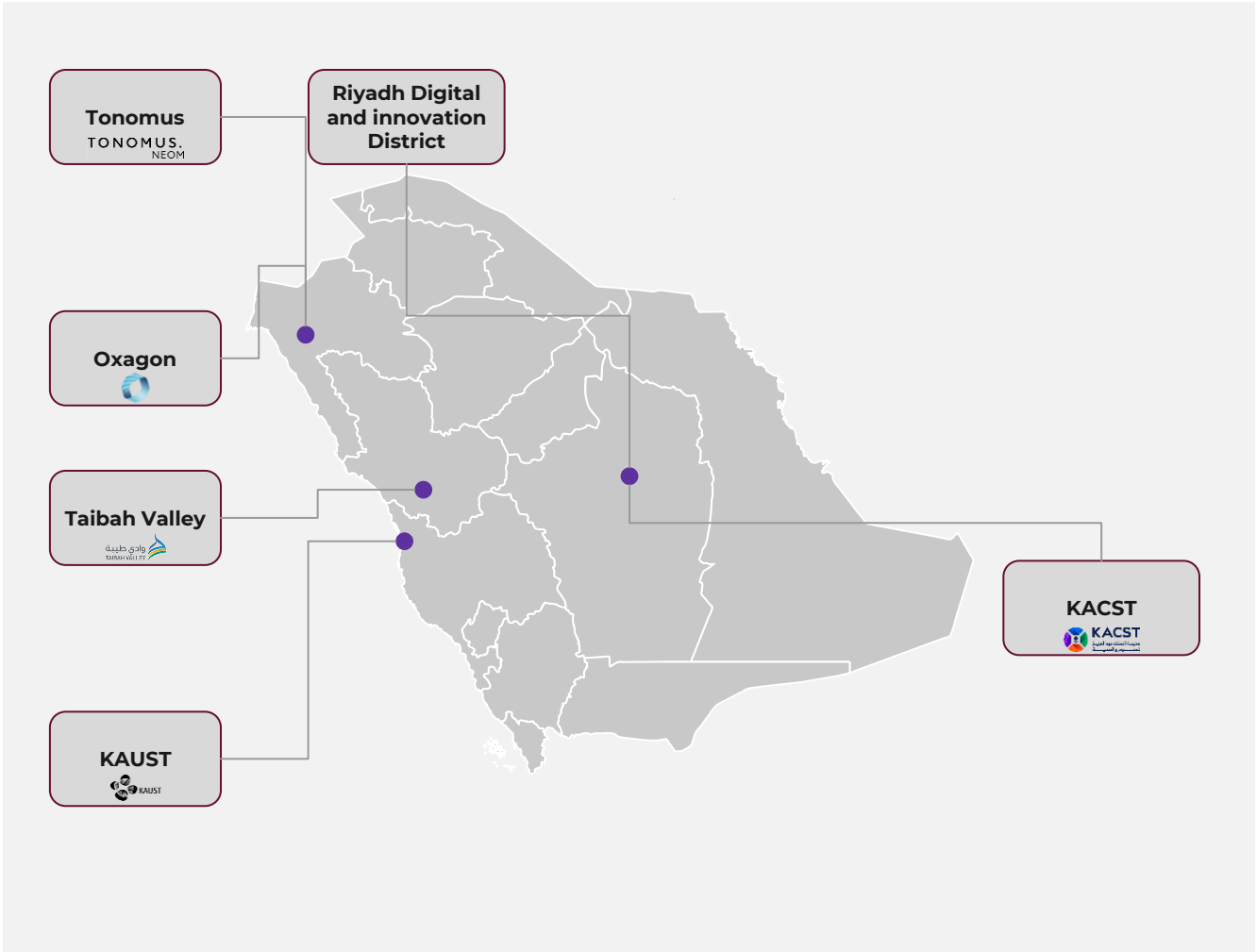
In the space and deep-sea exploration sector, KSA is prioritizing RDI to build a comprehensive and cutting-edge space ecosystem. KSA is investing in advanced infrastructure for satellite development, launch capabilities, and space research to drive innovation in space technologies and exploration. KSA is leading these efforts with ambitious projects, such as the planned Space Port, which will be a key hub for innovative space missions and satellite launches. This spaceport will not only serve government objectives but also stimulate innovation in commercial space activities, enabling KSA to become a global leader in satellite launches and space exploration. A strong focus on RDI is also seen in KSA's local satellite manufacturing capabilities. KSA, in collaboration with international partners like Lockheed Martin, is advancing local capabilities in satellite assembly and integration. The development of the Satellite Assembly, Integration, and Testing (AIT) Center is a pivotal step toward self-reliance and innovation in satellite production, reducing dependence on foreign suppliers and strengthening the resilience of the Saudi space supply chain.

Source: 1. The National News report

Furthermore, Neo Space Group (NSG) has been established, a national champion in the satellite and space sector, which will drive RDI in advanced space technologies and position the Kingdom of Saudi Arabia as a key player in global space innovation. NSG will enhance the space and satellite sector by developing local capabilities and boosting its strategic position within the growing global space economy. KSA is also investing in the infrastructure needed for deep-sea exploration. One prominent project is the Red Sea Research Center, which focuses on exploring the unique biodiversity and potential mineral resources of the Red Sea. The center is equipped with state-of-the-art research vessels, such as the R/V Thuwal, and advanced underwater robotics to conduct deep-sea research. These investments are not only aimed at scientific discovery but also at developing the technologies and infrastructure needed to exploit these resources sustainably, thereby supporting KSA's broader goals in marine and deep-sea exploration.

KSA's commitment to building a robust ecosystem, advanced infrastructure, and resilient supply chains is evident in these strategic investments and initiatives. KSA is driving innovation in wireless logistics through cutting-edge advancements in ecosystem infrastructure and supply chain technologies. Recent developments include the deployment of AI-driven wireless tracking systems, IoT-enabled smart warehouses, and drone-based delivery solutions, transforming how goods are managed and transported. The integration of 5G networks across logistics hubs ensures seamless connectivity, optimizing supply chain efficiency and reducing delays. By fostering an ecosystem that leverages advanced wireless technologies, KSA is enhancing transparency, reducing costs, and setting new benchmarks for global logistics innovation, aligning with its ambition to become a regional logistics hub.

Illustration 15: Multiple innovation clusters existing or to be launched in KSA with relevance to Economies of the Future



Outlook for ecosystem infrastructure and supply chain

The development of ecosystem infrastructure and resilient supply chains is becoming increasingly vital. The outlook for these areas is characterized by substantial investments, strategic partnerships, and a focus on building the necessary infrastructure to sustain long-term growth.

In the field of digital and AI, the Kingdom of Saudi Arabia is poised to significantly expand its digital infrastructure to meet the growing demands of these sectors. A key initiative includes the expansion of innovation hubs, which continue to serve as a central hubs for AI research and development, offering state-of-the-art computational resources and fostering collaborations with international tech companies. Additionally, KSA plans to develop new hyper-scale data centers, with global tech giants like Google and Oracle already committing to establishing cloud regions within KSA. These centers will provide the high-performance computing power necessary for advanced AI research and large-scale data processing. KSA is also expected to continue efforts to localize the production of AI hardware through partnerships with leading global technology firms, aiming to strengthen the local supply chain and reduce dependency on foreign imports.

For smart cities and cognitive urban environments, the KSA's future investments are centered around its megacity projects. Moreover, there is a strong focus on localizing the production of key technologies for smart cities. KSA is expected to continue developing technology parks which provide the infrastructure necessary for local manufacturing of IoT devices, sensors, and other essential smart city technologies. Public-private partnerships will play a crucial role, with ongoing collaborations anticipated between the government and international companies to develop and deploy the infrastructure needed for these smart city projects.

Universities are spearheading initiatives by launching state-of-the-art RDI centers like the National Center for Artificial Intelligence, which serves as a collaborative hub for startups and researchers. Meanwhile, the establishment of Dhahran Techno Valley provides critical infrastructure for innovation, bringing academia and industry together to commercialize cutting-edge research in engineering and smart mobility.

KSA's groundbreaking Project Transcendence, a $100 billion initiative[1], exemplifies the Kingdom's commitment to advancing its digital infrastructure. This ambitious project aims to develop AI-powered data centers, foster domestic startups, and create a talent pipeline to establish KSA as a global leader in AI. Collaborations with global tech giants like Google Cloud and Oracle, along with strategic investments in hyper-scale computing, enable high-performance capabilities essential for research and innovation across diverse sectors, from autonomous transportation to space technologies.

Additionally, Saudi Arabia is driving infrastructure in space and deep-sea exploration through initiatives like the Red Sea Research Center. These projects aim to enhance capabilities in satellite development, underwater robotics, and advanced logistics systems. Partnerships with international companies such as Lockheed Martin are supporting the development of a self-sufficient satellite industry, while investments in AI-driven supply chain solutions are transforming the nation's logistics sector. Together, these efforts ensure a resilient and innovation-driven ecosystem to support the Kingdom's long-term growth in future industries.

KSA is also focused on building a comprehensive space ecosystem. KSA is leading the development of infrastructure essential for satellite manufacturing, testing, and launching, while actively fostering partnerships with global aerospace companies to bring advanced space technologies to KSA. These efforts are designed to drive innovation in the space sector and facilitate the growth of a self-sufficient domestic space industry. Central to this initiative is the exploration of opportunities for local manufacturing of satellite components, which will enhance the resilience and independence of KSA's space sector. Additionally, RDI initiatives at leading institutions, particularly through the Red Sea Research Center, are contributing to the development of innovative technologies that can be applied to both space exploration and deep-sea research. These initiatives are closely aligned with KSA's broader plan to establish itself as a key player in the global space economy.

Source: 1. Arab News, "Why 2024 was a pivotal year for AI adoption and innovation in Saudi Arabia" (2024)

4.5 Linkages and Cultural Promotion

Status quo and current efforts

The Kingdom of Saudi Arabia has been actively fostering linkages and promoting a culture of innovation across the key themes of Economies of the Future. These efforts are designed to create a vibrant ecosystem where knowledge exchange, collaboration, and cultural acceptance of new technologies are encouraged.

KSA has made significant strides in promoting AI both culturally and through the establishment of linkages with global tech leaders. One of the key initiatives in this space is the Global AI Summit. This summit, first held in 2020, has become an annual event that gathers AI experts, policymakers, and industry leaders from around the world to discuss the future of AI. The summit serves as a platform for knowledge exchange, collaboration, and the promotion of AI in KSA, highlighting KSA's ambitions in this field. The event also includes cultural components, such as AI art exhibitions and public engagement sessions, aimed at making AI more accessible and understood by the general public. Additionally, KSA has organized events like the AI Artathon, which invites artists and AI developers to collaborate on projects that merge technology with art, showcasing the cultural possibilities of AI. Other notable events include a series of hackathons designed to engage the local population, particularly the youth, in AI-related activities and foster innovation by encouraging the practical application of AI technologies.

KSA has also initiated several programs and events to promote the concept and benefits of cognitive urban living to the wider public. The Smart City Expo Riyadh is a flagship event that brings together experts, government officials, and technology providers to discuss the latest trends in smart city development. This expo not only serves as a forum for industry linkages but also includes workshops and exhibitions aimed at educating the public about the benefits and functionalities of smart city technologies. Culturally, KSA is promoting the concept of smart cities through public awareness campaigns that emphasize the role of smart technologies in improving the quality of life. The Future Urbanism program includes public talks, workshops, and interactive exhibits designed to engage the community in discussions about the future of urban living. These efforts are complemented by educational programs in schools and universities that focus on urban planning, sustainability, and the role of technology in creating smarter cities.

KSA has also been instrumental in promoting the culture and awareness for new physical frontiers. KSA has been active in building partnerships with global space agencies such as NASA, ESA, and JAXA to foster collaboration and knowledge exchange. For example, the country participated in international space conferences and events, helping to position itself as a growing player in the global space community. Moreover, it has launched initiatives such as the Space Generation Program, which targets young Saudis with workshops, competitions, and scholarships designed to ignite interest in space sciences and exploration. These programs aim to engage the next generation of Saudi scientists and engineers, linking space exploration to the KSA's broader vision of innovation and leadership in the global space community.

Saudi Arabia has been proactive in establishing international collaborations to advance its Economies of the Future agenda. Notably, KSA has partnered with South Korea to explore AI and smart city technologies, aiming to integrate advanced solutions into urban development projects. Additionally, KSA has been instrumental in promoting sustainable development through AI-driven initiatives, enhancing environmental standards and resource management. These partnerships underscore KSA's commitment to leveraging global expertise to foster innovation within the country.

Saudi Arabia is actively fostering linkages and cultural promotion to strengthen its AI and digital ecosystem, driving collaboration between government, industry, and academia. Through global partnerships, innovation hubs, and knowledge-sharing platforms, the Kingdom is creating a dynamic environment for AI research, entrepreneurship, and technology exchange.

Outlook for linkages and cultural promotion

As the Kingdom of Saudi Arabia continues to advance its vision for the Economies of the Future, fostering linkages and promoting a culture of innovation will be crucial for sustaining momentum in the relevant fields. The future outlook for these efforts is centered on deepening international collaborations, enhancing public engagement, and integrating these advanced technologies into the cultural fabric of KSA.

KSA is expected to expand its international linkages through partnerships with leading global institutions, research centers, and technology companies. This will involve not only participating in global forums and summits but also hosting world-class events that bring together experts, innovators, and policymakers from around the world. The Global AI Summit, for example, is likely to grow in prominence as a key platform for showcasing KSA's advancements in AI and fostering global collaborations. Additionally, KSA plans to increase its involvement in international smart city initiatives, positioning megacity projects as models of future urban living that other countries can learn from and collaborate on. These efforts will be supported by increased participation in global space exploration initiatives, with KSA expected to form new partnerships and join international missions. These events engage global AI experts and developers in solving real-world problems using AI, positioning Saudi Arabia as a leader in AI-driven innovation.

Cultural promotion will play an equally important role in embedding these technologies within Saudi society. KSA plans to enhance public awareness and acceptance of AI, smart cities, and space exploration through targeted educational programs, public exhibitions, and media campaigns. These initiatives will aim to demystify complex technologies and highlight their potential benefits to everyday life. For instance, the Saudi government is likely to expand its support for hackathons, AI artathons, and innovation challenges that engage the youth and broader public in the development and application of these technologies. Training programs will continue to be key tools for fostering local talent and promoting a culture of innovation among Saudi citizens. In addition to educational and public engagement efforts, KSA is expected to launch more initiatives that connect cultural heritage with modern technology. This might include projects that use AI and smart city technologies to preserve and promote Saudi Arabia's rich cultural history. In October 2025, KSA is hosting the Times Higher Education World Academic Summit, a landmark event aligning with Vision 2030 to emphasize the role of universities in fostering progress and innovation. This event underscores KSA's global stature as a hub for collaborative research in cutting-edge fields such as AI, space technologies, and modern mobility.

KSA is also poised to expand its footprint in global research initiatives by establishing specialized R&D centers in key areas such as AI ethics, autonomous transportation, and green energy. These centers will serve as hubs for collaboration with international experts, ensuring that Saudi-led innovations contribute to global advancements. Additionally, KSA is planning to launch public engagement platforms such as interactive exhibitions and digital labs, allowing citizens to experience and understand the potential of emerging technologies. These initiatives aim to inspire a new generation of innovators while embedding advanced technologies into the cultural and societal framework of KSA.

Looking ahead, KSA plans to deepen its international collaborations and enhance public engagement to embed advanced technologies into its cultural fabric. KSA is set to host the Global Smart City Forum, bringing together experts, government officials, and technology providers to discuss the latest trends in smart city development. Furthermore, initiatives are expected to continue to engage the local population, particularly the youth, in AI-related activities and fostering a culture of innovation. These efforts aim to ensure that as KSA modernizes, it maintains a strong connection to its cultural heritage.

4.6 Governance Model

RDIA, in collaboration with all relevant stakeholders for Economies of the Future will steer research, development and innovation in the field across KSA. By employing a strategic, mission-oriented approach, RDIA and the ecosystem stakeholders work together to ensure that RDI initiatives are closely aligned with the Kingdom of Saudi Arabia's objectives of diversifying the economy and advancing future capabilities. This governance model not only drives the KSA's Economies of the Future agendas, but also fosters an environment conducive to innovation, paving the way for a resilient and forward-looking technological landscape.

- **Strategic mission governance:** To ensure effective oversight and execution of transformative initiatives, RDIA has established dedicated Mission Steering Committees in collaboration with academia, industry, and government experts. These committees are entrusted with advancing key missions, including the development of AI technologies, smart city infrastructure, and space exploration initiatives. By aligning their efforts with KSA's strategic priorities, these expert-led committees play a pivotal role in driving precise and impactful execution of each mission.
- **Engagement with key stakeholders:** A cornerstone of RDIA's approach is fostering a collaborative ecosystem through active engagement with stakeholders across sectors. Partnering ministries, universities, research institutions, industry leaders, and international collaborators are brought together to exchange knowledge, share resources, and co-create innovative solutions. This extensive collaboration ensures that initiatives in AI, smart cities, and space exploration benefit from collective expertise, accelerating the KSA's transition into a leader in cutting-edge technologies and next-generation industries.
- **Policy development and implementation:** Policy landscape that strongly supports research, development, and innovation in critical sectors is being developed and adopted. In partnership with relevant government ministries and agencies, it develops and enforces policies aimed at promoting the commercialization of advanced technologies, fostering sustainable innovation, and nurturing high-tech industries. By establishing clear regulatory frameworks, RDIA ensures that these efforts align with national economic objectives and position KSA as a global leader in AI, smart cities, and space exploration.
- **Sector-wide coordination:** Coordination across the AI, smart cities, and space sectors is essential for achieving the KSA's strategic objectives. RDIA works closely with relevant ministries and stakeholders, including both public and private entities, to align all efforts with the national RDI priorities. This coordination is facilitated through advisory councils and specialized committees that provide technical and scientific expertise, ensuring that RDI initiatives are cohesive and strategically aligned. This integrated approach ensures that KSA's efforts in these sectors can respond effectively to both domestic needs and global opportunities.
- **Monitoring and evaluation:** Key component of the governance model is the continuous monitoring and evaluation of ongoing RDI projects and initiatives within the AI, smart cities, and space exploration sectors. RDIA, along with its governmental partners, ensures that projects are progressing as planned and delivering the intended economic, technological, and societal outcomes. This rigorous oversight guarantees accountability and transparency, ensuring that all initiatives contribute meaningfully to the KSA's long-term goals in the Economies of the Future.

Through this structured and collaborative governance model, RDIA and its partners ensure that KSA's key sectors are not only aligned with national priorities but are also positioned to make a significant impact on the global stage. By leveraging robust policies, strategic coordination, and continuous stakeholder engagement, the Kingdom is laying the foundation for a future where it leads in innovation and excellence across AI, smart cities, and space exploration.

SUCCESS STORIES

Illustration 16: Kingdom of Saudi Arabia has made exemplary progress across multiple fronts in Economies of the Future

'ALLaM' marks a significant leap for Arabic language capabilities in AI development

KSA announced the launch of open-source Arabic Large Language Model (LLM), 'ALLaM'. It is the first Saudi-developed AI system designed to answer user questions regarding different knowledge domains in Arabic. This groundbreaking model leverages cutting-edge AI technology.

First ever Saudi made humanoid robots

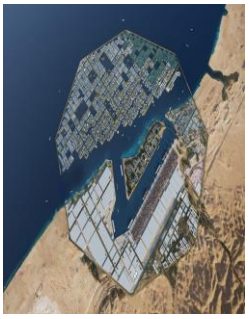
KSA introduced its first humanoid robots, Sara and Mohammad built locally. These robots are designed to reflect Saudi cultural values while showcasing cutting-edge AI capabilities. Sara is powered using a proprietary large language model, avoiding reliance on external programs such as ChatGPT.

KSA's first female astronaut reached ISS

KSA successfully sent its first female astronaut, Rayyanah Barnawi, to the International Space Station (ISS), accompanied by Saudi astronaut Ali A Qarni. During their time on the ISS, they conducted 14 scientific experiments, 11 of which were pioneering research studies in microgravity. These experiments spanned various fields of science, adding valuable insights and contributing to the global understanding of space and impact on various scientific phenomena.

Pioneering the future of livability

KSA has one of the largest and most ambitious development projects globally, covering an area of ~26,500 square kilometers and will be powered by 100% renewable energy. Oxagon, the advanced manufacturing and innovation city, commenced construction on its research and innovation (R&I) campus. Spanning over 200,000 square meters, it will feature cutting-edge labs, prototyping areas, co-working spaces, and digitally enabled facilities.



Riyadh Smart City Transformation

Riyadh's Smart City Transformation is a flagship initiative driving urban innovation through AI, IoT, and digital infrastructure. The city has implemented AI-driven traffic management systems, reducing congestion, and smart energy grids, cutting energy consumption. With IoT-enabled sensors deployed across public services, Riyadh is enhancing citizen quality of life while fostering sustainable growth.

Source: IoT World, Saudi Gazette; KSA Giga-projects, MEP Middle East, Argaam;

SUCCESS STORIES

KSA has made exemplary progress across multiple fronts in Economies of the Future

Trial of smart, self driving vehicle

KSA has taken a major leap forward in transportation innovation with the launch of its trial phase for 'Dhahaina' ('Smart'), a self-driving electric vehicle (AV). Aligned with the objectives set in the National Transport and Logistics Strategy, this initiative seeks to provide smart mobility solutions that anticipate future market developments.

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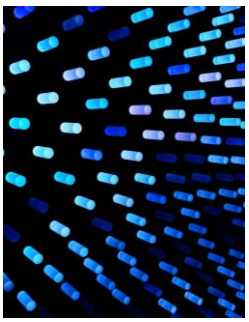
First Arabic AI Center for Natural Language Processing

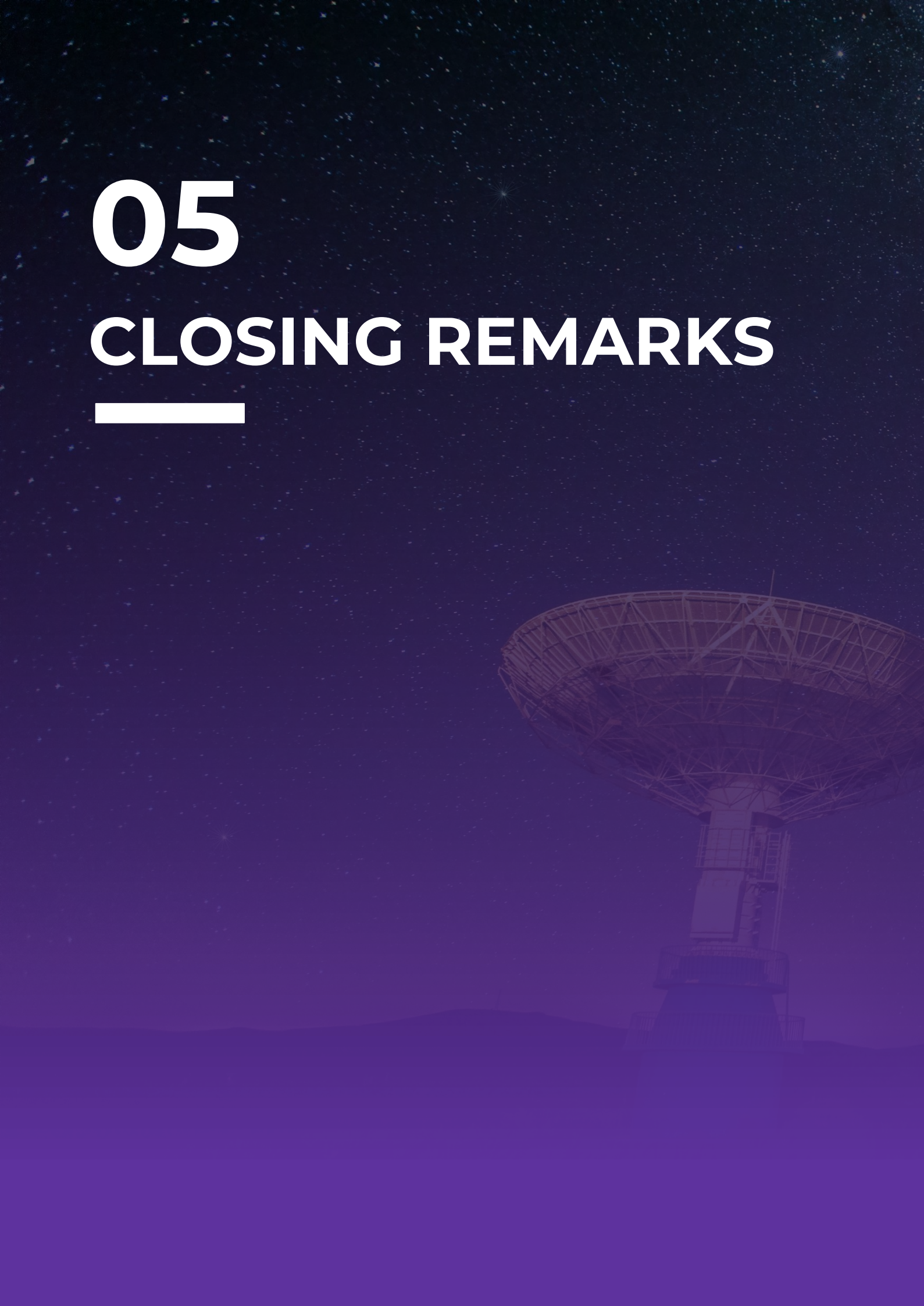


King Salman Global Academy for Arabic Language (KSGAAL) unveiled its Arabic AI Center, the premier hub for Natural Language Processing (NLP). The center focuses on creating linguistic resources, developing cutting-edge computer tools and applications, and ultimately revolutionizing Arabic natural language processing for language interpretation and generation.

These success stories highlight KSA's leadership in Economies of the Future. By investing in innovative advancements and fostering strategic partnerships, KSA is progressing towards its goal of becoming a global leader in future-oriented economies.

Source: Wired;

05
CLOSING REMARKS



As we conclude this comprehensive exploration of the Kingdom of Saudi Arabia's ambitious journey toward shaping the Economies of the Future, it is evident that the nation stands at the cusp of a transformative era. The strategic initiatives and forward-thinking policies outlined in this report reflect a robust commitment to driving innovation, fostering sustainable development, and positioning KSA as a global leader in emerging technologies and industries.

Our journey is characterized by a mission-oriented approach that not only addresses the grand challenges of today but also lays a resilient foundation for the future. By leveraging cutting-edge technologies in AI, smart cities, space exploration, and deep-sea research, KSA is not just adapting to the rapidly evolving global landscape but is actively shaping it. The strategic investments in human capital, infrastructure, and governance ensure that KSA is well-prepared to navigate the complexities of the 21st century and beyond.

The path forward is clear: to continue building on the strong momentum already achieved, to deepen our collaborations both locally and globally, and to relentlessly pursue excellence in every domain of research, development, and innovation. The Economies of the Future are not merely an aspirational goal but a strategic imperative that will secure KSA's place at the forefront of global innovation.

As we move forward, the collective efforts of government entities, private sector partners, academic institutions, and international collaborators will be crucial in realizing the ambitious vision laid out in this report. Together, we are creating a future where technological leadership, sustainable practices, and human ingenuity converge to create unprecedented opportunities for growth and development.

KSA's commitment to this journey is unwavering. As we continue to innovate, adapt, and lead, we are confident that KSA will emerge not only as a beacon of innovation in the region but as a global powerhouse in the Economies of the Future.

LIST OF ILLUSTRATIONS

GLOSSARY

Abbreviations	Full form
AAL	Average Annual Loss
AGI	Artificial General Intelligence
AI	Artificial Intelligence
AIT	Assembly, Integration, and Testing
AR	Augmented Reality
CAGR	Compound annual growth rate
CCTV	Closed-Circuit Television
Cobots	Collaborative robots
CoEs	Centers of Excellence
DLT	Distributed Ledger Technology
ESA	European Space Agency
EU	European Union
EV	Electrical Vehicle
FBB	Fixed Broadband
FDI	Foreign Direct Investment
FD-RAN	Fully-decoupled Radio Access Network
FTTB	Fiber to the Building
FTTH	Fiber to the Home
GCI	Global Connectivity Index
GDP	Gross Domestic Product
Gen AI	Generative Artificial Intelligence
GEO	Geostationary Earth Orbit
GII	Global Innovation Index
HPC	High-Performance Computing
ICAIRE	International Center for AI Research and Ethics
IDC	International Data Corporation
IMD	International Institute for Management Development
IoT	Internet of Things
ISR	Intelligence, surveillance, and reconnaissance
IT/ITC	Information Technology
JAXA	Japan Aerospace Exploration Agency
KACST	King Abdulaziz City for Science and Technology
KAFD	King Abdullah Financial District
KAUST	King Abdullah University of Science and Technology
LEO	Low Earth Orbit
LT	Language Technology

GLOSSARY

Abbreviations	Full form
MBB	Mobile Broadband
Mbps	Megabits per second
MDDI	Ministry of Digital Development and Information
MDO	Multidisciplinary design optimization
MENA	Middle East and North Africa
MEO	Medium Earth Orbit
MR	Mixed Reality
MTDCs	Multi-tenant Data Centres
MW	Megawatt
NASA	National Aeronautics and Space Administration
NICDP	National Industrial Corridor Development Programme
NISQ	Noisy Intermediate-Scale Quantum
NLP	Natural Language Processing
OEM	Original equipment manufacturer
PIF	Public Investment Fund
PNT	Positioning, navigation, and timing
RDI	Research, Development, and Innovation
RDIA	Research, Development, and Innovation Authority
RFID	Radiofrequency Identification
ROVs	Remotely Operated Vehicles
SAF	Sustainable Aviation Fuel
SAR	Saudi Riyal
SLAM	Simultaneous Localization and Mapping
STV	Saudi Technology Ventures
UAM	Urban Air Mobility
UK	United Kingdom
UNCATD	United Nations Conference on Trade and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States
USD	United States Dollar
UTM	UAV Traffic Management (UTM)
V2I	Vehicle to Infrastructure
VC	Venture Capital
VR	Virtual Reality
WEF	World Economic Forum

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