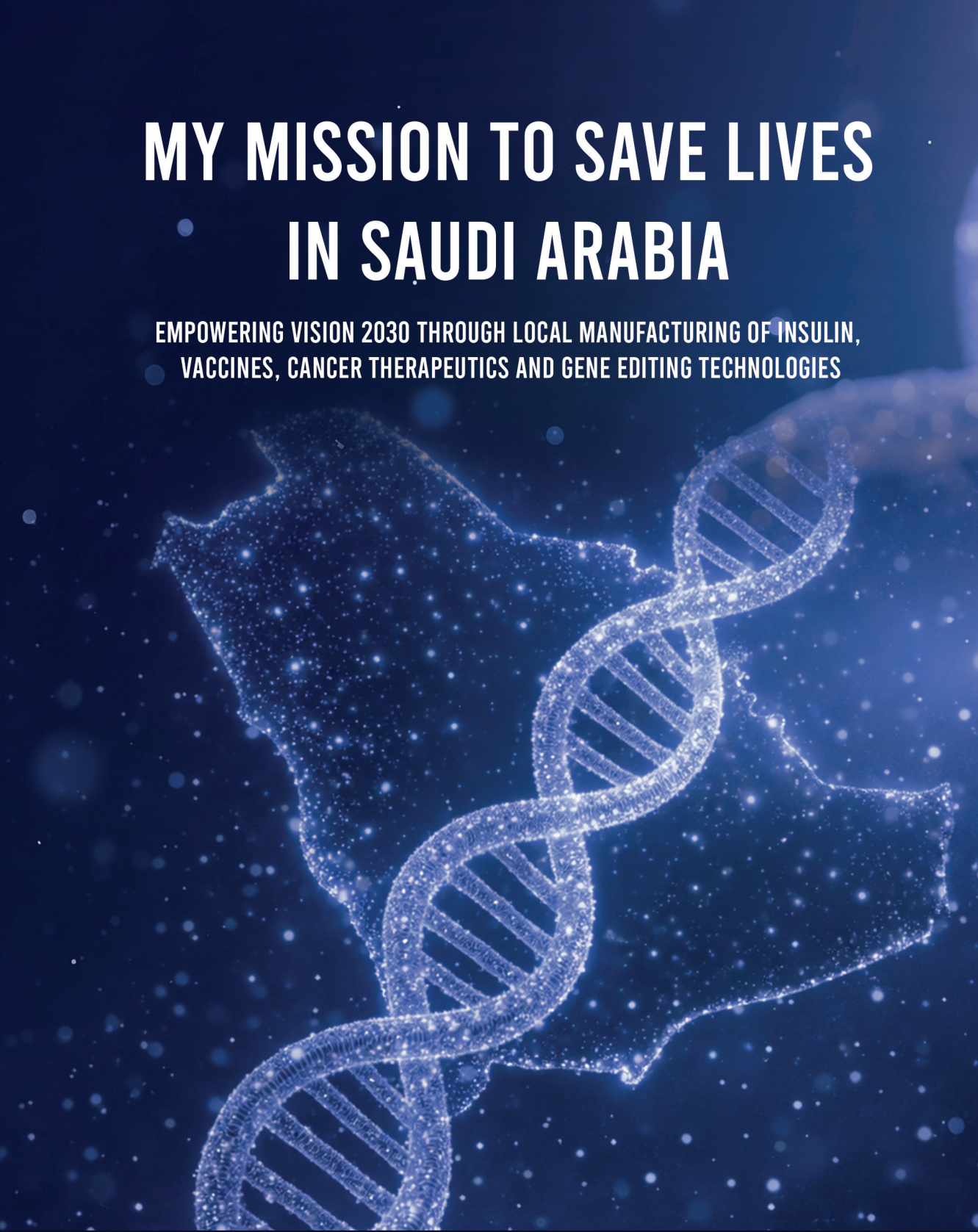
MY MISSION TO SAVE LIVES IN SAUDI ARABIA

EMPOWERING VISION 2030 THROUGH LOCAL MANUFACTURING OF INSULIN, VACCINES, CANCER THERAPEUTICS AND GENE EDITING TECHNOLOGIES



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First edition.

Preface

In medicine, the difference between security and vulnerability is often measured by the quiet availability of a few essential treatments: insulin for the patient who depends on it each day, vaccines prepared before an outbreak gathers force, and cancer therapies that must be available when treatment cannot wait. We often speak of healthcare in terms of hospitals, physicians, and technology, and rightly so. Yet behind all of these stands a more fundamental question: can a nation ensure that the medicines on which life depends are available, affordable, and within reach when they are needed most?

For me, that question has never been theoretical. It has shaped the work of my life. Over more than three decades, I have devoted myself to helping build in Saudi Arabia the capability to manufacture essential medicines and advanced biotechnology products within the Kingdom itself. This has meant working not only to localize insulin production, vaccine manufacturing, and cancer therapeutics, but also to lay the foundations of a broader national biotechnology ecosystem, one capable of serving our people in ordinary times and protecting them in moments of crisis.

This book is the account of that mission. It is the story of a conviction that grew stronger with experience: that health security cannot rest indefinitely on dependence. A country may import medicines, technologies, and expertise for many years, but sooner or later it must decide whether it will remain only a consumer of what others produce, or whether it will acquire the knowledge, institutions, and industrial capacity to produce for itself. In the field of biotechnology, that choice carries consequences not only for the economy, but for dignity, resilience, and life itself.

My journey has unfolded alongside a wider transformation in the Kingdom of Saudi Arabia. The National Biotechnology Strategy, launched under the leadership of HRH Crown Prince and Prime Minister Mohammed bin Salman in January 2024, represents a decisive national commitment to the future of biotechnology in our country. Its ambition is not limited to scientific progress alone. It is also an expression of national purpose: to strengthen self-reliance in vaccines, biomanufacturing, genomics, and related fields, while building a sector capable of contributing to economic diversification, public health, and global medical progress.

In many respects, this national strategy gives formal expression to aspirations that have long guided my own work. My mission has never been solely about industry, and never solely about science. It has always been about people: the diabetic patient whose life depends on reliable insulin supply; the child protected by vaccination; the cancer

patient whose treatment must not be delayed; the young Saudi scientists, engineers, and professionals whose talent can build a stronger future for the Kingdom. To localize biotechnology manufacturing is, in the end, to protect lives, strengthen institutions, and widen the horizon of what our nation can achieve.

This journey has demanded perseverance, partnership, and faith. It has involved vision, setbacks, and renewal. It has required not only scientific and industrial effort, but also the patience to build institutions, the courage to persist when progress was slow, and the belief that Saudi Arabia could and should take its place among the nations shaping the future of biotechnology. If there is one thread running through all that follows, it is the belief that the localization of biotechnology manufacturing is not merely an economic ambition. It is a national responsibility.

In the pages that follow, I invite the reader into that journey: into the ideas that inspired it, the institutions that were built, the challenges that had to be faced, and the larger hope that gives all of it meaning. This book is both a personal record and a national story. Above all, it is offered in the belief that by building the capacity to make life-saving medicines within our own country, we do more than develop an industry. We affirm the value of human life, the dignity of national self-reliance, and the responsibility to prepare wisely for the future.

Dr. Khaled Al-Mosa
Riyadh, 2026

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Introduction

Scientific advancement has brought humanity to a threshold at which biological processes are no longer only observed in nature: they can be understood, designed with, and directed toward urgent human needs. Biology has become not only a field of knowledge, but a source of manufacturing capability through which medicines, vaccines, and therapies can be produced where they are required.

"Our world is built on biology and once we begin to understand it, it then becomes technology."

- Ryan Bethencourt

Bethencourt's point is that biology, understood, becomes a tool for production.

Biotechnology, as it is understood today, has bestowed immeasurable benefits upon humanity, with proportions that were once unimaginable. It serves as the gateway to boundless possibilities and extraordinary breakthroughs that have the potential to revolutionize the way we live, heal, and sustain our planet. Through biotechnology, we are reminded that we are living in an era where science holds the promise of improving lives in ways that were previously beyond our imagination.

"Biotechnology is the future. It is the only way we are going to be able to feed and fuel the world's growing population."

- Craig Venter

Venter sets the stake plainly: biotechnology is now indispensable to feeding and powering the world.

The term biotechnology has been characterized from various perspectives. Fundamentally, biotechnology is defined as "the application and manipulation of technology that reflects biological processes upon whole or part of a living organism in their natural form, in order to produce a product, a system, a new environment, or to solve problems."

Based on different perspectives, Biotechnology is defined in various ways by different countries and organizations. In Australia, it is defined as the devising, optimizing, and scaling-up of biochemical and cellular processes for the industrial production of useful compounds. The defining feature is the involvement of biological catalysts. In its broadest sense, biotechnology includes industrial processes based on biological systems involving naturally occurring microorganisms, microorganisms modified by genetic engineering, or isolated cells of plants or animals. It also involves the genetic manipulation of cells to

produce new strains of plants or animals.

Definitions of biotechnology vary across jurisdictions, each reflecting national priorities. Canada describes it as the application of biological organisms, systems, or processes to manufacturing or service industries, using microbial, plant, or animal cells. The European Federation of Biotechnology defines it as the integrated use of biochemistry, microbiology, and engineering sciences to achieve industrial application of microorganisms, cultured tissue cells, and parts thereof. Germany frames it as the introduction of biological methods within technical processes and industrial production, integrating microbiology, biochemistry, technical chemistry, and process engineering. France treats it as the industrial exploitation of microorganisms, animal and plant cells, and subcellular fractions derived from them. The International Union of Pure and Applied Chemistry (1981) defines it as the application of biochemistry, biology, microbiology, and chemical engineering to industrial processes and products across healthcare, energy, agriculture, and the environment. Japan considers it a technology that uses biological phenomena to copy and manufacture useful substances. The Netherlands views it as the science of production processes based on the action of microorganisms and their active components, and the use of cells and tissues from higher organisms, excluding medical technology, agriculture, and traditional crop breeding. The FDA defines biotechnology as the application of biological systems and organisms to technical and industrial processes. Biotechnology is defined in the UK as the application of biological organisms, systems, or processes to manufacturing and service industries. The Swiss Government adopts the same definition as the European Federation of Biotechnology, which describes biotechnology as the integrated use of biochemistry, microbiology, and engineering sciences to achieve the technological (industrial) application of the capabilities of microorganisms, cultured tissue cells, and parts thereof. Lastly, the OECD describes biotechnology as the application of scientific and engineering principles to the processing of materials by biological agents to provide goods and services, encompassing techniques such as gene and RNA vectors, bioinformatics, and nanobiotechnology.

These definitions reflect the diverse perspectives and applications of biotechnology across different regions and sectors. For Saudi Arabia, however, this is not a theoretical matter. It determines whether insulin can be supplied reliably, whether vaccines can be produced in a crisis, whether cancer therapies can be made accessible, and whether the Kingdom stands only as a purchaser of advanced medicines or also as a producer. Biotechnology encompasses a wide range of techniques, including gene and RNA vectors, bioinformatics, and nanobiotechnology, among others. It is a field that continues to evolve, driven by scientific advancements and the growing need to address complex

global challenges.

The Phases of Biotechnology Development

The rapid advancements in biotechnology have launched a series of transformative phases, each marked by groundbreaking discoveries and developments that address human needs in unprecedented ways. Biotechnology's progress has been driven by keen observations and their practical applications, evolving in complexity with the advent of new technologies and a deeper understanding of life-science principles.

By tracing the evolution of biotechnology, we can categorize its development into three distinct stages:

Ancient Biotechnology

The Ancient Biotechnology Phase encompasses the earliest period of human history, dating back to prehistoric times when humans first began to harness natural processes for practical purposes. It is characterized by simple observations and rudimentary techniques applied to food, clothing, and shelter, and includes the use of fermentation to produce bread, beer, and wine. Early agricultural practices, including the domestication of plants and animals, also fall under this category.

Key discoveries during this phase include:

- *Fermentation:* One of the earliest and most significant discoveries in ancient biotechnology was fermentation. Early humans observed that certain foods and beverages could be transformed through natural processes involving microorganisms. Fermentation was used to produce bread, beer, and wine, revolutionizing food preservation, and production. For example, grains were fermented to produce beer, and grapes were fermented to produce wine. These processes not only enhanced the flavor and nutritional value of food but also allowed for longer storage periods.
- *Domestication of Plants and Animals:* The domestication of plants and animals marked a major milestone in ancient biotechnology. Early humans transitioned from a nomadic lifestyle of hunting and gathering to settled agricultural practices. They began to selectively breed plants and animals to improve yield and utility. Key examples include:
- *Crops:* Early humans domesticated crops like wheat, rice, and barley, selecting for traits such as higher yield, better taste, and easier harvesting. This led to the development of stable food supplies and the establishment of agricultural societies.
- *Animals:* The domestication of animals such as cattle, sheep, and goats provided a reliable source of meat, milk, and wool. Selective breeding improved the traits of

these animals, making them more suitable for human use.

- *Cheese and Curd Production:* Ancient biotechnology also saw the discovery of various food products through observation. Cheese, for example, is one of the earliest biotechnological products. Early humans discovered that adding rennet to sour milk resulted in the formation of cheese. Similarly, curd was produced through the fermentation of milk. These products were valuable for their nutritional content and longer shelf life.
- *Yeast Utilization:* Yeast, one of the oldest exploited microbes, played a crucial role in ancient biotechnology. It was used to make bread, vinegar, and alcoholic beverages. The use of yeast in bread-making allowed us to produce leavened bread, which was lighter and more palatable. Vinegar, with its low pH, was particularly valuable for food preservation.
- *Food Preservation and Storage:* Early humans developed various methods for preserving and storing food. They used cold caves to store perishable items and created pots for storing grains and liquids. These techniques ensured a stable food supply and reduced the risk of spoilage.
- *Crossbreeding and Animal Breeding:* Ancient biotechnology also included the practice of crossbreeding and animal breeding. One of the earliest examples of crossbreeding is the mule, an offspring of a male donkey and a female horse. Mules were used for transportation, carrying loads, and farming before the advent of tractors and trucks. This practice marked the beginning of systematic animal breeding and showcased the benefits of crossbreeding for human use.

Before the year 1800, numerous developments in biotechnology can be regarded as significant discoveries or advancements. These early innovations stemmed from simple observations about nature and were applied to improve human life, addressing basic needs such as food, clothing, and shelter. Initially, early humans relied on raw meat from scavenging, but they eventually transitioned to agriculture. This shift allowed them to cultivate food near their shelters, ensuring a stable food supply. They understood the importance of water, light, and other factors for optimal plant growth. By sowing plant seeds near their homes and domesticating animals, early humans were able to enhance their living conditions and reduce the dangers associated with hunting.

This period also saw the initial development of farming techniques and food storage, together with the first systematic crossbreeding of animals. breeding. One of the earliest examples of crossbreeding is the mule, an offspring of a male donkey and a female horse. Mules were used for transportation, carrying loads, and farming before the advent of tractors and trucks. This practice marked the beginning of systematic animal breeding

and showcased the benefits of crossbreeding for human use.

These ancient developments laid the groundwork for modern biotechnology. The advancements made during this phase were driven by practical needs and a deep understanding of the natural world. Early humans learned to manipulate biological processes to their advantage, setting the stage for more sophisticated interventions in later phases of biotechnology.

Classical Biotechnology

The Classical Biotechnology phase emerged during the 19th and early 20th centuries. It saw significant advances in the understanding and manipulation of biological systems, including selective breeding and hybridization, which improved agricultural practices and produced more resilient crops and livestock. This era extended up to the mid-20th century and was characterized by the application of scientific principles to enhance agricultural practices, food production, and medical treatments. The discovery of enzymes and their role in biochemical reactions further propelled the field, enabling the industrial production of various biological products. The advancements made during this era were driven by observations and scientific evidence, leading to practical applications that improved human life.

Key discoveries during this phase include:

- *Pasteurization:* One of the most notable advancements during this phase was the development of pasteurization by Louis Pasteur in the mid-1800s. Pasteurization involves heating liquids to kill harmful microorganisms, significantly improving food safety and public health1. This process revolutionized the dairy industry and other sectors by ensuring the safety of consumable liquids.
- *Discovery of Enzymes:* The identification of enzymes and their catalytic properties was another milestone. Enzymes are biological catalysts that accelerate chemical reactions in living organisms. Their discovery facilitated the industrial production of various biological products, such as cheese and bread, transforming food processing.
- *Mendelian Genetics:* Gregor Mendel, often referred to as the "Father of Genetics," conducted experiments on pea plants in the mid-19th century. His work led to the formulation of the principles of inheritance, including dominant and recessive traits, and independent assortment. Mendel's discoveries laid the foundation for the field of genetics, which is integral to modern biotechnology.
- *Hybridization:* The creation of hybrid plants, such as hybrid corn, was a significant development during this phase. Hybridization involves crossbreeding plants to produce offspring with desirable traits, leading to increased agricultural productivity

and food security. This technique has been instrumental in developing crops that are more resilient to diseases and environmental stresses.

- *Fermentation:* Although fermentation was practiced long before the Classical Biotechnology phase, its scientific basis was elucidated during this period. Louis Pasteur's germ theory demonstrated the role of microorganisms in fermentation, leading to the production of alcoholic beverages, bread, and vinegar. This understanding paved the way for controlled fermentation processes in various industries.

The discoveries and innovations of Classical Biotechnology laid the groundwork for the Modern Biotechnology phase, where genetic engineering and recombinant DNA technology would further revolutionize the field. By enhancing our understanding of biological systems and their applications, Classical Biotechnology has contributed significantly to the progress of biotechnology as we know it today.

Modern Biotechnology

The Modern Biotechnology phase began in the latter half of the 20th century and continues to the present day. This phase is characterized by groundbreaking discoveries and technological innovations, including genetic engineering, recombinant DNA technology, and the development of sophisticated tools for manipulating genetic material. These advancements have revolutionized medicine, agriculture, and industrial processes, leading to the creation of genetically modified organisms (GMOs), biopharmaceuticals, and other cutting-edge applications.

Key discoveries during this phase include:

- *Recombinant DNA Technology:* The development of techniques to splice and recombine DNA from different organisms, leading to the production of insulin and other biopharmaceuticals, transforming healthcare.
- *CRISPR-Cas9:* A revolutionary gene-editing technology that allows for precise modifications to the genome, with applications in medicine, agriculture, and beyond, opening a new era of genetic engineering.
- *Human Genome Project:* The complete mapping of the human genome, which has provided invaluable insights into genetics and paved the way for personalized medicine, revolutionizing our understanding of human biology.
- Through these phases, biotechnology has evolved from simple observations to complex applications, driven by technological innovations and a deeper understanding of life-science principles. Each phase has contributed to the development of biotechnology as we know it today, offering endless possibilities and remarkable breakthroughs

that have the potential to revolutionize the way we live, heal, and sustain our planet.

As the field of biotechnology continues to evolve, its history is being enriched by a myriad of technological advancements. These advancements have led to the application of biotechnology across various fields and sub-disciplines, each distinguished by a unique color code based on common uses and applications (Figure 1.1).

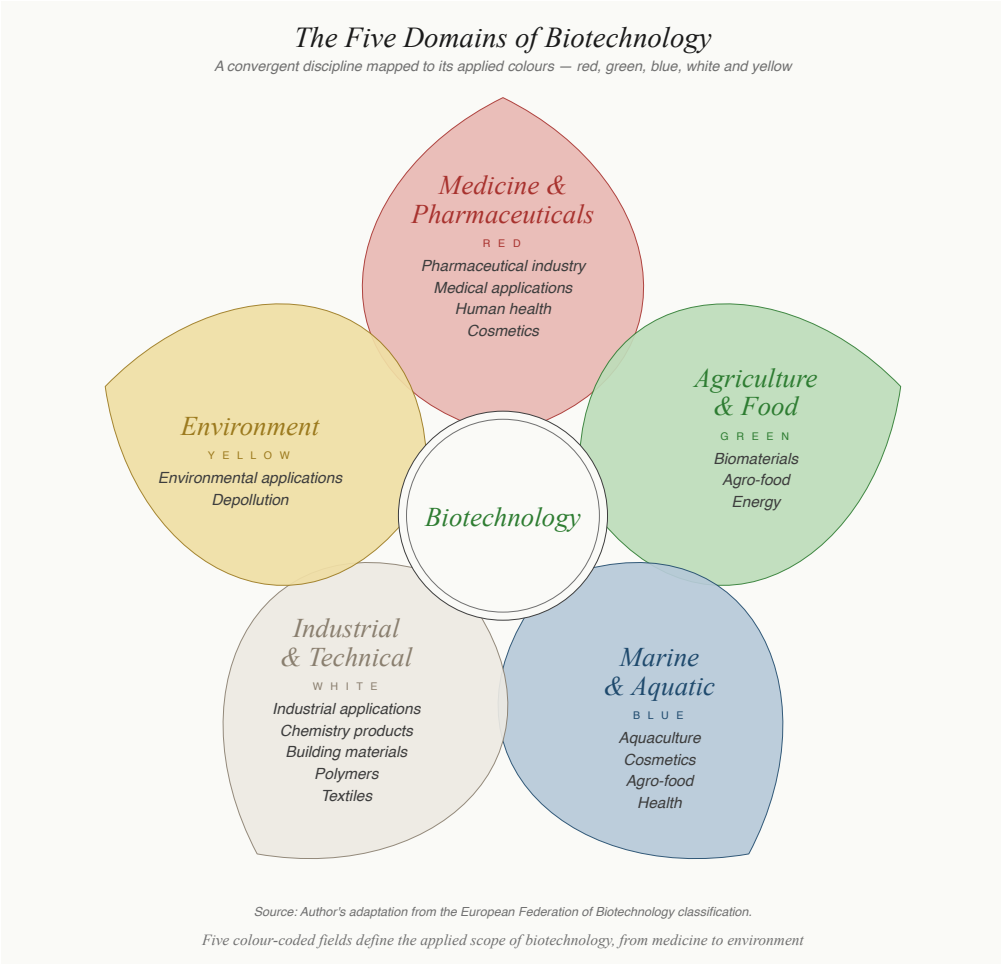

Figure 1.1

Main applications of biotechnology using the color codes.

Red: This color signifies the application of biotechnology in the medical and pharmaceutical industries. It encompasses the development of new drugs, vaccines, and diagnostic tools, as well as advancements in gene therapy and regenerative medicine.

Red biotechnology is pivotal in improving healthcare outcomes and addressing complex medical challenges.

Green: Represents application of biotechnology in agriculture, food production, biomaterials, and energy, green biotechnology focuses on enhancing crop yields, developing pest-resistant plants, and creating sustainable biofuels. It also includes the production of biodegradable materials and the improvement of food quality and safety.

Blue: This color signifies the application of biotechnology in aquaculture. Blue biotechnology involves the use of marine and freshwater organisms to develop products and processes that benefit human health, agriculture, and industry. It includes the cultivation of fish, shellfish, and algae, as well as the extraction of valuable compounds from marine organisms.

White: Representing the application of biotechnology in industrial manufacturing, white biotechnology focuses on the use of biological processes and organisms to produce chemicals, materials, and energy. It includes the development of bio-based products, such as bioplastics and biofuels, and the optimization of industrial processes to reduce environmental impact.

Yellow: This color signifies the application of biotechnology for environmental and depollution science. Yellow biotechnology involves the use of biological systems to address environmental challenges, such as pollution and waste management. It includes bioremediation techniques to clean up contaminated environments and the development of sustainable waste treatment processes.

Through these color-coded applications, biotechnology is making significant strides in various sectors, driving innovation, and improving the quality of life. Each color represents a distinct area of focus.

PART I: THE VISION

Chapter 1
Saudi Vision 2030

"All success stories start with a vision,
and successful visions are based on strong pillars."
- HRH Crown Prince and Prime Minister Mohammed bin Salman

On 25 April 2016, His Royal Highness Prince Mohammed bin Salman bin Abdulaziz Al Saud, the Crown Prince, First Deputy Prime Minister, and Minister of Defense, launched Saudi Vision 2030, an ambitious framework designed to transform Saudi Arabia's economic, social, and cultural fabric. This initiative aims to diversify the Kingdom's oil-reliant economy, promote social progress, and elevate various sectors, offering significant opportunities for companies expanding into Saudi Arabia.

For this book, Vision 2030 is not background decoration. It is the national setting in which my mission became part of a larger transformation. It linked health security with economic diversification, gave industrial policy new urgency, and made clear that national resilience depends not only on infrastructure and capital, but on scientific capability.

Saudi Vision 2030 represents the Kingdom's quest to become a central hub for business and scientific development. As the world's largest oil exporter and a key OPEC member, Saudi Arabia has long relied on oil, which accounts for 43% of GDP and 75% of government revenues. Vision 2030 sets out a strategic plan to reduce that reliance and diversify the economy.

Beyond industrial reform, Crown Prince Mohammed bin Salman has extended Vision 2030 to include social and cultural reform.

Saudi Vision 2030 stands on three core pillars: creating a *vibrant society, fostering a thriving economy, and building an ambitious nation. Each pillar contains specific goals and initiatives to reshape the Kingdom's future.*

A Vibrant Society

This pillar focuses on enhancing the quality of life and nurturing national identity through social and cultural initiatives.

Key targets include:

- Increasing the number of Umrah visitors from 8 million to 30 million annually.

- Establishing the world's largest Islamic Museum.
- Doubling the number of UNESCO-listed heritage sites.
- Promoting healthier lifestyles by encouraging 40% of citizens to exercise weekly (up from 13%).
- Expanding access to healthcare and fostering values of tolerance and moderation.

A Thriving Economy

Diversifying Saudi Arabia's economy is the central challenge of Vision 2030.

Strategies include:

- Attracting foreign direct investment (FDI) and fostering non-oil industries.
- Launching special tax-free economic zones and privatizing state-owned enterprises.
- Promoting innovative megaprojects like NEOM.
- Investing in renewable energy, mining, and research to align with global sustainability goals.

Key economic goals by 2030:

- Increase non-oil exports and small-to-medium-enterprise (SME) contributions to GDP.
- Boost FDI to 5.7% of GDP.
- Raise women's workforce participation to 30%.
- Reduce unemployment to 7%.

An Ambitious Nation

Vision 2030 also seeks to modernize governance and engage civil society. The government is driving transparency, tackling corruption, and encouraging volunteerism among citizens.

Targets include:

- One million volunteers annually.
- Doubling non-profit sector contributions to 5% of GDP.
- Climbing global rankings in government effectiveness and e-governance.

Vision 2030 is a bold transformation that positions Saudi Arabia as a global leader in innovation, sustainability, and cultural engagement, and as a rising force in biotechnology and pharmaceuticals.

Industries have been tasked with balancing local commitments with international opportunities. The principle of "Thinking Globally, Acting Locally" is the cornerstone for

sustainable growth and long-term global competitiveness.

The plan establishes a regulatory framework that fosters innovation, advances research and development (R&D), and attracts foreign investment. At its core is the recognition that Saudi Arabia must address local healthcare needs while emerging as an international competitor in the sector.

Saudi Arabia's Vision 2030 launches a series of transformative mega-projects designed to diversify the economy, expand tourism, and elevate quality of life.

These mega projects are categorized into:

- Urban and Lifestyle mega-projects
- Tourism & Heritage Projects
- Green & Environmental Initiatives Projects
- Infrastructure & Energy Projects
- Culture, Sports & Innovation Projects

A. Urban and Lifestyle Mega-Projects

1. The Qiddiya Project

Launched in 2018 under the patronage of King Salman bin Abdulaziz, Qiddiya is more than a development project; it is a bold manifestation of Saudi Arabia's Vision 2030, designed to diversify the economy and elevate quality of life for citizens and visitors alike.

Conceived as a global hub for entertainment, sports, and culture, Qiddiya City is the flagship initiative of the Qiddiya Investment Company (QIC), a wholly owned subsidiary of the Public Investment Fund (PIF). The project spans 376 square kilometers southwest of Riyadh and is the world's first purpose-built city dedicated to the "Power of Play." That philosophy shapes every element of Qiddiya's design, from its theme parks to its sports academies.

Qiddiya's infrastructure is ambitious and multifaceted, designed to host international sports arenas, concert halls, racetracks, and academies for both athletic and artistic development. Among its most anticipated attractions are the Six Flags Qiddiya theme park, featuring Falcon's Flight, the world's longest, tallest, and fastest roller coaster, and Aquarabia, the region's largest water park. The city will also include a Performing Arts Center, capable of hosting over 260 annual events, and the world's first mixed-use Gaming and Esports District, with a peak seating capacity of 73,000 across four venues.

Qiddiya is more than a leisure destination; it is a strategic lever for economic transformation. With 67% of the Saudi population under the age of 35, the city is poised

to become a magnet for youth engagement, employment, and innovation. By offering world-class entertainment within the Kingdom, Qiddiya aims to reduce outbound tourism, stimulate domestic spending, and generate more than 325,000 direct, indirect, and induced jobs upon full operation.

The project is expected to attract 48 million annual visits, house up to 600,000 residents, and contribute an estimated $36 billion to Saudi Arabia's GDP. These figures underscore Qiddiya's role in two pillars of Vision 2030: a vibrant society and a thriving economy.

Beyond its economic and recreational value, Qiddiya is a cultural renaissance where tradition meets innovation and Saudi identity finds modern expression in art, sport, and storytelling. The city's design respects the natural geography of its site, integrating urban living with outdoor adventure.

Qiddiya is not just a city; it is a statement, a declaration that Saudi Arabia is ready to lead in the global arena of entertainment and cultural development, while nurturing the aspirations of its people through the transformative power of play.

2. The NEOM Project: A Futuristic City

In 2017, Saudi Arabia unveiled one of the most ambitious urban projects in modern history: NEOM, a futuristic region on the Red Sea coast in the north west of the Kingdom. Led by His Royal Highness Prince Mohammed bin Salman bin Abdulaziz, Crown Prince and Prime Minister Mohammed bin Salman, NEOM is envisioned as a global hub for innovation, sustainability, and human-centric living, and a cornerstone of Vision 2030's drive to diversify the economy and reduce dependence on oil.

NEOM spans 26,500 square kilometers and runs entirely on renewable energy. It is designed to balance technological advancement with environmental stewardship, and offers a blueprint for sustainable living and working. The Public Investment Fund leads the development, positioning NEOM as a living laboratory for future urbanism.

The NEOM region comprises several distinct mega-projects, each with a unique thematic and functional identity: THE LINE, OXAGON, TROJENA, and SINDALAH.

THE LINE

A Vertical City of the Future. Launched in 2021, THE LINE is NEOM's most iconic sub-project. It redefines urban living through a linear model stretching 170 kilometers across desert and coastal terrain. Designed for nine million residents, THE LINE eliminates cars and roads, runs on renewable energy, and preserves 95% of its surrounding land for nature.

The city's architecture features two parallel, mirrored skyscrapers rising 500 meters above sea level and spaced 200 meters apart. All essential services (education, healthcare, retail, and recreation) are accessible within a five-minute walk, and high-speed transit enables end-to-end travel in 20 minutes. THE LINE exemplifies a zero-carbon, AI-powered urban ecosystem that prioritizes human well-being, access to nature, and environmental resilience.

OXAGON

Known as "The Floating Industrial Nexus," Oxagon was launched in 2021 as NEOM's industrial and logistics powerhouse. Situated on the Red Sea's south western edge, it is set to become the world's largest floating structure, integrating advanced manufacturing, smart logistics, and clean-energy systems.

Positioned along global trade routes that carry 13% of world commerce, Oxagon offers unparalleled connectivity to international markets. It features a next-generation port, a logistics hub, and a circular-economy industrial quarter, all designed to support Industry 4.0 technologies including robotics, AI, and IoT. Residential communities, wellness centers, and educational institutions complete a livable industrial city that balances commerce with quality of life.

TROJENA

Known as "A Mountain Retreat for All Seasons," Trojena was launched in 2022 as NEOM's high-altitude tourism and adventure destination. Set in the Sarwat Mountains at elevations reaching 2,600 meters, Trojena offers sub-zero winter temperatures and a moderate year-round climate suited to skiing, hiking, and stargazing.

The development includes a ski village with 30 kilometers of slopes, a man-made lake for water sports, and clusters for wellness, exploration, and entertainment. Trojena will host the 2029 Asian Winter Games, a historic first for winter sports in the Gulf. Its architecture blends futuristic design with the mountainous terrain through observatories, amphitheaters, and luxury resorts.

SINDALAH

Known as the "Gateway to the Red Sea," Sindalah was launched in 2022 as NEOM's luxury island destination. Located within the Red Sea's marine ecosystem, Sindalah spans 840,000 square meters and is designed to rival yachting and leisure hotspots such as Monaco and the Caribbean.

The island features a world-class marina with 86 berths for yachts up to 75 meters, luxury hotels, wellness centers, and over 50 high-end retail outlets. Sindalah is accessible

via ferry and seaplane, serving as NEOM's entry point to the Red Sea and offering year-round sailing and diving experiences.

Sindalah's design emphasizes sustainability, blending advanced technology with ecological preservation. The island protects coral reefs and marine biodiversity while offering immersive experiences in gastronomy, sport, and culture.

3. Diriyah Gate

Known as "The Cultural Heartbeat of Saudi Arabia," Diriyah lies northwest of Riyadh along the banks of Wadi Hanifah. This visionary giga-project, one of the flagship developments under the Public Investment Fund, seeks to revive and celebrate six centuries of Najdi culture. Diriyah is more than a city; it is a living testament to the Kingdom's origins, spiritual values, and architectural legacy.

At the core of Diriyah's cultural significance is At-Turaif, a UNESCO World Heritage Site and the ancestral home of the House of Al Saud. At-Turaif, founded in the 15th century as a mud-brick settlement, became the capital of the First Saudi State in 1727 under Imam Muhammad bin Saud. Its preservation and restoration reflect Saudi Arabia's commitment to honoring its historical roots while embracing modernity.

The architecture is rooted in Najdi design: geometric patterns, earth-toned textures, and shaded courtyards, integrated with contemporary urban planning to create a city that resonates with visitors and residents alike.

Diriyah is a cornerstone of Vision 2030, Saudi Arabia's national transformation strategy. Officially designated as a giga-project in 2023, Diriyah aims to become a globally recognized cultural and tourism destination. The development spans 14 square kilometers, with plans for over 18,000 residential units, 28 luxury hotels, and 50 million annual visitors by 2030.

The city offers a holistic lifestyle where one can live, work, shop, dine, and engage with heritage in a walkable, sustainable environment. Initiatives include:

- Water conservation and energy efficiency programs
- Climate change resilience strategies
- Wellness and public health infrastructure
- Cultural and educational institutions, including museums, universities, and heritage centers.

Diriyah's urban design promotes 100% walkability, encouraging physical activity, reducing carbon emissions, and fostering community interaction. The city's layout includes 31 mosques, 16 schools, 9 museums, and 8 public parks, all interconnected by

pedestrian-friendly pathways.

Diriyah is a dynamic cultural hub as much as a historical site that hosts festivals, exhibitions, and immersive experiences. From the House of Al Saud Museum to the Bujairi Terrace, each landmark is curated to deepen public understanding of Saudi Arabia's heritage while inviting global audiences to engage with its evolving narrative.

The project also unlocks significant economic opportunities, generating 178,000 direct jobs and attracting investment across hospitality, retail, and entertainment sectors.

4. New Murabba

Known as "Riyadh's Gateway to the Future," New Murabba is a bold vision for reshaping the urban landscape at the heart of Saudi Arabia's capital. Launched in 2023 under the patronage of HRH Crown Prince Mohammed bin Salman, it represents a transformative leap in Riyadh's evolution into a global metropolis. Conceived as part of Vision 2030, the initiative aims to establish the world's largest modern downtown, redefining urban living, commerce, and cultural engagement.

Spanning an impressive 19 square kilometers at the intersection of King Salman and King Khalid roads, New Murabba is designed to accommodate hundreds of thousands of residents. The district will encompass over 25 million square meters of floor area, including more than 104,000 residential units, 9,000 hotel rooms, and nearly one million square meters of retail space. In addition, the development will feature 1.4 million square meters of office space, 620,000 square meters of leisure assets, and 1.8 million square meters dedicated to community facilities such as schools, healthcare centers, and mosques.

The New Murabba Development Company (NMDC) oversees the project with an emphasis on sustainability, walkability, and technology. Every residence will be within a fifteen-minute walk of essential amenities, supported by an internal transport system and a location just twenty minutes from King Khalid International Airport.

The district's infrastructure is designed to promote active lifestyles and environmental harmony, with 25% of its area allocated to green spaces and wadis, fostering biodiversity and ecological resilience.

At the symbolic and structural core of New Murabba stands the Mukaab, a cubic tower measuring 400 meters in each dimension. Inspired by traditional Najdi architecture, it will host retail, luxury residences, hotel accommodations, and commercial spaces. The tower's spiral base and interior will use holographic technologies and immersive experiences, positioning it as a global destination for tourism and creativity.

Beyond its architectural grandeur, the Mukaab embodies the Kingdom's ambition to diversify its economy and enhance quality of life. The project is expected to contribute SAR 180 billion to Saudi Arabia's non-oil GDP and generate over 334,000 direct and indirect jobs. It also aligns with broader goals of fostering private sector growth, increasing local content, and establishing Riyadh as a hub for innovation and global investment.

In sum, New Murabba is more than a city district; it is a statement of intent. It reflects Saudi Arabia's commitment to harmonizing heritage with progress, and to crafting urban spaces that are not only functional but deeply aspirational.

5. Jeddah Central Project

The Jeddah Central Project bridges heritage and modernity in Saudi Arabia's urban renaissance. A flagship initiative under Vision 2030, it embodies the Kingdom's ambition to transform its cities into globally competitive destinations. Launched in 2021 under the patronage of HRH Crown Prince Mohammed bin Salman, the project reflects a national commitment to cultural preservation, economic diversification, and sustainable development.

Located on the Red Sea coast, the Jeddah Central Project spans 5.7 million square meters in the heart of the city. Its proximity to Makkah and Madinah positions it as a nexus for tourism, pilgrimage, and investment, and the development aims to elevate Jeddah into the world's top 100 cities by combining heritage-inspired architecture with modern infrastructure. Its design philosophy draws from Hijazi culture reinterpreted through a contemporary lens, ensuring the city embraces modernity while remaining anchored in its historical identity. Sustainability is a core tenet: the project meets international environmental standards and incorporates natural promenades, coral farms, and vehicle-restricted beach zones to protect the coastal ecosystem.

Central to the project are four iconic landmarks:

- The Opera House, envisioned as a cultural beacon for performing arts.
- The Museum, dedicated to preserving and showcasing Jeddah's rich history.
- The Sports Stadium, designed to host international events and foster community engagement.
- The Oceanarium, which will serve both educational and recreational purposes.

Complementing these are a world-class marina, 2.1 km of sandy beaches, luxury beach resorts, retail districts, and modern residential zones offering over 17,000 housing units and 2,700 hotel rooms.

The project is a cornerstone of the Public Investment Fund program, which seeks to

unlock new sectors and diversify the Kingdom's revenue streams. It exemplifies how Vision 2030 is more than a policy framework; it is a transformative force reshaping Saudi Arabia's urban, cultural, and economic environment.

6. Mohammed Bin Salman Nonprofit City

In the evolving landscape of Saudi Arabia's urban and social transformation, the Mohammed Bin Salman Nonprofit City, commonly referred to as "*Misk City*" , *emerges as a pioneering initiative. As the first nonprofit city of its kind globally, Misk City is a purpose-built urban ecosystem designed to embody the values and strategic objectives of the Mohammed bin Salman Foundation (Misk). Rooted in the ethos of youth empowerment, innovation, and sustainable development, the city represents a bold reimagining of urban space as a catalyst for human potential.*

Misk City was conceived to host and amplify the Misk Foundation's ecosystem, in alignment with Vision 2030. Its human-centric design emphasizes inclusivity, creativity, and lifelong learning, serving as a platform where young people can live, learn, collaborate, and innovate in an environment tailored to their aspirations.

Strategically located near Wadi Hanifa and the Irqah neighborhood in Riyadh, the city spans approximately 3.4 square kilometers. Its masterplan integrates residential, commercial, educational, and cultural zones, with over 44% of the total area dedicated to green open spaces, underscoring its commitment to sustainability and well-being.

Misk City's infrastructure is meticulously curated to foster a holistic lifestyle. It includes:

- Educational Institutions: Designed to nurture future leaders through formal and informal learning environments.
- Innovation Hubs: Spaces such as the City Hub and Malfa Hall serve as incubators for startups, creative projects, and community engagement.
- Arts and Sports Facilities: These venues promote cultural expression and physical well-being, reinforcing the city's multidimensional approach to youth development.
- Residential and Hospitality Offerings: With 500 villas, townhouses, and over 6,000 apartments, the city accommodates approximately 18,000 residents, supported by hotels and retail outlets.

Central to Misk City's identity is the enduring legacy of the Misk Foundation. Over the past decade, Misk has championed youth empowerment through a diverse portfolio of initiatives, including:

- Leadership development programs
- Entrepreneurial incubation and acceleration

- Cultural and educational workshops
- Global networking events and mentorship platforms

These efforts have cultivated a generation of Saudi youth equipped with the skills, confidence, and global outlook necessary to lead in an increasingly complex world.

Mohammed Bin Salman Nonprofit City is more than a physical space; it is a manifestation of a national vision that places youth a defining feature of development. By integrating education, innovation, culture, and sustainability into its urban fabric, Misk City sets a precedent for nonprofit urbanism and redefines the role of cities in shaping human futures.

B. Tourism & Heritage Projects

1. Red Sea Global

Few initiatives in global tourism combine luxury, sustainability, and cultural heritage as profoundly as Red Sea Global (RSG). A flagship development under Vision 2030, RSG prioritizes ecological regeneration, cultural preservation, and economic diversification.

Spanning approximately 28,000 square kilometers along Saudi Arabia's western coastline, the Red Sea Global site encompasses an archipelago of over 90 pristine islands, many of which remain untouched by human development. The region is characterized by a diverse array of natural features, including dormant volcanoes, expansive desert dunes, and dramatic mountain canyons. Notably, the Red Sea is home to the world's fourth-largest barrier reef system, a thriving marine ecosystem that supports endemic coral species and vibrant aquatic biodiversity.

The Red Sea region also holds deep cultural and historical resonance. Archaeological sites and heritage landmarks offer insights into ancient trade routes, maritime traditions, and the spiritual legacy of the Arabian Peninsula, and these elements are being integrated into the development framework so that tourism does not eclipse the region's historical identity.

The Red Sea Global project officially welcomed its first guests in 2023, marking the commencement of a phased rollout that will culminate in 2030. Upon completion, the destination will feature:

- 50 luxury hotels offering approximately 8,000 rooms
- 1,000 residential properties designed for long-term stays and investment
- An international airport to facilitate global connectivity
- Conservation zones preserving 75% of the archipelago's natural landscape.

The development is guided by principles of regenerative tourism, aiming to achieve a 30% net positive conservation impact by 2040 through habitat restoration and biodiversity enhancement.

Red Sea Global is more than a tourism venture; it is a strategic lever for national transformation. The project is expected to contribute to Saudi Arabia's GDP by 2030 and generate direct, indirect, and induced jobs. It also serves as a model for sustainable development, integrating renewable energy systems, zero-waste construction protocols, and community engagement programs.

Red Sea Global represents a new frontier in destination development, harmonizing luxury with responsibility and innovation with tradition. As it unfolds, the project promises to redefine tourism in the Kingdom and set global benchmarks for regenerative travel.

2. Amaala

Along the coastline of northwestern Saudi Arabia, AMAALA reimagines luxury tourism through wellness, sustainability, and cultural immersion. Inspired by the Red Sea, the transformative power of art, and a holistic ethos of wellness, AMAALA is positioned as the world's first integrated family wellness destination, an enclave where restorative experiences are embedded in the landscape and design.

Spanning approximately 4,000 square kilometers, AMAALA is being developed as a year-round destination that caters to a wide spectrum of interests. From sun-soaked marine adventures and high-performance sports to immersive arts and cultural experiences, the project promises a curated journey for every visitor. This ambitious undertaking aligns with Saudi Arabia's Vision 2030, which seeks to diversify the national economy and elevate the Kingdom's global standing in sustainable tourism.

The development is spearheaded by Red Sea Global, a subsidiary of the Public Investment Fund (PIF), and is strategically located within the Prince Mohammed bin Salman Natural Reserve. This location not only offers breathtaking natural beauty but also demonstrates AMAALA's commitment to environmental stewardship.

The initial phase of AMAALA centers on the Triple Bay masterplan, a coastal enclave designed to harmonize luxury hospitality with marine conservation and wellness. The Triple Bay is expected to unveil eight hotels comprising approximately 1,300 rooms. Upon full completion, AMAALA will feature over 3,000 hotel rooms across 25 hotels, alongside 943 luxury residential villas, high-end retail outlets, gourmet dining establishments, a state-of-the-art yacht club, and comprehensive wellness and recreational facilities.

AMAALA's development philosophy is rooted in ecological preservation. Only 5% of the total land area is designated for construction; the remaining 95% is safeguarded to protect the region's ecosystems and cultural heritage. The project operates on renewable energy, maintains a zero-carbon footprint, and sends no waste to landfill, positioning AMAALA as a global example of regenerative tourism.

AMAALA is more than a tourism initiative; it is a paradigm shift in how destinations can integrate luxury, wellness, and sustainability. As Saudi Arabia continues to invest in transformative projects under Vision 2030, AMAALA stands as a beacon of innovation, offering a glimpse into a future where travel heals, inspires, and preserves.

3. AlUla

AlUla project is a living museum of time and transformation. In the heart of northwestern Saudi Arabia lies AlUla, a region of breathtaking geological formations and profound historical significance. Often described as a "living museum, " AlUla is home to sandstone outcrops, ancient tombs, and archaeological marvels that span over 200,000 years of largely underexplored human history. From the Nabataean city of Hegra, Saudi Arabia's first UNESCO World Heritage site, to the ancient Dadanite and Lihyanite kingdoms and the storied AlUla Old Town, this region offers a rare convergence of natural beauty and cultural depth.

AlUla is undergoing a transformative renaissance, emerging as a global destination for heritage tourism, archaeological exploration, and cultural exchange. Spearheaded by the Royal Commission for AlUla (RCU), the project is a cornerstone of Saudi Arabia's Vision 2030, which seeks to diversify the national economy and elevate the Kingdom's cultural profile on the world stage.

The development strategy is both ambitious and sensitive. It aims to unlock AlUla's potential as a once-in-a-lifetime experience for visitors, while preserving its fragile ecosystems and historical integrity. This dual mandate (development and conservation) is reflected in a series of initiatives across archaeology, tourism, education, and the arts.

The Royal Commission's approach to AlUla's development is rooted in sustainability and inclusivity. Urban planning and economic initiatives are designed to respect the region's natural and cultural character, while empowering local communities through education, training, and employment. Programs such as the AlUla Scholarship and Hammayah (Protection) initiatives engage residents directly in the stewardship of their heritage.

One of the flagship projects is the Sharaan Nature Reserve, which aims to restore ecological balance and reintroduce native species. Designed by renowned architect Jean

Nouvel, the Sharaan Resort blends luxury with environmental consciousness, offering a model for regenerative tourism in desert ecosystems.

With 2 million projected annual visitors and a meaningful contribution to GDP, AlUla is poised to become a cultural capital of the Middle East. Its development is about storytelling, identity, and the reawakening of a region whose history has long been buried beneath the sands.

AlUla's journey from ancient crossroads to modern cultural hub exemplifies how heritage can serve as a foundation for sustainable development. It is a sign of the power of place, memory, and vision.

4. Rua Almadinah

Few initiatives in Saudi Arabia's urban development fuse heritage, hospitality, and strategic planning as powerfully as Rua Al Madinah. Led by Rua Al Madinah Holding, a wholly owned subsidiary of the Public Investment Fund, the project redefines the spiritual and cultural experience of Madinah through modern urban design and infrastructure.

The Rua Al Madinah project goes beyond real estate; it is a comprehensive urban revitalization strategy aimed at enhancing the experience of both residents and millions of pilgrims who visit the city annually. Located just east of the Prophet's Mosque, the development spans approximately 1.35 million square meters and is designed to integrate hospitality, retail, residential, and cultural components into a cohesive ecosystem.

Central to the project's vision is the creation of a spiritually enriching and architecturally significant environment. The master plan includes up to 47,000 hotel rooms, over 95,000 square meters of retail space, and a remarkable allocation of 63% of the site for green and open areas. Pedestrian corridors, some as wide as 60 meters, are designed to ensure seamless access to the mosque's squares, while vehicular traffic is strategically separated to enhance safety and mobility.

Rua Al Madinah Holding's approach reflects the broader goals of Saudi Arabia's Vision 2030, particularly the objective of increasing the capacity to host Hajj and Umrah pilgrims to 30 million annually by the year 2030. The project's emphasis on sustainability is evident in its adoption of green technologies, including underground waste collection systems, energy-efficient shading, and solar-powered infrastructure. By harmonizing tradition with innovation, Rua Al Madinah stands as a flagship model of how urban planning can serve both spiritual heritage and modern functionality. It is a mark of the Kingdom's commitment to elevating Madinah as a global Islamic and cultural destination.

5. THE RIG, A New Frontier in Adventure Tourism

In the Arabian Gulf, a project called THE RIG. promises to redefine adventure tourism. Not a theme park or a traditional resort, it is a bold reimagining of offshore oil platforms as immersive destinations for global travelers.

The inception of THE RIG. was formally announced in 2021 by Saudi Arabia's Public Investment Fund (PIF). The project was heralded as the world's first adventure tourism destination built on an offshore platform, drawing architectural inspiration from the very oil rigs that have long symbolized the Kingdom's industrial prowess.

The Oil Park Development Company (OPDC) was established to lead development, in line with the PIF Strategy 2021–2025 and its goal of diversifying the economy through tourism and entertainment. THE RIG. is more than a leisure destination; it is a strategic initiative to elevate the Kingdom's standing as a premier tourist hub, while generating employment and improving quality of life in the Eastern Region.

Spanning over 300,000 square meters, THE RIG. is located approximately 40 kilometers off the coast, near Juraid Island and the Berri Oil Field. This location was chosen not only for its proximity to key industrial landmarks but also for its potential to offer truly immersive marine experience.

The destination will feature:

- Three hotels with a combined total of 800 rooms
- Eleven restaurants offering diverse culinary experiences.
- A vibrant mix of retail outlets
- A suite of thrilling activities, including extreme sports, diving centers, and immersive entertainment zones,

Visitors access THE RIG. via fast ferries, helicopters, and seaplanes, departing from terminals in Dammam City and Jubail Industrial City, ensuring seamless connectivity from mainland Saudi Arabia.

A core element of the project, THE RIG celebrates Saudi Arabia's oil-and-gas heritage, transformed into sustainable tourism. The project is being developed to international environmental standards, with a strong emphasis on eco-experiences, community empowerment, and responsible operations.

By blending extreme adventure with warm hospitality, THE RIG. aims to become a global benchmark for offshore tourism. It is a measure of the Kingdom's commitment to innovation, sustainability, and cultural legacy, an unprecedented leap into the future of travel.

C. Green and Environmental Initiatives Projects

In a region long defined by arid deserts and oil-rich terrain, Saudi Arabia is positioning itself as a global leader in environmental stewardship. Under Vision 2030, the Kingdom has launched a series of ambitious green initiatives designed to combat climate change, restore ecosystems, and build a sustainable future. Among them are:

1. Green Riyadh Project

Green Riyadh seeks to transform the capital of Saudi Arabia from a desert metropolis into a verdant sanctuary. One of the most ambitious urban afforestation projects in the world, it was launched in 2019 under the patronage of the Custodian of the Two Holy Mosques, King Salman bin Abdulaziz.

Green Riyadh is far more than a beautification effort; it is a strategic initiative designed to elevate Riyadh into the ranks of the top 100 most livable cities globally. The project aligns with Saudi Vision 2030, a national blueprint for economic diversification and environmental sustainability. By increasing access to green spaces, improving air quality, and enhancing the overall well-being of residents, Green Riyadh aims to redefine urban life in the Kingdom.

The scale of the project is staggering as millions of trees will be planted across the city. These trees will populate:

- Neighborhood gardens and parks
- Mosques and schools
- Universities and healthcare facilities
- Streets, roads, and public squares

The initiative includes the development of 43 grand parks, afforestation of neighborhood parks, and greening of schools, mosques, and health facilities. A network of kilometers of treated water infrastructure will support irrigation, using 100% recycled water, a reflection of the project's commitment to sustainability.

Green Riyadh is designed to deliver a cascade of benefits:

- Improved air quality, with a projected 3–6% reduction in CO_2 levels
- Lower urban temperatures by 1.5–2°C
- Reduced energy consumption by 650 GWh annually
- Enhanced biodiversity and ecological resilience
- Increased real estate value and healthcare cost savings, with an estimated $19 billion in economic return by 2030.

The project also aims to raise the per capita green space from 1.7 square meters to 28 square meters, a sixteen-fold increase that will dramatically reshape the city's landscape.

Green Riyadh is more than a local initiative; it is a model for global urban transformation. By integrating environmental stewardship with urban planning, the project reflects the Kingdom's commitment to the United Nations Sustainable Development Goals, particularly those related to climate action, health, and sustainable cities.

As Riyadh blossoms into a green oasis, it sends a message that even in the harshest climates, cities can thrive in harmony with nature.

2. King Salman Energy Park – A Vision of Industrial Sustainability

In Eastern Saudi Arabia, the King Salman Energy Park (SPARK) stands as a reflection of the Kingdom's ambition to lead in energy innovation and industrial development. A cutting-edge industrial hub, SPARK is designed to connect international markets with the opportunities of Saudi Arabia's energy sector.

King Salman Energy Park project was officially inaugurated in 2018 by His Royal Highness Prince Mohammed bin Salman bin Abdulaziz, Crown Prince, and Prime Minister of Saudi Arabia. This milestone marked the beginning of a transformative journey for the region, positioning SPARK as a world-class center for energy, technology, and industrial services.

SPARK's vision extends beyond infrastructure. It aims to diversify the Kingdom's revenue streams, reduce dependence on oil, and accelerate the adoption of clean-energy technologies. The park supports a full spectrum of energy businesses, from multinational corporations to small and medium-sized enterprises, through its integrated ecosystem and advanced logistics.

SPARK hosts industrial, technology, and service facilities, making it one of the most comprehensive energy hubs in the region. A key feature of the development is its dedicated logistics zone and dry port, which will streamline the movement of goods and materials, enhance supply chain efficiency and reduce operational costs for tenants.

The park's infrastructure is built on a "plug and play" model, offering ultramodern facilities that cater to the specific needs of energy companies. Its proximity to major transportation networks, including highways and railways, strengthens its role as a gateway to the regional energy market.

SPARK is not only a symbol of industrial progress but also a pioneer in environmental stewardship. In 2020, it became the first industrial city in the world to receive Silver Level accreditation for Leadership in Energy and Environmental Design (LEED). This

prestigious certification, awarded by the U.S. Green Building Council, recognizes SPARK's commitment to sustainable construction practices, energy efficiency, and reduced carbon emissions.

The LEED certification reveals SPARK's dedication to creating a high-quality living and working environment while minimizing its ecological footprint. The park incorporates innovative technologies such as non-metallic rebar, green concrete, and locally sourced materials to enhance durability and reduce environmental impact.

SPARK's integrated sustainability practices and forward-thinking design have positioned it as a model for industrial cities worldwide. By fostering a collaborative ecosystem for energy-related enterprises and championing environmental responsibility, SPARK is helping to redefine the future of industrial development in the Middle East.

As Saudi Arabia continues toward economic diversification and environmental resilience, SPARK remains a cornerstone of Vision 2030.

3. Saudi Green Initiative – Blueprint for Sustainability

In the face of escalating climate and environmental challenges, Saudi Arabia has embarked on a transformative journey toward sustainability. At its heart lies the Saudi Green Initiative (SGI), a comprehensive national strategy to reshape the Kingdom's environmental future and contribute to global climate action.

Launched in 2021 by His Royal Highness Prince Mohammed bin Salman bin Abdulaziz, Crown Prince and Prime Minister, SGI represents a whole-of-society approach to sustainability. It unites government agencies, private enterprises, and civil society under a shared mission: to combat climate change, enhance quality of life, and safeguard the environment for future generations.

SGI is a catalyst for transformation, designed to accelerate Saudi Arabia's transition to a green economy and position the Kingdom as a global leader in climate innovation.

SGI is guided by three overarching targets:

- Emissions Reduction: Central to SGI is the Kingdom's commitment to achieving net zero emissions by 2060, a goal pursued through the Circular Carbon Economy (CCE) model. This approach emphasizes carbon reuse, recycling, and removal, enabling sustainable economic growth without compromising environmental integrity.
- Afforestation: SGI envisions the planting of 10 billion trees across Saudi Arabia over the coming decades, rehabilitating 40 million hectares of degraded land. This massive greening effort aims to reverse desertification, restore biodiversity, and improve air quality.

- Land and Sea Protection: SGI aims to protect Saudi Arabia's terrestrial and marine environments.

Since its inception, SGI has activated initiatives, each aligned with its core targets. These initiatives span sectors such as renewable energy, biodiversity conservation, carbon capture, and sustainable urban development. Collectively, they represent an investment exceeding $186 billion, underscoring the Kingdom's resolve to drive sustainable growth.

Key achievements include:

- Millions of trees are planted across hectares of land.
- 1.3 GW of renewable energy connected to the national grid, powering over 750,000 homes.
- The commissioning of four high-efficiency gas-fired power plants with a combined capacity of 5.6 GW.
- The launch of the world's largest clean hydrogen project in NEOM, expected to produce 600 tons per day by 2026.

SGI thrives on collaboration between the public and private sectors, fostering innovation and aligning national efforts with international climate goals. It is a cornerstone of Vision 2030, Saudi Arabia's broader strategy to diversify its economy and build a sustainable future.

By linking environmental stewardship to economic development, SGI is reshaping the Kingdom and redefining its role on the global stage.

4. The Middle East Green Initiative: Blueprint for Climate Action

The Kingdom of Saudi Arabia launched the Middle East Green Initiative (MGI) in 2021, marking a pivotal shift toward regional climate cooperation. MGI goes beyond a policy framework. It is a transformative alliance designed to catalyze sustainable development, mitigate climate risks, and foster economic diversification across the region.

Inaugurated by His Royal Highness Prince Mohammed bin Salman bin Abdulaziz, Crown Prince, and Prime Minister of Saudi Arabia, MGI represents a first-of-its-kind regional coalition aimed at addressing the unique vulnerabilities of climate change. The initiative was formally introduced during the inaugural MGI Summit held in Riyadh on October 25, 2021, which convened leaders from across the region to forge a unified climate agenda.

MGI is anchored by two ambitious targets:

- The reduction and removal of 670 million tons of carbon dioxide equivalent (CO_2e) emissions.

- The afforestation of 50 billion trees across the Middle East, contributing to the restoration of 200 million hectares of degraded land.

These goals align with global climate commitments while addressing region-specific environmental degradation. Saudi Arabia's leadership in establishing regional centers, such as the Regional Hub for Climate Change and the Regional Carbon Capture, Utilization and Sequestration Hub, demonstrates its commitment to operationalizing MGI's roadmap.

The governance architecture of MGI was ratified in October 2022 during a ministerial meeting chaired by H.E. Eng. Abdulrahman bin Abdulmohsen Al-Fadley, Saudi Arabia's Minister of Environment, Water and Agriculture. Representatives from 20 countries across Asia and Africa participated, culminating in the approval of the MGI Governance Charter. This charter outlines the collaborative mechanisms for member states, including bilateral coordination, knowledge exchange, and joint funding strategies.

A dedicated MGI Secretariat is being established in Riyadh to oversee implementation, monitor progress, and facilitate stakeholder engagement.

Beyond environmental restoration, MGI is designed to stimulate economic growth through green job creation, private sector investment, and the development of circular carbon economy technologies. The initiative also aims to reduce the economic burden of climate-related phenomena, such as dust storms.

MGI's multi-sectoral approach, spanning clean fuel solutions, sustainable fisheries, and early storm warning systems, reflects a holistic vision for climate resilience and sustainable development.

The Middle East Green Initiative exemplifies a strategic convergence of environmental stewardship and economic modernization. By fostering regional solidarity and institutional innovation, MGI offers a replicable model for climate governance in other vulnerable regions. As the initiative matures, its success will depend on sustained political will, inclusive stakeholder engagement, and adaptive policy mechanisms.

D. Infrastructure & Energy Projects

1. Riyadh Metro: A Transformative Leap in Urban Mobility

Urban infrastructure shapes the socioeconomic and environmental trajectory of modern cities. Under Vision 2030, the Riyadh Metro stands as a landmark achievement in sustainable urban planning. One of the most ambitious infrastructure projects in the Middle East, it reduces traffic congestion, lowers carbon emissions, and enhances quality

of life through integrated mobility.

The Riyadh Metro is a fully operational, six-line rapid transit system spanning 176 kilometers and connecting 85 stations across the capital city. It is the largest metro system in the Middle East and the longest driverless train network globally. The project forms the backbone of the King Abdulaziz Project for Riyadh Public Transport, which also includes a complementary bus rapid transit (BRT) network covering 85 kilometers.

The metro system was inaugurated in phases beginning December 1, 2024, with full operational capacity achieved by January 5, 2025.

The Orange Line (Line 3), the final segment to be launched, stretches 41 kilometers from Jeddah Road in the west to the Second Eastern Ring Road near Khashm Al Aan in the east, significantly enhancing east-west connectivity.

The project was initiated in 2013, with contracts awarded to three global consortia: BACS (Bechtel, Almabani, CCC, Siemens), ANM (Webuild, Bombardier, Ansaldo, Larsen & Toubro, Nesma), and FAST (FCC, Atkins, Alstom, Samsung C&T, Strukton). Construction began in 2014, with a total investment of approximately $22.5 billion.

The metro features elevated underground tracks, with trains operating at headways of 3 to 7 minutes. Each train comprises 2–4 coaches and utilizes regenerative braking and solar-powered systems to enhance energy efficiency. Ticketing is facilitated through the Darb mobile app, self-service kiosks, and station offices, with payment options including credit cards, bank transfers, and mobile devices.

The Riyadh Metro is expected to reduce daily car trips by approximately 250,000, saving nearly 400,000 liters of fuel and significantly lowering urban air pollution. With a projected capacity of 3.6 million passengers per day, the system is designed to accommodate Riyadh's growing population while promoting a shift from private vehicles to public transit.

The metro also contributes to economic diversification by creating jobs, stimulating real estate development around transit hubs, and attracting foreign investment in smart mobility technologies. Its integration with Riyadh's broader transport ecosystem, including buses, taxis, and pedestrian pathways, positions the city as a model for sustainable urban development in the Gulf region.

The completion of the Riyadh Metro marks a transformative milestone for Saudi Arabia's infrastructure. It aligns technological innovation, environmental stewardship, and urban modernization. For cities facing mobility challenges, the Riyadh Metro offers a blueprint for inclusive, efficient, and future-ready public transport.

2. Sakaka Solar Power Plant: Pioneering Renewable Energy in KSA

As global energy systems pivot toward sustainability, Saudi Arabia is transforming its energy mix and reducing dependence on fossil fuels. Central to this is the Sakaka Solar Power Plant, the Kingdom's flagship renewable project under Vision 2030. Located in Al Jouf province, Sakaka is the first utility-scale solar facility developed under the Custodian of the Two Holy Mosques Renewable Energy Initiative.

Inaugurated in 2021, the Sakaka Solar Power Plant was conceived as a flagship project within the National Renewable Energy Program (NREP), administered by the Ministry of Energy. The initiative aims to generate 58.7 GW of renewable energy by 2030, aligning with Saudi Arabia's broader goals of environmental stewardship, economic diversification, and energy security.

Developed by ACWA Power in partnership with Algihaz Holding, the project was executed under a Build-Own-Operate (BOO) model, with a 25-year power purchase agreement signed with the Saudi Power Procurement Company. The total investment reached approximately $302 million, and the plant was constructed by a consortium led by Mahindra Susten and Chint Solar.

The Sakaka facility spans 6 square kilometers and comprises over 1.2 million photovoltaic panels using single axis tracking technology. With a generation capacity of 300 megawatts (MW), the plant is expected to produce 930 gigawatt-hours (GWh) of electricity annually, enough to power approximately 55,000 homes.

Notably, Sakaka achieved a record-breaking levelized cost of electricity (LCOE) of $0.023 per kilowatt-hour (kWh), positioning it among the most cost-efficient solar projects globally. This achievement is attributed to Saudi Arabia's high solar irradiance, streamlined regulatory processes, and competitive bidding frameworks.

The plant contributes to a reduction of approximately 530,000 tons of carbon dioxide emissions annually, supporting Saudi Arabia's climate mitigation goals and its participation in the Circular Carbon Economy (CCE) framework.

Beyond environmental benefits, Sakaka has catalyzed local economic development: 97% of the operational team comprises Saudi nationals, with 90% drawn from the Al Jouf region.

The project also supports the Liquid Fuel Displacement Program by substituting solar energy for oil-based power generation, thereby conserving valuable hydrocarbon resources for export and industrial use.

Sakaka embodies the principles of Vision 2030 by integrating sustainability, innovation,

and regional development. It serves as a blueprint for future renewable energy projects, including the Sudair Solar PV Plant and the NEOM Green Hydrogen initiative. The success of Sakaka reinforces Saudi Arabia's position as a regional leader in clean energy and demonstrates the feasibility of large-scale solar deployment in arid environments.

The Sakaka Solar Power Plant is more than a technical achievement; it is a strategic asset in Saudi Arabia's energy transformation. By leveraging its geographic advantages and policy foresight, the Kingdom has positioned Sakaka as a model for renewable energy development in the Middle East and beyond.

3. Rabigh Desalination Plant: Water Innovation and Sustainability

Water scarcity is a defining challenge for arid regions, and in Saudi Arabia, population growth and industrial expansion place rising pressure on limited freshwater resources. Saudi Arabia has responded by becoming a global leader in desalination, and the Rabigh Desalination Plant is a flagship example. Developed under the guidance of KACST and the Saline Water Conversion Corporation (SWCC), Rabigh exemplifies the Kingdom's commitment to sustainable water infrastructure.

Construction of the Rabigh Desalination Plant began in 2017, reflecting a coordinated effort between national research institutions and operational agencies. KACST provided technical expertise in advanced water treatment technologies, while SWCC oversaw implementation and integration into the national water grid. The plant was designed to support Saudi Arabia's broader goals under Vision 2030, including the creation of a resilient domestic water sector and the reduction of environmental impacts associated with conventional desalination.

One of the plant's most distinctive features is its use of industrial-scale crystalline absorption cooling, a novel approach that enhances thermal efficiency while minimizing ecological disruption. This technology enables the plant to operate with zero salt return, a significant advancement over traditional desalination systems that discharge brine into marine environments. By capturing and repurposing salt, the Rabigh facility contributes to circular resource use and reduces salinity stress on coastal ecosystems. The plant's operational metrics are equally impressive: it produces 5,000 cubic meters of desalinated water and 700 kilograms of salt per day, consuming only 3.5 megawatts (MW) of thermal energy and 1.5 MW of electrical energy. These figures underscore the potential of hybrid thermal-electric systems to deliver sustainable water solutions on scale.

The Rabigh plant combines technological sophistication with environmental stewardship. Its zero-discharge design addresses one of the most persistent challenges in desalination (brine pollution), while energy-efficient operations reduce carbon emissions

and operating costs.

Economically, the plant supports regional development by creating skilled employment opportunities, fostering local expertise in water engineering, and reducing the cost of water provision in underserved areas. The extracted salt also holds commercial value, with potential applications in food processing, pharmaceuticals, and industrial manufacturing.

Rabigh's success aligns with Saudi Arabia's Vision 2030 objectives, particularly in the domains of environmental sustainability, technological innovation, and infrastructure modernization. As the Kingdom continues to invest in renewable energy and smart infrastructure, future expansions of the Rabigh model may include integration with solar thermal systems and deployment of AI-driven monitoring platforms to optimize performance.

The Rabigh Desalination Plant is more than a technical achievement; it is a strategic asset in Saudi Arabia's pursuit of sustainable development. By leveraging cutting-edge science and institutional collaboration, the facility sets a new benchmark for desalination and reinforces the Kingdom's leadership in water innovation.

4. The AlKhafji Desalination Plant: A Vision 2030 Milestone

In the arid northeast of Saudi Arabia, the city of AlKhafji hosts the AlKhafji Desalination Plant, one of the Kingdom's most transformative recent infrastructure projects. Launched in 2018 under the patronage of His Royal Highness Prince Mohammed bin Salman bin Abdulaziz, Crown Prince and Prime Minister Mohammed bin Salman, the facility represents a pioneering leap in sustainable water management and renewable -energy integration.

The AlKhafji Desalination Plant is globally recognized as the largest solar-powered seawater reverse osmosis (RO) facility. It was conceived as a strategic response to the Kingdom's growing freshwater demand and its commitment to reducing carbon emissions under the framework of Vision 2030. The plant can produce up to 90,000 cubic meters of potable water daily, serving approximately 150,000 residents in the region.

Anchoring the plant's innovation lies its expansive solar array, covering 90 hectares and generating 15 MW of clean energy. This solar power drives the plant's ultra-filtration pre-treatment and advanced RO systems, which force seawater through semipermeable membranes to remove salt and contaminants. The process is further enhanced by technologies such as Ecodosing™, which minimizes biofouling and chemical usage, thereby extending membrane life and improving operational efficiency.

Developed in collaboration with the King Abdulaziz City for Science and Technology

(KACST), the plant integrates cutting-edge research in reverse osmosis, dust-repellent nano-coatings, and smart metering systems. These innovations not only reduce the cost per cubic meter of desalinated water but also contribute to a 40% reduction in post-treatment emissions and a 16,000-barrel decrease in crude oil consumption annually.

The AlKhafji project exemplifies Saudi Arabia's strategic pivot toward clean energy and resource stewardship. It aligns with Vision 2030's broader goals of enhancing quality of life, fostering local technological development, and positioning the Kingdom as a global leader in sustainable infrastructure. As of mid-2024, the plant had already delivered over 7 million cubic meters of fresh water and achieved a 14,000-ton reduction in CO_2 emissions.

This initiative underscores the potential of solar desalination as a scalable solution to water scarcity in arid regions.

5. The Low Power Research Reactor: First Step in Civil Nuclear Research

In November 2018, Saudi Arabia marked a historic milestone in its scientific and energy sector with the inauguration of the Low Power Research Reactor (LPRR), the Kingdom's first nuclear research reactor. The ceremony, led by His Royal Highness Prince Mohammed bin Salman bin Abdulaziz, Crown Prince and Prime Minister, signaled the nation's strategic entry into peaceful nuclear technology as part of its broader Vision 2030 agenda.

The LPRR is housed within the King Abdulaziz City for Science and Technology (KACST) and was developed in collaboration with King Abdullah City for Atomic and Renewable Energy (KACARE), the Nuclear and Radiological Regulatory Commission (NRRC), and a consortium of international experts. Designed as an open-pool reactor, the LPRR operates at a thermal power of 100 kW and is cooled by natural circulation of light water. This configuration ensures low-pressure operation and high safety margins, making it ideal for research, training, and isotope production.

Technically, the reactor features a core composed of cylindrical fuel assemblies, surrounded by light water, and partially reflected by graphite blocks. Reactivity is controlled via six control rods integrated into the shutdown system. The facility includes six laboratories and irradiation units, along with four advanced simulation and training centers for nuclear systems. These assets support a wide range of applications, including energy research, medical isotope development, and radiopharmaceutical innovation.

The LPRR project is a cornerstone of Saudi Arabia's effort to localize nuclear technologies and build indigenous expertise. Over 30 Saudi engineers and researchers participated in its design and commissioning, reflecting a deliberate strategy to cultivate

national competencies in reactor operation, safety protocols, and regulatory compliance. The International Atomic Energy Agency (IAEA) reviewed and validated the reactor's safety specifications, ensuring alignment with global best practices.

Beyond its technical merits, the LPRR contributes to Vision 2030's goals of economic diversification and sustainable energy development. By fostering nuclear literacy and research capacity, the reactor supports long-term infrastructure for the Saudi National Atomic Energy Project and enhances public awareness of peaceful nuclear applications. Its 40-year operational lifespan positions it as a durable platform for innovation, education, and international collaboration.

E. Culture, Sports & Innovation

1. The Sports Boulevard: Riyadh's Linear Park for a Healthier Future

In the heart of Riyadh's evolving urban landscape, the Sports Boulevard stands as a flagship initiative of Saudi Arabia's Vision 2030, designed to promote public health, cultural vitality, and environmental sustainability.

Officially launched on March 19, 2019, by the Custodian of the Two Holy Mosques, King Salman bin Abdulaziz Al Saud, the project reflects the Kingdom's ambition to transform Riyadh into one of the most livable cities in the world.

The Sports Boulevard reimagines urban space as a corridor for wellness, recreation, and community engagement. Stretching 135 kilometers along Prince Mohammed bin Salman Road, it connects Wadi Hanifa in the west to Wadi Al-Sulai in the east, forming the largest linear park in the world. This green artery integrates pedestrian walkways, cycling paths, equestrian trails, and multi-use sports facilities.

Beyond its athletic function, the Sports Boulevard serves as a cultural and environmental hub. It hosts year-round events, exhibitions, and performances that celebrate Saudi heritage and contemporary art. The project's design philosophy merges modern urban aesthetics with ecological sensitivity, guided by the Sports Boulevard Design Code, which ensures architectural coherence, accessibility, and environmental stewardship.

The initiative aligns with the Quality-of-Life Program under Vision 2030, which seeks to enhance individual well-being through improved public spaces, active lifestyles, and inclusive cultural experiences. By encouraging walking, cycling, and horse riding, the Sports Boulevard addresses sedentary behavior and fosters a health-conscious urban culture. Its integration of green infrastructure also contributes to climate resilience, air quality improvement, and biodiversity conservation within the capital.

As of 2025, the Sports Boulevard has become a symbol of Riyadh's urban renaissance, attracting residents, tourists, and investors alike. It exemplifies how infrastructure can serve as a catalyst for behavioral change, community cohesion, and sustainable development.

2. Riyadh Art: Transforming the Capital into a Gallery Without Walls

In alignment with Saudi Arabia's Vision 2030, the Riyadh Art initiative represents a transformative cultural movement designed to reimagine the urban landscape of the Kingdom's capital. Conceived as one of four megaprojects under the Royal Commission for Riyadh City (RCRC), Riyadh Art seeks to embed artistic expression into the fabric of daily life, positioning Riyadh as a global cultural hub and a beacon of creative economy development.

Launched on March 19, 2019, by King Salman bin Abdulaziz Al Saud, and overseen by the National Megaprojects Committee chaired by Crown Prince Mohammed bin Salman, Riyadh Art was envisioned as a civic art initiative of unprecedented scale. The program aims to install over 1,000 public artworks across the city, integrating art into residential neighborhood, parks, squares, metro stations, bridges, and tourist destinations.

This initiative is strategic, not decorative. Riyadh Art contributes directly to Vision 2030's cultural and economic goals by fostering artistic engagement, enhancing urban aesthetics, and stimulating investment in creative industries. It reflects a deliberate shift toward a more open, cosmopolitan society where cultural production is both celebrated and economically viable.

The Riyadh Art program is structured around ten permanent sub-programs and two annual festivals, including the Noor Riyadh light festival and the Tuwaiq International Sculpture Symposium. These platforms serve to democratize artistic access, promote local and international talent, and encourage community participation through workshops and public installations.

Artworks are strategically placed to maximize visibility and impact, at city entrances, transport corridors, and civic landmarks, creating what the RCRC describes as a "gallery without walls." This spatial integration of art fosters civic pride, enhances quality of life, and transforms Riyadh into a living canvas of cultural expression.

Beyond aesthetics, Riyadh Art is a catalyst for economic diversification. By nurturing the creative economy, the initiative has generated over 20,000 job opportunities and attracted more than 240 participating artists from around the world. It also contributes to tourism, drawing over 1.29 million visitors annually, and encourages private sector investment in cultural infrastructure.

Socially, the program enriches lives by offering daily moments of joy and reflection. It cultivates a sense of belonging and shared identity among residents, while positioning Riyadh as a destination for global art enthusiasts.

Riyadh Art exemplifies how visionary urban planning can harness the power of culture to drive economic growth, social cohesion, and international recognition. As Saudi Arabia continues its journey toward modernization and global integration, initiatives like Riyadh Art serve as both symbols and instruments of transformation.

3. The Royal Arts Complex: A Cultural Beacon in King Salman Park

As part of Saudi Arabia's cultural renaissance under Vision 2030, the Royal Arts Complex is a flagship initiative to elevate Riyadh as a regional and global center for artistic excellence. Led by the King Salman Park Foundation in collaboration with the Ministry of Culture, the Complex is a multidimensional cultural hub integrating heritage, innovation, and civic engagement in the heart of the capital.

The Royal Arts Complex is set to become one of the most iconic landmarks within King Salman Park, itself one of the world's largest urban parks. The Complex is being designed by renowned Spanish architect Ricardo Bofill, whose vision harmonizes contemporary aesthetics with Salmani architectural principles, a style rooted in the cultural and historical identity of Riyadh. This fusion of modernity and tradition aims to offer visitors a distinctive spatial and sensory experience, reinforcing the Kingdom's commitment to cultural authenticity and innovation. The Complex will comprise seven major cultural assets, each aligned with the strategic objectives of Vision 2030 to inspire talent, foster creativity, and enrich the national cultural sector. These assets include:

- Museum of World Cultures: A signature architectural feature that will serve as a gateway to global artistic and cultural narratives.
- National Theater: A premier venue for performing arts, designed to host national and international productions.
- Royal Institute of Traditional Arts: A cornerstone of cultural preservation and education, housing three specialized academies:
- Academy of Traditional Visual Arts
- Academy of Cultural Heritage and Restoration
- Academy of Theatrical Arts

In addition, the Complex will feature a cultural cinema complex tailored for local and international film festivals, a sculpture and artwork pavilion, and a specialized library dedicated to arts and culture. A dome-shaped exhibition space will serve as a dynamic venue for showcasing emerging talent and hosting cultural events, reinforcing the

Complex's role as a living laboratory for artistic expression.

The Royal Arts Complex is a strategic instrument for cultural diplomacy, economic diversification, and social transformation. By cultivating artistic talent and providing platforms for cultural exchange, the Complex contributes to the development of a robust creative economy. It also enhances Riyadh's urban identity, positioning the city as a magnet for cultural tourism and international collaboration.

The initiative reflects Vision 2030's broader goals of nurturing national pride, promoting cultural literacy, and embedding creativity into the Kingdom's development narrative. Through its integrated design and inclusive programming, the Royal Arts Complex exemplifies how cultural infrastructure can serve as a catalyst for societal enrichment and global engagement.

4. The Saudi Genome Program: Pioneering Genomic Medicine

In an era of precision medicine and data-driven healthcare, Saudi Arabia has launched the Middle East's most ambitious genomic initiative: the Saudi Genome Program (SGP).

This national endeavor aims to construct a comprehensive genetic database of Saudi society, laying the foundation for transformative advances in personalized medicine, disease prevention, and healthcare cost reduction. The program reflects Saudi Arabia's strategic commitment to integrating biotechnology into its Vision 2030 roadmap for national development.

The Saudi Genome Program was inaugurated in 2018 under the patronage of His Royal Highness Prince Mohammed bin Salman bin Abdulaziz, Crown Prince and Prime Minister Mohammed bin Salman. It uses advanced genomic technologies to address the high prevalence of genetic disorders in the Kingdom. By decoding the genetic blueprint of the Saudi population, the program aims to sharpen diagnostic accuracy, optimize therapeutic interventions, and enable proactive disease prevention.

The SGP is particularly significant given the Kingdom's unique demographic and genetic profile, which includes high rates of consanguinity and inherited disorders. Through large-scale sequencing and bioinformatics analysis, the program seeks to identify pathogenic variants and develop targeted interventions that are culturally and clinically relevant.

In 2022, the Saudi Genome Program entered a new strategic phase with the launch of SGP 2.0, a visionary roadmap designed to elevate the Kingdom's global standing in genomics. This phrase outlines a series of bold yet attainable objectives, including:

- Establishing Saudi Arabia as a global hub for collaborative research on prevalent

genetic diseases

- Positioning the Kingdom as a regional leader in genetics and genomics within the MENA region
- Integrating genomics into national healthcare delivery to ensure equitable access to high-quality care

SGP 2.0 emphasizes cross-sectoral partnerships, international collaboration, and the development of local expertise in bioinformatics, genetic counseling, and clinical genomics. It also aligns with broader goals of economic diversification by fostering a biotechnology ecosystem capable of generating intellectual property, employment, and innovation.

The Saudi Genome Program is poised to revolutionize healthcare delivery in the Kingdom. By enabling personalized medicine, it allows clinicians to tailor treatments based on individual genetic profiles, thereby improving outcomes and reducing adverse drug reactions. Moreover, the program supports early detection of genetic predispositions, facilitating preventive care and reducing long-term healthcare expenditures.

From a policy perspective, SGP contributes to the Kingdom's public health resilience, enhances research capacity, and supports the ethical governance of genomic data. It also reinforces Saudi Arabia's role as a regional leader in biotechnology innovation and precision health.

The Saudi Genome Program shows how visionary leadership and investment in biotechnology can reshape national health systems. As the Kingdom advances toward Vision 2030, SGP offers a model of genomic integration in innovation, equity, and scientific excellence.

5. Ceer: Driving Saudi Arabia's Electric Vehicle Revolution

As Saudi Arabia accelerates its transition toward a diversified, innovation-driven economy, the launch of Ceer marks a pivotal moment in the Kingdom's industrial and technological evolution.

Announced in 2022 by HRH Crown Prince Mohammed bin Salman in collaboration with the Public Investment Fund, Ceer is the Kingdom's first electric vehicle (EV) brand. It is a strategic initiative to catalyze a new automotive ecosystem rooted in sustainability, advanced manufacturing, and global competitiveness.

Ceer is more than a commercial venture; it is a cornerstone of Saudi Arabia's Vision 2030 agenda to reduce economic dependence on oil and foster high-tech industries. The brand aims to design, manufacture, and sell a range of electric vehicles tailored to consumers in

Saudi Arabia and the broader Middle East and North Africa (MENA) region. By doing so, Ceer is expected to:

- Stimulate domestic and foreign investment in the automotive and technology sectors.
- Create thousands of high-skilled jobs for Saudi citizens.
- Contribute significantly to GDP growth through industrial diversification.
- Position the Kingdom as a regional leader in sustainable mobility.

Ceer's development is underpinned by a strategic partnership with Hon Hai Precision Industry Co. (Foxconn), a global leader in electronics manufacturing. Foxconn will engineer the electrical architecture of Ceer vehicles, integrating advanced infotainment systems, connectivity solutions, and autonomous driving capabilities. Additionally, Ceer will leverage component technology licensed from BMW, ensuring that its vehicles meet the highest international standards for safety, performance, and quality control.

This triadic collaboration, between PIF, Foxconn, and BMW, exemplifies Saudi Arabia's approach to industrial policy: combining sovereign investment with global expertise to build competitive, future-ready industries.

Ceer's emergence aligns with several Vision 2030 pillars, including:

- Sustainability and environmental stewardship through zero-emission transport
- Localization of advanced manufacturing and technology transfer
- Empowerment of Saudi talent in engineering, design, and innovation
- Expansion of non-oil exports and regional supply chain integration

The brand also contributes to the Kingdom's broader goals of reducing carbon emissions, enhancing urban mobility, and positioning Saudi Arabia as a hub for green technology in the Gulf region.

Ceer is a bold leap into the future of transportation, blending national ambition with global innovation. As Saudi Arabia continues to redefine its economic environment, Ceer stands as a symbol of what is possible when leadership, investment, and technology converge.

6. Boutique Group: Reimagining Heritage Through Luxury Hospitality

As Saudi Arabia advances Vision 2030, cultural tourism has emerged as a strategic pillar for economic diversification. Boutique Group, a hospitality enterprise wholly owned by the Public Investment Fund, exemplifies this by converting historic palaces into ultra-luxury destinations. Its mission is two-fold: to preserve and celebrate Saudi heritage, and to offer world-class experiences to domestic and international travelers.

Established under the auspices of the PIF, Boutique Group reflects the Kingdom's commitment to leveraging sovereign investment for cultural revitalization and economic growth. The company operates at the intersection of heritage conservation and luxury tourism, transforming royal residences and historic sites into experiential hospitality venues that embody Saudi Arabia's rich cultural legacy.

This initiative aligns with Vision 2030's goals to enhance the tourism sector's contribution to GDP, create employment opportunities, and promote Saudi Arabia as a premier destination for cultural and heritage tourism.

Boutique Group's properties are distinguished by their architectural authenticity and cultural resonance. Each destination is carefully restored to preserve its historical significance while incorporating contemporary design elements that reflect modern Saudi elegance. Upon arrival, guests are immersed in the Kingdom's cultural narrative, through architectural motifs, curated art collections, and locally inspired landscaping.

Key features of Boutique Group destinations include:

- Art galleries and exhibition spaces that showcase Saudi and regional artists.
- Elegant public areas and tranquil gardens designed for reflection and leisure.
- Culinary venues offering traditional and fusion cuisine.
- Dedicated cultural zones for performances, workshops, and educational programming.
- Sculpture installations and fountains that enhance the aesthetic and symbolic value of each site.

These elements collectively create a multisensory experience that fosters cultural appreciation and emotional connection, while reinforcing the Kingdom's identity as a steward of heritage and innovation. Boutique Group contributes to the local economy by generating employment in hospitality, heritage management, and creative industries. It also supports small and medium enterprises (SMEs) through partnerships with local artisans, chefs, and cultural practitioners. By revitalizing historic sites, the company ensures that Saudi heritage is not only preserved but actively lived and shared. From a cultural diplomacy perspective, Boutique Group enhances Saudi Arabia's soft power by offering international visitors a nuanced and authentic understanding of the Kingdom's history, values, and artistic traditions.

Boutique Group represents a paradigm shift in heritage tourism, where preservation meets innovation and luxury becomes a conduit for cultural storytelling. As Saudi Arabia redefines its global image, initiatives like Boutique Group show how strategic investment and cultural stewardship create enduring value. Saudi Vision 2030 marks a pivotal

moment in the Kingdom's transformation. Its goals for economic diversification, social progress, and cultural enrichment form a strategic framework for a vibrant society, a thriving economy, and an ambitious nation. As Saudi Arabia implements this blueprint, it is redefining its role in the global stage and unlocking new opportunities for innovation and growth. Sustained commitment to Vision 2030 will shape the future of the Kingdom for generations to come.

Chapter 2

KSA Supreme Committee for Research, Development, And Innovation

"These aspirations and priorities will enhance the Kingdom's global competitiveness and leadership, in line with the directions of Saudi Vision 2030, and strengthen the Kingdom's position as the largest economy in the region."

His Royal Highness Prince Mohammed bin Salman bin Abdulaziz Al Saud

The Supreme Committee for Research, Development, and Innovation (KSA-RDI) of the Kingdom of Saudi Arabia was established on March 9, 2021, under the leadership of Crown Prince and Prime Minister Mohammed bin Salman. The Committee is tasked with defining the nation's RDI priorities for the next twenty years, ensuring alignment with Vision 2030.

Purpose and Role

- Strategic Oversight: The Committee defines the long-term aspirations and priorities for research, development, and innovation in Saudi Arabia.
- Vision 2030 Alignment: It supports the Kingdom's transformation into a knowledge-based economy, reducing reliance on oil and fostering high-value science and technology sectors.
- Global Competitiveness: The Committee aims to strengthen Saudi Arabia's position as a regional and global leader in innovation.

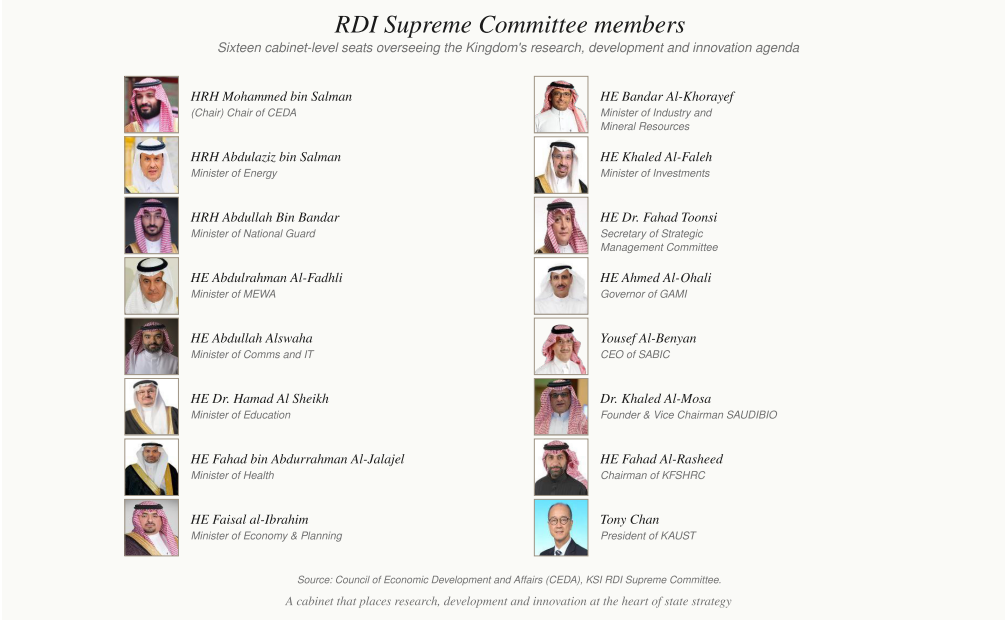

Figure 2.1

Composition of the Supreme Committee for Research, Development, and Innovation (RDI) Under the Leadership of His Royal Highness the Crown Prince and Prime Minister

National Aspirations and Priorities (2021–2040)

The Committee announced four major priority areas:

- *Health and Wellness* – Advancing medical research, biotechnology, and healthcare innovation.
- *Sustainable Environment and Supply of Essential Needs* – Addressing food security, water sustainability, and ecological resilience.
- *Energy and Industrial Leadership* – Driving innovation in renewable energy, advanced manufacturing, and industrial technologies.
- *Economies of the Future* – Building futuristic sectors such as AI, digital economy, NEOM, and the Red Sea Project.

Long-Term Ambitions

- *Investment Target:* Increase RDI spending to 2.5% of GDP by 2040, a significant leap from current levels.
- *Institutional Support:* Works alongside the Research, Development, and Innovation Authority (RDIA), established on June 2, 2021, which provides funding, coordination,

and regulatory support.

- *Global Partnerships:* Encourages collaboration with international institutions to accelerate scientific and technological breakthroughs.

Strategic Importance

The KSA Supreme Committee for Research, Development, and Innovation (RDI) is not just an administrative body; it is a cornerstone of Saudi Arabia's innovation ecosystem. By setting clear priorities and mobilizing resources, it ensures that the Kingdom:

- Develops localized biotechnology and healthcare solutions.
- Positions itself as a regional hub for advanced industries.
- Builds resilience in food, water, and energy security.
- Creates future-ready economies powered by digital transformation and sustainability.

This Committee is a pivotal driver of Saudi Arabia's ambition to become a global leader in science, technology, and innovation.

On 9 March 2021, the Kingdom of Saudi Arabia launched a transformative strategy to become a global leader in Research, Development, and Innovation: the KSA Supreme Committee for Research, Development, and Innovation (RDI), chaired by HRH the Crown Prince. The initiative marks a pivotal shift in the Kingdom's development trajectory.

As a member of the Kingdom's Supreme Committee for Research, Development & Innovation, the Council of Economic and Development Affairs, and the Council of Ministers, I was appointed to represent the private sector. My role is to help shape and advance this vision, and to ensure that biotechnology, healthcare, and industrial innovation remain at the forefront of Saudi Arabia's RDI agenda.

The Supreme Committee has set a series of audacious goals. By 2040, Saudi Arabia aims to rank among the leading nations on the Global Innovation Index and to lead the MENA region, with HRH the Crown Prince having accelerated the regional leadership target to 2030. The strategy targets a budget envelope of SAR 115 billion in RDI expenditure by 2040, approximately 2.5% of GDP. It also envisions 140,000 researchers by 2040, 360,000 jobs by 2050, and a SAR 230 billion contribution to GDP by mid-century.

Four strategic focus areas guide this transformation: Health and Wellness; Sustainability and Essential Needs; Energy and Industrials; and Economies of the Future. These domains align with national priorities and global challenges. RDI is recognized as a key driver of economic growth, productivity, and sovereignty. For Saudi Arabia, the stakes are high: existential pressures such as water scarcity and climate change, and economic

vulnerabilities including limited diversification and declining oil demand.

Despite prior efforts, the Kingdom's RDI sector faces significant gaps. Current funding is just 0.4% of GDP, far below the 2.5% benchmark of leading innovators. Researcher density is low, at 834 full-time equivalents per million people, against a G20 average of 2,800. Regulatory rigidity, data and procurement inefficiencies, and limited venture capital investment (0.07% of GDP versus a 0.15% benchmark) further hinder progress. A "system shock" is needed to reset the trajectory and build momentum.

The strategy embraces a fundamentally different approach from conventional economic sectors, guided by stable funding, tolerance for high risk and reward, long-term returns, alternative impact metrics, bottom-up innovation aligned with top-down direction, and global integration. To achieve its goals, the Kingdom must push the boundaries of its RDI ecosystem: becoming a regional leader by 2030, a global challenger by 2040, and ultimately a global superpower in science and innovation.

The vision and mission of the RDI strategy are rooted in Saudi Arabia's historical legacy as a cradle of innovation. As articulated by the Supreme Committee: "At the birthplace of one of the most innovative civilizations in history, KSA aspires to emerge as a global innovation challenger to transform lives and advance human progress. KSA will achieve this vision by empowering the brightest minds to find the boldest answers to global challenges in health and wellness, energy and industry, sustainability, and economies of the future."

The Saudi Supreme Committee for Research, Development, and Innovation (RDI) is built on four main pillars (national priorities): Health & Wellness, Sustainable Environment & Supply of Essential Needs, Energy & Industrial Leadership, and Economies of the Future.

The Four Pillars of Saudi RDI

1. Health & Wellness

- Focus on advancing biotechnology, pharmaceuticals, and healthcare innovation.
- Strengthening vaccine development, precision medicine, and digital health solutions.
- Enhancing quality of life and addressing regional/global health challenges.

2. Sustainable Environment & Supply of Essential Needs

- Ensuring food security, water sustainability, and ecological resilience.
- Promoting research in agriculture, desalination, and environmental technologies.
- Supporting long-term sustainability in line with Vision 2030 goals.

3. Energy & Industrial Leadership

- Driving innovation in renewable energy, hydrogen, and advanced industrial

technologies.

- Expanding localization of high-value industries such as petrochemicals, mining, and manufacturing.
- Positioning Saudi Arabia as a global leader in energy transition and industrial competitiveness.

4. Economies of the Future

- Building futuristic sectors such as artificial intelligence, robotics, and the digital economy.
- Supporting mega-projects like **NEOM and the Red Sea Project as testbeds for innovation.**
- **Creating new economic models that diversify beyond oil and foster global partnerships.**

Strategic Importance

- These pillars were announced on March 9, 2021, by Crown Prince Mohammed bin Salman, who chairs the Committee.
- They serve as the national RDI priorities for the next two decades (2022–2040).
- The Committee aims to raise RDI investment to 2.5% of GDP by 2040, positioning Saudi Arabia as a global innovation hub.

The Supreme Committee's pillars are designed to **transform Saudi Arabia into a knowledge-driven economy, ensuring resilience in health, sustainability, energy, and future industries.**

The strategy adopts a mission-oriented approach that rallies the ecosystem around shared goals, breaks disciplinary silos, and addresses both local and global challenges. For each focus area, a set of missions has been developed from national priorities, strategic aspirations, and expert insights. The strategy supports a wide scope of research to encourage bottom-up innovation, while placing dedicated governance and funding emphasis on selected missions.

Wave 1 of these missions, to be launched within five years, includes:

- Reducing the withdrawal of non-renewable water by 90% and cutting water production costs by 50% by 2035.
- Halving the incidence of infectious diseases significant to KSA by 2035.
- Achieving net-zero emissions by 2060.
- Developing cost-effective technologies to convert 80–85% of crude oil to chemicals by 2030.

- Establishing five Cognitive Cities in KSA by 2040, going beyond the concept of Smart Cities.

To ensure successful execution, a comprehensive delivery model has been developed. This includes a strategic roadmap with the necessary exemptions for the Research, Development, and Innovation Authority (RDIA), a funding model aligned with national aspirations, and a governance framework covering mission, functional, and financial oversight. Risk-management protocols are embedded to identify and mitigate challenges.

The funding model sets out a ramp-up strategy for public and private investment, balancing institutional funding with grants and awards. It describes the mix of resources across the RDI value chain, ensuring that every stage, from ideation to commercialization, is adequately supported.

Governance and Strategic Oversight

The Supreme Committee operates within a governance framework that reflects the Kingdom's commitment to strategic clarity and coordinated execution. This framework is organized into three tiers:

1. Priority Setting

The Committee defines national RDI priorities in close coordination with the Council of Economic and Development Affairs. Supported by the General Secretariat, it communicates policies, issues budget guidelines, and approves return-on-investment strategies.

2. Coordination and Fund Allocation

The Committee proposes the national RDI budget envelope and ensures that funding decisions align with strategic goals. It oversees coordination across ministries and sectors to keep execution focused, efficient, and mission-driven.

3. Execution Oversight

While implementation is carried out by affiliated entities such as national laboratories, universities, and private sector organizations, the Supreme Committee maintains strategic oversight. It ensures that programs are formulated, resources are allocated, and outcomes are monitored in alignment with national priorities.

Strategic and Coordination Flow

To ensure successful execution, a detailed delivery model has been developed, including a strategic roadmap, governance structures, funding mechanisms, and risk management frameworks. The funding model aligns with national aspirations, balancing public and private investment, institutional support, and grants across the RDI value chain.

This governance model (Figure 2.2) reflects the national direction established under Vision 2030 and formalised through the Council of Ministers' framework, which mandates unified planning, coordination, and oversight across the Kingdom's research, development, and innovation ecosystem. By consolidating previously fragmented efforts into an integrated, high-impact structure anchored by COM-supervised bodies such as the Council of Economic and Development Affairs and its Strategy Committee, the Kingdom ensures that scientific inquiry and technological advancement align with national priorities and global competitiveness. This unified approach strengthens institutional coherence and positions Saudi Arabia to redefine its innovation sector and advance toward global leadership in RDI.

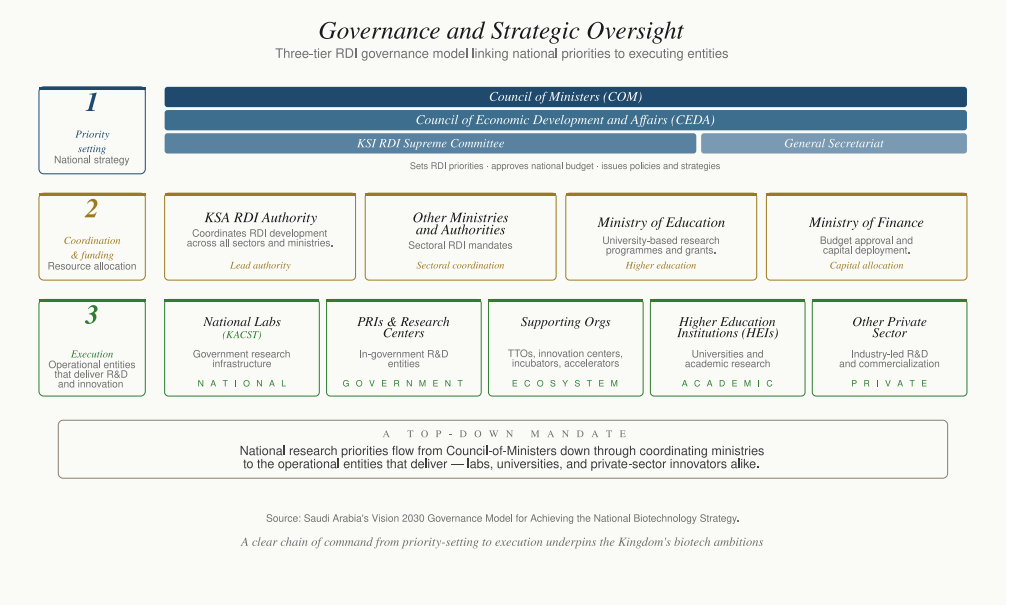

Figure 2.2
Governance and Strategic Oversight

Leadership in Action: My Role in Shaping Saudi Arabia's Biotechnology Future

As a member of Saudi Arabia's Supreme Committee for Research, Development, and Innovation from 2021 to 2024, I have had the honor of representing the private sector in one of the most transformative chapters of our Kingdom's innovation journey. My tenure was driven by a singular purpose: to align scientific ambition with strategic execution in Health and Wellness.

Throughout this period, I focused on bridging biotechnology manufacturing, R&D, medical research, digital health, and life-sciences development. My strategic foresight helped guide national efforts to modernize healthcare delivery, integrate emerging technologies, and foster innovation across the public and private sectors. Under my leadership, Saudi Arabia accelerated its adoption of precision medicine, expanded its genomic research capabilities, and laid the foundation for next-generation therapeutic platforms.

My contributions reflect the ethos of the RDI Committee: expertise meeting purpose, and leadership as a catalyst for impact. I championed initiatives that raised scientific standards while prioritizing accessibility, efficiency, and patient-centered care. I worked to shape policies that encourage collaboration between academia, industry, and government, creating an ecosystem that supports sustainable growth in biotechnology.

Beyond organizational milestones, I have been committed to strengthening Saudi Arabia's public-health resilience, cultivating homegrown talent, and elevating the Kingdom's position on the world stage. My work centers on empowerment: enabling researchers to explore new frontiers, inspiring institutions to embrace bold innovation, and positioning the Kingdom to lead in global biotechnology.

As Saudi Arabia continues toward becoming a global biotech hub, I remain dedicated to serving as a guiding force, demonstrating how vision, expertise, and strategic action converge to shape a healthier and more prosperous future.

A Nation Reimagined

The Supreme Committee is far more than a policy-making entity; it is the strategic nucleus of a nation reimagining its future. In an era of rapid technological change and global competition, Saudi Arabia has chosen not to follow but to lead. Through the Committee's visionary leadership, the Kingdom is embedding innovation into the fabric of its national identity, becoming a society not only prepared for the future but actively shaping it.

This transformation is guided by Vision 2030's principles of economic diversification,

knowledge-based growth, and global leadership in science and technology. As Saudi Arabia advances toward 2040, the RDI Committee serves as a beacon of progress, bringing scientific inquiry, technological advancement, and human ingenuity together to forge a new era of prosperity and resilience.

The Committee's work spans sectors, catalyzing breakthroughs in biotechnology, artificial intelligence, clean energy, and advanced manufacturing. It fosters collaboration between academia, industry, and government, so that innovation is not siloed but shared and scaled. Its initiatives unlock Saudi talent, attract global expertise, and position the Kingdom as a hub for transformative R&D.

As the Kingdom advances toward 2040 under Vision 2030, the Supreme Committee illuminates a path where science, technology, and human ingenuity converge to forge a new era of prosperity. Among its most influential voices, my work exemplifies the caliber of leadership driving this transformation: visionary, purposeful, and deeply committed to the promise of innovation. Through these efforts, Saudi Arabia is not merely adapting to change; it is defining it.

This is the essence of a nation being reimagined: a nation that dares to dream beyond convention, that invests in the power of ideas, and that leads with purpose on the global stage. The RDI Committee is the architect of this transformation, and its leaders are the stewards of a future in which science serves society and innovation drives national progress.

The establishment of the Supreme Committee for Research, Development, and Innovation marks a transformative step in Saudi Arabia's pursuit of a diversified, knowledge-driven economy. By setting clear national priorities and aligning with Vision 2030, the Committee is laying the groundwork for scientific advancement, technological progress, and sustained global competitiveness. As the Kingdom continues to invest in research and innovation, it is poised to become a regional leader in cutting-edge industries and a model for strategic development. The Committee's work will shape not only the future of the Kingdom's economy but also its role on the world stage, driving prosperity for generations to come.

Chapter 3

National Biotechnology Strategy

The Saudi National Biotechnology Strategy was launched on 25 January 2024, by Crown Prince and Prime Minister Mohammed bin Salman. It is a comprehensive roadmap to position Saudi Arabia as a global biotechnology hub by 2040, focusing on vaccine sovereignty, biomanufacturing, genomics, and advanced therapeutics

Purpose and Vision

- Global Hub by 2040: The strategy aims to make Saudi Arabia a leading center for biotechnology research, development, and manufacturing.
- Vision 2030 Alignment: It supports economic diversification, healthcare sustainability, and localization of critical industries.
- Health & Security: Strengthens national resilience in vaccines, medicines, and food security.

Strategic Directions

1. Vaccines

- Develop end-to-end vaccine manufacturing capabilities.
- Achieve self-sufficiency and enable exports across the MENA region.

2. Biomanufacturing

- Localize production of insulin, cancer therapeutics, and advanced biologics.
- Build industrial-scale facilities to reduce reliance on imports.

3. Genomics & Precision Medicine

- Integrate genomic medicine into healthcare systems.
- Advance research in genetic therapies, diagnostics, and personalized treatments.

4. Agricultural & Environmental Biotechnology

- Enhance food and water security through biotech-driven solutions.
- Support sustainability in agriculture and environmental protection.

Economic & Social Impact

- *Investment Target:* Significant increase in biotech R&D spending on fuel innovation.
- *Job Creation:* Thousands of high-skilled jobs in biotech, pharma, and research sectors.
- *Global Competitiveness:* Position Saudi Arabia as a regional exporter of vaccines and biopharmaceuticals.

- *Quality of Life:* Improve healthcare outcomes and resilience against pandemics.

Strategic Importance

- The strategy is a cornerstone of Vision 2030's innovation agenda, complementing the Supreme Committee for RDI's four pillars.
- It ensures Saudi Arabia's biotech sovereignty, reducing dependency on global supply chains.
- It creates opportunities for international partnerships in cutting-edge biotech fields.

In short, the Saudi National Biotechnology Strategy (2024–2040) is designed to transform the Kingdom into a biotech powerhouse, securing health resilience, driving economic diversification, and fostering global leadership in advanced life sciences.

My Contributions Toward Fulfilling Three of the Four Pillars of the National Biotechnology Strategy Before 2030

Saudi Arabia's biotechnology sector has moved from aspiration to achieving real outcomes. I am proud to have played a role in this advancement through a portfolio of organizations that spans the entire biotech value chain: SAUDI Biotechnology Manufacturing Company (SAUDIBIO) for insulin and cancer therapies; Vaccine Industrial Company (VIC) for human vaccines; Biotech Industrial Engineering Company (BIOERA) for constructing biotech facilities; Biotech Innovations Company for research and development; Biotechnology Training Institute (BTI) for specialized training; ANIVAX Company for veterinary biotechnology; and Dr. Khaled Al-Mosa Consulting, which advises biotech operators and start-ups.

Together, these organizations are now foundational to Saudi Arabia's healthcare resilience, technological advancement, and scientific development. Under my leadership, we have brought the domestic manufacture of critical medical products on-shore, including insulin, biologics, cancer treatments, and human and veterinary vaccines, reducing reliance on imports and strengthening national health security. I have also advanced specialized biotech-engineering capabilities, implemented training programs for the next generation of biotech professionals, and delivered integrated solutions across the biotechnology value chain. These efforts have strengthened the Kingdom's capacity to meet current and future health challenges, and established Saudi Arabia as an emerging regional leader in biotechnology.

At SAUDIBIO I established the Kingdom's first multipurpose sterile biologics manufacturing facility. Through our partnership with Novo Nordisk, it produces high-quality insulin pens and vials with a projected annual capacity of 100 million units by

2027, meeting EU GMP Annex I and SFDA standards. These products address the region's growing diabetes burden while reducing dependence on imported treatments. Our focus extends to biosimilars and cancer therapies, supporting the Kingdom's strategic goal of pharmaceutical self-sufficiency.

The partnership between SAUDIBIO and Novo Nordisk represents a defining moment in Saudi Arabia's transition toward a selfsustaining biopharmaceutical ecosystem. As the Kingdom advances its National Biotechnology Strategy and strengthens its healthsecurity framework, Novo Nordisk emerges as a pivotal international collaborator whose expertise directly accelerates the nation's capacity to manufacture highvalue biologics. Through a series of technologytransfer agreements, qualitysystem integrations, and longterm supply frameworks, Novo Nordisk enables SAUDIBIO to establish itself as the first Saudi facility capable of producing innovator insulin and other complex biologics under globally recognized GMP standards.

Novo Nordisk's contribution extends beyond manufacturing know-how. The company brings a century of leadership in diabetes care, biologics formulation, and aseptic production, capabilities essential to the Kingdom's ambition of localizing more than half its insulin demand. The collaboration positions Saudi Arabia as a regional manufacturing hub and a future exporter of high-quality biopharmaceuticals. It also develops a skilled national workforce through structured training, technical mentorship, and operational immersion within Novo Nordisk's global manufacturing network.

For SAUDIBIO, the collaboration provides a strong platform for expanding biologics capabilities. Following Lifera's 2023 acquisition of a 70% stake, SAUDIBIO's integration into the PIF-backed biopharma platform further elevates the partnership's strategic importance. With Novo Nordisk's guidance, SAUDIBIO is positioned to expand beyond insulin to include additional biologics essential to national health resilience.

Beyond our milestone in localizing insulin manufacturing with Novo Nordisk, I spearheaded a further initiative by formalising a localization agreement with Sandoz in 2020. The agreement was established during my tenure as General Director and Chairman of the Board at SAUDIBIO, prior to my departure in 2021. By bringing Sandoz on board, SAUDIBIO significantly expanded its technical capabilities and commercial portfolio, particularly in oncology-focused biosimilars and cancer therapeutics. The partnership enabled SAUDIBIO to begin development and domestic production of critical treatments for high-priority cancer indications, addressing the Kingdom's urgent healthcare needs. It strengthened Saudi Arabia's ability to produce advanced cancer therapies locally and positioned SAUDIBIO as a leader in the regional fight against cancer.

The SAUDIBIO–Sandoz partnership shows how collaboration between multinational pharmaceutical innovators and emerging national biotech platforms can accelerate domestic industry and raise healthcare standards. By leveraging Sandoz's expertise in biosimilars and cancer therapeutics, SAUDIBIO fortified its manufacturing infrastructure, raised its technical know-how, and diversified its product offering. The model strengthens supply-chain sovereignty by reducing reliance on imported medicines, sets new benchmarks for quality and access, and helps Saudi patients benefit from cutting-edge therapeutics while lifting the standard of care across the region.

In 2022 I founded the Vaccine Industrial Company (VIC), marking a milestone for Saudi Arabia as it became home to the largest human vaccine manufacturing facility in the Middle East and the nation's first of its kind. The endeavor was launched in collaboration with CSL Seqirus, the global leader in cell-based vaccine technology. Together, we are building an advanced platform capable of producing SFDA-approved, cell-based seasonal influenza vaccines locally, the first time Saudi Arabia will supply its citizens with domestically manufactured innovator vaccines. The partnership goes further still: VIC, CSL Seqirus, and the Saudi Ministry of Health have entered into a landmark agreement to provide up to 70 million doses of pandemic-response vaccines, ensuring that in a public-health crisis Saudi Arabia will be able to protect its entire population swiftly. VIC is advancing national vaccine sovereignty and strengthening Saudi Arabia's preparedness for future health emergencies, positioning the Kingdom as a regional leader in vaccine innovation and production.

By 2025, my organizations, including SAUDI Biotechnology Manufacturing Company (SAUDIBIO), Vaccine Industrial Company (VIC), Biotech Industrial Engineering Company (BIOERA), Biotech Innovations Company for R&D, Biotechnology Training Institute (BTI), ANIVAX Company (Veterinary Biotech), and Dr. Khaled Al-Mosa Consulting Firm, will have reached significant milestones across three of the four key pillars defined in Saudi Arabia's National Biotechnology Strategy: Vaccines, Biomanufacturing, and Gene Editing Technologies. These achievements represent a major breakthrough for the Kingdom, propelling it to the forefront of biotechnology within the region, well ahead of the Vision 2030 timeline. My efforts have strengthened national healthcare resilience and spurred industrial innovation, positioning Saudi Arabia as a leader in advanced biotechnologies and paving the way for sustained progress and global competitiveness through 2030 and beyond.

Biotechnology, the fusion of biology and technology, harnesses living systems to deliver solutions across healthcare, environmental sustainability, and industrial manufacturing. In healthcare, it has revolutionized treatment and prevention, from recombinant

DNA enabling insulin production to gene therapy for genetic disorders. Monoclonal antibodies engineered to mimic immune responses are now central to treating cancers and autoimmune disease, and biotechnology has accelerated vaccine development and global readiness for emerging viral threats.

Beyond healthcare, biotechnology plays a vital role in advancing agriculture, promoting sustainability, and transforming industrial processes, making it a cornerstone of Saudi Arabia's vision for a knowledge-driven, resilient economy.

My Role in Advancing Saudi Arabia's National Biotechnology Strategy

Pioneering Biologics Manufacturing

Building Vaccine Sovereignty

We are developing a state-of-the-art facility in collaboration with CSL Seqirus to produce seasonal influenza and pandemic-response cell-based vaccines. CSL Seqirus operates a global R&D and manufacturing network across the United States, Europe, and Australia, and is recognized for pioneering cell-based and adjuvanted influenza vaccines.

Implementing the National Biotechnology Strategy

The four pillars are:

- *Vaccines* – Comprehensive manufacturing, regional R&D leadership, and export capability.
- *Biomanufacturing* – Localization of biologics, biosimilars, and advanced therapies.
- *Genomics* – Integration of precision medicine and leadership in genomic information.
- *Plant Optimization* – Biotechnology-driven food security, crop resilience, and sustainability.

As of 2025, my initiatives have advanced three of the four strategic pillars, Vaccines, Biomanufacturing, and Gene-Editing Technologies, five years ahead of the 2030 target. VIC has established the region's largest vaccine production facility. SAUDIBIO has localized the manufacture of insulin, biologics, and advanced therapies, reducing reliance on imports. Biotech Innovations Company has advanced vaccine and biotechnology R&D, delivered specialized training, and supported gene-therapy development.

A Foundational Milestone

This achievement goes beyond incremental progress; it is a foundational breakthrough. By delivering 75% of the strategy's pillars in fifteen years (2010–2025), my companies have demonstrated the Kingdom's capacity to turn Vision 2030 into concrete outcomes.

We have driven innovation, created skilled employment, and established Saudi Arabia as a significant player in international medical science.

Biotechnology as a Cornerstone of Transformation

In January 2024, His Royal Highness Crown Prince and Prime Minister Mohammed bin Salman unveiled the National Biotechnology Strategy, a bold initiative placing biotechnology foundational to the Kingdom's future. More than a policy framework, it is a strategic roadmap for economic diversification, societal advancement, and global leadership in life sciences.

- In healthcare, it has revolutionized treatment and prevention, from recombinant DNA enabling insulin production to gene therapy for genetic disorders.
- Monoclonal antibodies now play a critical role in treating cancers and autoimmune diseases.
- Biotechnology accelerates vaccine development, enhancing global readiness for emerging threats.

Beyond healthcare, biotechnology advances agriculture, promotes sustainability, and transforms industrial processes, making it a cornerstone of Saudi Arabia's vision for a knowledge-driven, resilient economy.

Vision Rooted in Transformation

Biotechnology is a strategic pillar of Vision 2030, the national blueprint for economic diversification, innovation, and societal progress. Recognizing its potential to address pandemics, genetic disorders, food insecurity, and climate change, the Kingdom is building a robust biotech ecosystem across healthcare, agriculture, industry, and environmental sustainability.

The strategy embodies sovereignty, resilience, and excellence. It aims to reduce reliance on imported technologies, empower domestic talent, attract international investment, and establish Saudi Arabia as a regional biotech hub by 2030 and a global leader by 2040. This vision is already materialising, supported by substantial capital, strong government backing, and the Kingdom's distinctive genetic and geographic assets.

In agriculture, biotechnology has transformed crop production by enhancing growth, yields, pest resistance, and nutritional value; approximately 80% of processed foods now contain biotech-derived ingredients. Innovations such as genetically engineered crops and the Sterile Insect Technique (SIT) have sharply improved pest control in orchards and vineyards.

Biofuels represent another advance. Derived from renewable sources such as algae, corn stover, and sugarcane bagasse, they offer a sustainable alternative to petroleum. Their production also protects food supplies, since inputs like algae thrive on wastewater and non-arable land.

Biological technologies are reshaping resource production with precision and environmental responsibility. The sector catalyses growth, creating skilled jobs, attracting investment, and fostering a knowledge-based economy. Biotechnology represents the convergence of biology and technology, and a hopeful path forward.

Strategic Pillars: The Four Engines of Innovation

each a vital domain of scientific advancement and economic growth. These pillars reflect Saudi Arabia's commitment to innovation, excellence, and sustainable development, particularly in healthcare.

Pillar 1: Vaccine Manufacturing

The COVID-19 pandemic revealed critical vulnerabilities in global supply chains and underscored the urgent need for domestic vaccine production. In response, Saudi Arabia has made vaccine manufacturing a strategic priority for self-sufficiency and regional health resilience.

The Kingdom is developing state-of-the-art facilities capable of producing mRNA, viral-vector, and protein-based vaccines tailored to regional health needs. This is supported by substantial investment in infrastructure, talent development, and regulatory frameworks, laying the foundation for rapid response in future outbreaks.

Saudi Arabia's approach is two-fold. First, it aims to establish end-to-end manufacturing capabilities covering research, development, production, and distribution. Second, it positions the Kingdom as a regional hub for late-stage vaccine innovation. Through strategic partnerships and advanced technologies, Saudi Arabia aims to reduce reliance on external suppliers, expand export capacity across MENA, and contribute to global progress in infectious-disease prevention.

By pursuing these initiatives, Saudi Arabia is building a resilient vaccine ecosystem that enhances national preparedness, supports regional health security, and advances its leadership in the biotechnology sector.

Pillar 2: Biomanufacturing Localization: Building a Domestic Powerhouse

Biomanufacturing lies at the heart of modern therapeutics, enabling the large-scale production of biologics, biosimilars, and cell-based therapies. These treatments are

transforming medicine, offering targeted solutions for chronic and life-threatening conditions including cancer, autoimmune disorders, and infectious diseases. Saudi Arabia has placed biomanufacturing at the center of its National Biotechnology Strategy and aims to build a resilient, self-sufficient, and globally competitive industry.

Central to this effort is the localization of biomanufacturing capabilities. By producing critical therapies domestically, including monoclonal antibodies engineered to replicate immune responses, the Kingdom is enhancing access to advanced treatments while reducing dependence on costly imports. These antibodies are essential in treating a wide range of conditions, from rheumatoid arthritis and multiple sclerosis to various forms of cancer and viral infections. Local production not only improves affordability and availability but also fosters the development of proprietary technologies and intellectual property, contributing to Saudi Arabia's scientific prestige and economic diversification.

The strategy envisions a biomanufacturing ecosystem that integrates research, development, production, and commercialization. It includes state-of-the-art facilities, regulatory excellence, and a skilled workforce developed through specialized training. By attracting foreign investment and encouraging public-private partnerships, the Kingdom aims to accelerate technology transfer and create thousands of high-quality jobs.

Localization also reduces healthcare expenditure by streamlining supply chains and improving cost-efficiency. As capabilities grow, the Kingdom positions itself as a leading exporter of biopharmaceuticals within the MENA region, with ambitions to become a regional biotech hub by 2030 and a global player by 2040.

Under this strategic framework, biomanufacturing is more than a technical endeavor; it is a national imperative that aligns with Saudi Arabia's broader goals of economic transformation, scientific leadership, and improved public health outcomes.

Pillar 3: Genomics: Precision Medicine and Population Health

Saudi Arabia's distinctive genetic profile, shaped by centuries of cultural continuity, tribal heritage, and geographic isolation, provides a valuable foundation for genomic research. This unique population structure, characterized by high rates of consanguinity and region-specific genetic traits, offers unparalleled opportunities to study the genetic basis of diseases, uncover novel mutations, and develop targeted therapies. Recognizing this potential, the Kingdom has made genomics a central pillar of its National Biotechnology Strategy.

Driving the initiative is a comprehensive national genomic database, designed to integrate into clinical practice and enable precision medicine. It will allow clinicians to tailor treatments to individual genetic profiles, improving therapeutic outcomes, reducing

adverse drug reactions, and enhancing preventive care, particularly for the rare genetic disorders more prevalent in the region.

Saudi Arabia is investing in genomics research and development, supported by progressive regulatory policies, ethical data-governance frameworks, and initiatives to expand access to genetic testing. The strategy also builds local expertise through academic partnerships, specialized training, and the establishment of advanced research centers.

Artificial intelligence and machine learning are being deployed to analyze vast genomic datasets. These tools enable researchers to identify patterns, predict disease risks, and discover therapeutic targets with unprecedented speed and accuracy. Combining computational power with biological insight accelerates the translation of genomic discoveries into clinical applications.

Through these integrated efforts, the Kingdom is positioning itself as a global leader in genomic science. It aims to attract top-tier researchers, biotech investors, and international collaborators, transforming Saudi Arabia into a hub for innovation in precision medicine. This strategic focus not only advances scientific knowledge but also contributes to the Kingdom's broader goals of healthcare transformation, economic diversification, and global competitiveness in the life sciences.

Pillar 4: Plant Optimization: Agricultural Innovation and Food Security

In a region of arid climate, scarce water, and limited arable land, biotechnology offers a powerful response to the challenges of sustainable agriculture and food security. Saudi Arabia has made plant optimisation a key pillar of its National Biotechnology Strategy, harnessing biotechnological tools to transform agriculture and reduce reliance on food imports.

A core element of this effort are genetically enhanced crops that are drought-resistant, pest-tolerant, and nutritionally fortified. These are tailored to Saudi Arabia's harsh conditions, ensuring stable yields under extreme weather. Improving crop resilience and productivity secures the food supply while conserving natural resources.

Advanced genetic engineering and precision breeding are accelerating crop improvement. In parallel, biological pest-control methods, notably the Sterile Insect Technique (SIT), protect fruit orchards and reduce the ecological impact of chemical pesticides. SIT releases sterilised male insects into the wild to suppress pest populations naturally, preserving biodiversity and supporting environmentally friendly farming.

Beyond food production, Saudi Arabia is exploring the potential of bioenergy as part of its sustainability agenda. Research into biofuel generation from algae and sugarcane

bagasse is underway, offering renewable alternatives to fossil fuels and contributing to the Kingdom's efforts to lower its carbon footprint. These initiatives align with broader goals of environmental stewardship and energy diversification.

The strategy's long-term vision includes reducing dependence on imported food by enhancing domestic agricultural output, improving nutritional quality, and building climate-resilient farming systems. These efforts are expected to contribute significantly to the non-oil GDP, create high-value jobs in the Agri-biotech sector, and foster innovation across rural and urban communities.

Integrating biotechnology into agriculture addresses immediate food-security concerns and lays the foundation for a sustainable, knowledge-driven economy. It reflects the Kingdom's commitment to science and technology as the means of overcoming environmental constraints.

A Holistic Vision for Biotech Transformation

Beyond its four strategic pillars (vaccine manufacturing, biomanufacturing, genomics, and plant optimization), the National Biotechnology Strategy embraces a broader, more integrated vision: the creation of a dynamic, inclusive, and future-ready biotech ecosystem. This holistic approach recognizes that true transformation requires more than infrastructure and technology: it demands a culture of innovation, a skilled workforce, and seamless collaboration across sectors.

Foundational to the vision is research excellence. The Kingdom is investing in world-class institutions, funding high-impact projects, and encouraging translational research that bridges laboratory discovery and real-world application, positioning Saudi Arabia as a global contributor to biomedical advancement.

Talent is equally vital. Through specialized training programs, academic partnerships, and initiatives such as the Biotechnology Training Institute, the strategy cultivates a new generation of scientists, engineers, and entrepreneurs equipped to lead the biotech revolution. By empowering local talent, Saudi Arabia is building a sustainable pipeline of innovators.

Cross-sector collaboration is another cornerstone. The Kingdom is engaging academia, industry, government, and international partners to create synergies that accelerate innovation. Biotech solutions are integrated into broader national priorities such as healthcare modernization, food security, environmental sustainability, and economic diversification.

The strategy is a catalyst for national transformation. Through localized pharmaceutical

production, advanced research capabilities, and a highly skilled workforce, Saudi Arabia is securing its healthcare future, reducing import dependency, and improving quality of life. These efforts also contribute to the non-oil GDP, create high-value jobs, and attract global investment.

As Saudi Arabia accelerates toward Vision 2030, its biotechnology sector is poised to become a beacon of global leadership. By aligning scientific ambition with strategic execution, the Kingdom is redefining its role on the world stage, as a creator, exporter, and thought leader in the life sciences.

Biotechnology as a Catalyst for Economic Transformation

The National Biotechnology Strategy is a bold economic engine designed to reshape Saudi Arabia's non-oil economy and elevate its global standing in the life sciences. By 2040, the strategy targets a contribution of more than $34.6 billion to non-oil GDP, around 3% of total economic output. This reflects the government's commitment to moving from a resource-dependent economy to one driven by innovation, knowledge, and advanced technology.

Job creation is a key component. The strategy projects 11,000 high-quality jobs by 2030, expanding to 55,000 by 2040, spanning biotechnology research, advanced biomanufacturing, regulatory science, clinical trials, education, and entrepreneurship. This diversity creates inclusive opportunities for Saudi citizens in a future-focused, innovation-led economy.

The strategy also attracts international investment by positioning Saudi Arabia as a stable, forward-thinking destination for biotech ventures. Through targeted incentives, streamlined regulatory pathways, and strategic infrastructure development, the Kingdom is cultivating an environment for public-private partnerships, foreign direct investment, and technology transfer. These efforts will fuel industries ranging from agile biotech start-ups to globally integrated pharmaceutical enterprises.

By focusing on vaccine development, genomic research, biomanufacturing, and plant optimisation, the strategy strengthens national self-reliance in critical health technologies. Saudi Arabia can produce essential medicines, respond swiftly to public-health emergencies, and reduce dependency on external suppliers, while exporting high-value biotech products to regional and global markets.

Ultimately, the National Biotechnology Strategy is a cornerstone for economic diversification, technological advancement, and societal well-being. It aligns with Vision 2030 and positions Saudi Arabia as a competitive player in the global bioeconomy.

Through this initiative, the Kingdom is investing in its people, its future, and its role in shaping the next era of global health and innovation.

Empowering Talent: The Human Engine of Saudi Arabia's Biotech Transformation

Executing a strategy as ambitious as the National Biotechnology Strategy requires more than cutting-edge laboratories and manufacturing facilities; it requires an empowered human-capital base. At the heart of this vision is a commitment to cultivating a new generation of highly skilled professionals to drive innovation, ensure operational excellence, and shape the future of the bioeconomy.

Recognizing that talent is the cornerstone of sustainable progress, Saudi Arabia is making substantial investments in education, training, and workforce development across the biotechnology spectrum. The Kingdom is actively nurturing scientists, researchers, engineers, and technical specialists who will serve as the intellectual and operational backbone of its emerging biotech ecosystem.

Academic institutions are fast-moving to meet this demand. Universities and colleges are expanding their biotechnology programs, integrating cutting-edge disciplines such as genomics, biomanufacturing, synthetic biology, and agricultural biotechnology into their curricula. These programs are designed to be interdisciplinary, blending life sciences with data analytics, engineering, and regulatory science to prepare students for the complex challenges of modern biotech industries.

In parallel, specialized training centers and research institutes, such as the Biotechnology Training Institute (BTI) are established to provide immersive, hands-on learning experiences. These facilities simulate real-world biomanufacturing environments, enabling trainees to gain practical skills in upstream and downstream processing, quality control, and Good Manufacturing Practice (GMP) standards. Such experiential learning bridges the gap between academic theory and industrial application, ensuring graduates are industry-ready from day one.

Beyond technical proficiency, these initiatives aim to instill a culture of scientific inquiry, innovation, and entrepreneurship. Students and professionals are encouraged to engage in collaborative research, participate in international exchange programs, and contribute to patent development and startup incubation. This holistic approach fosters not only competence but also creativity and leadership.

By embedding excellence into its educational ecosystem and cultivating domestic expertise, Saudi Arabia is laying the foundation for a resilient, self-sustaining

biotechnology sector. This talent-driven model ensures the Kingdom's biotech ambitions are powered by a skilled local workforce capable of driving sustainable growth, scientific discovery, and global competitiveness.

Regulatory Ecosystem: Catalyzing Biotechnology Innovation in Saudi Arabia

A thriving biotechnology sector requires more than scientific ambition; it demands a robust, agile, and forward-thinking regulatory ecosystem. Saudi Arabia is fortifying its regulatory framework to accelerate the development and deployment of biotech innovations, with the Saudi Food and Drug Authority (SFDA) leading this transformation.

The SFDA has adopted a progressive approach to regulation, streamlining the approval process for clinical trials, fast-tracking the evaluation of breakthrough therapies, and maintaining rigorous standards for safety, efficacy, and ethical compliance. These reforms are designed to reduce time-to-market for critical treatments while ensuring public trust in emerging technologies. By balancing innovation with oversight, the SFDA is creating an environment where scientific advancement can flourish without compromising patient safety.

This regulatory evolution is a cornerstone of Saudi Arabia's broader ambition to reshape its healthcare sector and establish itself as a biotechnology powerhouse. The launch of the National Biotechnology Strategy, anchored in the Kingdom's Vision 2030, reflects a strategic commitment to sectoral growth, scientific excellence, and national self-reliance. The strategy provides a comprehensive blueprint for developing domestic capabilities in vaccine production, biomanufacturing, genomics, and agricultural biotechnology, each supported by enabling policies and streamlined regulatory pathways.

Saudi Arabia's strategic embrace of biotechnology addresses global challenges across sectors. In healthcare, it enables life-saving therapies and personalised medicine. In agriculture, it supports climate-resilient crops and sustainable farming. In industry, it promotes cleaner, more efficient production methods that reduce environmental impact. These cross-sector applications position biotechnology as a transformative force for national progress and global impact.

By building on its current accomplishments and launching targeted initiatives, Saudi Arabia is not only advancing its domestic biotech capabilities but also laying the foundation for sustainable economic diversification. The Kingdom's regulatory reforms, combined with strategic investments and international collaborations, are positioning it as a competitive player in the global bioeconomy, one that can drive innovation, attract investment, and shape the future of life sciences.

Strategic Advantages: Why Saudi Arabia Is Poised to Lead in Biotechnology

Saudi Arabia's biotechnology ambitions are underpinned by a set of strategic advantages that position the Kingdom to lead in the life sciences. These strengths form the foundation of the National Biotechnology Strategy and support Vision 2030's goals of economic diversification, technological advancement, and societal well-being.

Robust Capital Base

Saudi Arabia benefits from substantial financial resources, including strong government investment and the backing of sovereign wealth funds such as the Public Investment Fund. These reserves enable the Kingdom to fund large-scale biotech infrastructure, support R&D, and attract global partnerships without the financial constraints that often limit emerging markets.

Expanding Healthcare Market

With a rapidly growing population and rising demand for advanced healthcare services, Saudi Arabia presents a fertile market for biotech innovation. The increasing prevalence of chronic diseases, coupled with a national push toward healthcare modernization, creates a strong demand for biopharmaceuticals, diagnostics, and personalized medicine.

Unique Genetic Landscape

Saudi Arabia's population features a distinctive gene pool shaped by centuries of cultural continuity and geographic isolation. This genetic diversity offers unparalleled opportunities for genomic research, rare disease studies, and precision medicine. The Kingdom's efforts to build a national genomic database will further unlock insights that can drive global breakthroughs in healthcare.

Government Commitment and Vision 2030 Alignment

The Kingdom's leadership has demonstrated unwavering commitment to biotechnology as a strategic priority. The National Biotechnology Strategy is fully aligned with Vision 2030, ensuring policy coherence, regulatory support, and long-term planning. This top-down approach accelerates implementation and fosters a stable environment for innovation and investment.

Strategic Geographic Position

Situated at the crossroads of East and West, Saudi Arabia serves as a natural gateway for regional distribution and global connectivity. Its location facilitates efficient supply chain logistics, making it an ideal hub for biomanufacturing, clinical trials, and export of biotech products across the MENA region and beyond.

Driving Sustainable Growth and Global Impact

Saudi Arabia recognizes the transformative potential of biotechnology and is committed to harnessing its full benefits. Through coordinated efforts between public institutions and private enterprises, the Kingdom is fostering a vibrant biotech ecosystem that promotes innovation, enhances quality of life, and supports economic diversification.

The National Biotechnology Strategy addresses both the challenges and opportunities within the sector. It emphasizes:

- Advancing R&D in genomics, vaccines, and therapeutics
- Building robust local biomanufacturing capabilities to ensure self-sufficiency
- Forming strategic alliances with leading global biotech firms and research institutions

These initiatives are designed to position Saudi Arabia not just as a regional leader, but as a global pioneer in biotechnology. By leveraging its strategic advantages and executing a holistic, forward-looking strategy, the Kingdom is reshaping the global biotechnology sector, setting the stage for enduring scientific, economic, and societal impact.

National Commitment to Biotech Development

Recognizing biotechnology as one of the most transformative frontiers of the 21st century, Saudi Arabia is strategically cultivating the sector to unlock its full economic, scientific, and societal potential. This effort is not a standalone initiative, it is deeply embedded within the Kingdom's broader national transformation agenda, Vision 2030, which aims to diversify the economy, elevate public services, and position Saudi Arabia as a global innovation leader.

At the core of this transformation is the National Biotechnology Strategy, a framework designed to address the challenges and opportunities of the biotech sector. It reflects a vision to build a resilient, self-sufficient, and globally competitive biotechnology ecosystem spanning healthcare, agriculture, industry, and environmental sustainability.

Public-Private Collaboration: Driving Sustainable Growth

Saudi Arabia is fostering dynamic partnerships between public institutions, private enterprises, academic bodies, and international stakeholders. These collaborations are essential for accelerating innovation, scaling infrastructure, and ensuring that biotech solutions are commercially viable and socially impactful. By aligning regulatory support, investment incentives, and talent development, the Kingdom is creating a fertile environment for biotech entrepreneurship and industrial growth.

Framework of the National Biotechnology Strategy

1. Accelerating Research and Innovation

Saudi Arabia is investing heavily in cutting-edge R&D across medical, agricultural, and industrial biotechnology. This includes funding translational research, establishing advanced research centers, and supporting innovation in areas such as gene therapy, synthetic biology, and bioinformatics. The goal is to generate homegrown breakthroughs that address regional health challenges and contribute to global scientific progress.

2. Strengthening Biomanufacturing Infrastructure

To reduce reliance on imports and enhance national self-sufficiency, the Kingdom is building robust biomanufacturing capabilities. This includes facilities for producing vaccines, biologics, biosimilars, and other high-value biotech products. These efforts are supported by regulatory reforms, workforce training, and technology transfer initiatives that ensure quality, scalability, and compliance with international standards.

3. Forging Global Partnerships

Saudi Arabia is actively forming strategic alliances with leading biotech firms, research institutions, and innovation hubs around the world. These partnerships facilitate knowledge exchange, accelerate clinical development, and enable access to advanced technologies. They also position the Kingdom as a trusted collaborator in global biotech networks.

A Vision for Global Impact

The Kingdom's long-term vision is to shape the future of biotechnology on a global scale. This includes:

- Enhancing public health outcomes through innovative therapies and diagnostics
- Promoting technological localization to build national resilience
- Diversifying the economy by creating high-value jobs and exportable biotech products
- Advancing sustainability through biotech-driven solutions in agriculture and industry

Saudi Arabia's biotechnology strategy is more than a national plan; it is a transformative movement that seeks to usher in a new era of scientific advancement, economic resilience, and societal well-being. By leveraging its strategic advantages and executing a bold, integrated vision, the Kingdom is poised to redefine its role in the global bioeconomy.

Toward 2040 and Beyond

Saudi Arabia's National Biotechnology Strategy represents far more than a policy framework; it is a bold declaration of intent and a reflection of the Kingdom's unwavering commitment to scientific excellence, technological innovation, and human advancement. Rooted in the transformative ambitions of Vision 2030, this strategy serves as a catalyst for economic diversification, healthcare modernization, and global competitiveness.

Rather than respond to global trends, Saudi Arabia is shaping the future. By establishing cutting-edge laboratories, cultivating scientific talent, and launching pioneering biotech enterprises, the Kingdom is building the foundation of a thriving biotechnology ecosystem. The effects of this strategy will extend well beyond Riyadh and Jeddah, positioning Saudi Arabia as both a regional powerhouse and a global leader.

A National Commitment to Global Leadership

By 2040, the Kingdom aims to be a global hub for biotechnology, a nexus of scientific discovery, industrial capability, and skilled talent. Through strategic initiatives in vaccine development, biomanufacturing, genomic research, and agricultural biotechnology, Saudi Arabia is laying the foundation for a healthier, more prosperous future and contributing meaningfully to global scientific progress.

The strategy's impact will extend beyond national borders, influencing international biotech standards, fostering collaborative research, and inspiring innovation worldwide. In doing so, Saudi Arabia affirms its role as a trailblazer in global science and technology, a nation leading through vision, investment, and innovation.

A New Chapter in Our National Progress

Reflecting on Saudi Arabia's biotechnology journey, a remarkable transformation is underway, and it goes beyond economic diversification. We are shaping a future built on intellectual ambition, scientific excellence, and global leadership in fields that mark humanity's progress. The shift signals a bold redefinition of our national identity, with innovation as the foundation of our strength and prosperity.

My leadership across SAUDIBIO, VIC, BIOERA, Biotech Innovations Company, BTI, ANIVAX, and Dr. Khaled Al-Mosa Consulting has fueled my dedication to advancing biotechnology in Saudi Arabia. I have played a central role in building the foundations of biologics manufacturing and in localizing vaccine production, both essential to the Kingdom's health-security framework. These responsibilities have been more than professional duties; they represent my personal mission to strengthen the Kingdom's

scientific and industrial capacities. By forming strategic partnerships with international leaders in biologics, I have helped transfer expertise, accelerate innovation, and empower Saudi Arabia to develop a self-sustaining biotechnology sector, supporting national ambitions for economic diversification and healthcare resilience.

Our nation's momentum is fueled by focused initiatives, substantial investment in research and infrastructure, and the growth of a thriving community of scientists, engineers, and innovators. The National Biotechnology Strategy stands as proof of our shared ambition, a declaration that Saudi Arabia is ready to push past traditional limits and break new ground in health, sustainability, and technological excellence. Saudi Arabia's transformation is driven by daring, targeted initiatives, large-scale investments in research and infrastructure, and the fostering of a vibrant community of scientists, engineers, and innovators. The National Biotechnology Strategy is not just a policy. It is a powerful statement of our collective determination and vision, boldly declaring that Saudi Arabia is ready to surpass traditional boundaries and lead the way into new domains of health, sustainability, and technological achievement.

This mission is more than a scientific pursuit; it is a lasting commitment that spans generations. It reflects the spirit of a nation that looks beyond obstacles, harnesses discovery to uplift humanity, and leads with steadfast purpose. I see that drive in our emerging researchers, industry partners, and the growing indigenous scientific workforce. As this era unfolds, Saudi Arabia is evolving and pioneering, setting new benchmarks in scientific achievement, sustainability, and human progress. With a clear vision and a remarkable capacity for innovation, we are reshaping the global biotechnology sector and leading the world toward greater advancement and prosperity.

PART II: THE FOUNDER'S JOURNEY: RISK, RESOLVE, AND REINVENTION

Chapter 4
Foundations of Excellence: Building Organizations That Thrive

Vision and Mission

My intellectual and scientific journey has been fueled by an unwavering commitment to advancing biotechnology manufacturing, strengthening healthcare, and fostering research and innovation, all with the ultimate purpose of **saving lives.**

By integrating industry experience with academic insight, I have worked to elevate Saudi Arabia's standing in medical sciences and biotechnology. It is an honor to be recognized as the "Godfather" of biotechnology manufacturing in the Kingdom, a title that reflects decades of dedication to building a resilient and innovative biotech ecosystem. Being recognized as the "Godfather" of biotechnology manufacturing in the Kingdom is a profound honor, validating not only my own efforts but the collective work of those who have joined me in building the Kingdom's biotech sector. It serves as a reminder that transformative change requires vision, persistence, and a steadfast commitment to building a resilient, innovative, and future-ready biotech ecosystem. This distinguished title was bestowed upon me by His Excellency Dr. Hussein A. Gezairy[^20], a towering figure in global and national health as the former Regional Director of the WHO Eastern Mediterranean Region, former Saudi Minister of Health, and Founder of the College of Medicine at King Saud University. His acknowledgment is both humbling and deeply meaningful, affirming the purpose and passion that have guided my journey in advancing biotechnology in Saudi Arabia (see Figure 4.1).

بسم الله الرحمن الرحيم

20 أبريل 2025 رسالة تقدير

الدكتور خالد الموسى أحدث تحولاً كبيراً في قطاع صناعات التكنولوجيا الطبية الحيوية في المملكة العربية السعودية من خلال رؤيته الإستثنائية وإنجازاته المبتكرة وتفانيه المستمر على مدار العقدين الماضيين. بصفته مؤسس الشركة السعودية للصناعات الطبية الحيوية (سعودي بايو)، والتي أحدثت ثورة صناعية في مجال التكنولوجيا الطبية الحيوية في المملكة، وإطلاق مبادرات رائدة مثل إنشاء أول مصنع لإنتاج الإنسولين في المملكة بالشراكة مع شركة Novo Nordisk. كما ساهمت شراكاته مع Sandoz-Novartis في تحقيق تقدم كبير في توطين علاجات السرطان، والإتفاقية مع شركة CSL Seqirus في نقل التقنية وتوطين صناعة اللقاحات، مما حقق الاكتفاء الذاتي للمملكة في هذه المجالات الحيوية.

لقد كان لي شرف العمل إلى جانبه كشريك على مدى العشرين عاماً الماضية، ويمكنني شخصياً التأكيد على عملة الإحترافي ونزاهته العميقة وسعيه الدائم نحو التميز. وقد ساهمت رؤيته المستقبلية أيضاً في تقدم البحث والتطوير والإبتكار في مجال التكنولوجيا الحيوية، بما في ذلك تأسيس شركة الإبتكارات الحيوية بالشراكة مع Baylor college of Medicine وتأسيس معهد تدريب في مجال التكنولوجيا الحيوية بالتعاون معNIBRT

تتماشى هذه الإنجازات المتميزة بسلاسة مع الإستراتيجية الوطنية للتقنية الحيوية التي أطلقها صاحب السمو الملكي الأمير محمد بن سلمان في العام 2024، مما يرسخ مكانة المملكة كقوة إقليمية في هذا المجال الحيوي بحلول العام 2030

تكريماً لمساهماته الفريدة وتأثيره المهني ونجاحه في بناء نظام بيئي متكامل للتكنولوجيا الطبية الحيوية في المملكة، أفتخر بمنحه هذا اللقب المميز "الأب الروحي" لصناعات التكنولوجيا الطبية الحيوية في المملكة العربية السعودية.

معالي الدكتور حسين بن عبد الرزاق الجزائري

المدير الإقليمي لمكتب منظمة الصحة العالمية الإقليمي لشرق البحر المتوسط

وزير الصحة السعودي الأسبق

مؤسس كلية الطب في جامعة الملك سعود

Figure 4.1

Recognition letter from HE Dr. Hussein A. Gezairy (Arabic original; English translation follows)

بسم الله الرحمن الرحيم

April 20, 2025

Recognition letter

Dr. Khaled Almosa has profoundly reshaped Saudi Arabia's biotechnology sector through his exceptional vision, groundbreaking achievements, and steadfast dedication over the last two decades. As the founder of Saudi Biotechnology Manufacturing Company (Saudi Bio), he revolutionized the industry by introducing biotechnology manufacturing to the Kingdom, leading pioneering initiatives such as Saudi Arabia's first insulin production facility in partnership with Novo Nordisk. His collaborations with Sandoz-Novartis propelled advancements in cancer therapeutics, while his partnership with CSL Seqirus successfully localized vaccine manufacturing, achieving self-sufficiency for Saudi Arabia in these critical areas.

Having had the privilege of working alongside him as a partner for the past 20 years, I can personally vouch for his unparalleled professionalism, integrity, and unwavering pursuit of excellence. His forward-thinking approach has also advanced biotechnology research and education, including the establishment of a biotech innovation company with Baylor College of Medicine and the founding of a biotechnology training institute in collaboration with NIBRT. These remarkable achievements align seamlessly with the National Biotechnology Strategy launched by HRH Crown Prince Mohammed bin Salman in 2024, firmly positioning Saudi Arabia as a global leader in this vital field.

In recognition of his extraordinary contributions, transformative influence, and his success in building a fully integrated biotechnology ecosystem in Saudi Arabia, I proudly grant him the distinguished title of "Godfather of Biotechnology Manufacturing in Saudi Arabia." His visionary endeavors continue to inspire progress and pave the way for a thriving future in biotechnology for generations to come.

HE. Dr. Hussein A. Gezairy

Ex-Regional Director, WHO Eastern Mediterranean Region
Ex-Saudi Minister of Health
Founder of the College of Medicine, King Saud University, Riyadh, Saudi Arabia

My core mission is to develop sustainable solutions that safeguard lives and strengthen our nation's capabilities. I am committed to advancing initiatives that promote community health, drive industry diversification, and reinforce healthcare resilience. As a member of

the Saudi Supreme Committee for Research, Development, and Innovation, chaired by HRH the Crown Prince, I have served as a key architect of the National Biotechnology Strategy. Launched by HRH Crown Prince and Prime Minister Mohammed bin Salman on 25 January 2024, the strategy positions biotechnology at the center of the Kingdom's future.

The strategy reflects Saudi Arabia's dedication to scientific progress, building a local biotechnology industry, and leveraging our resources for global distinction. My role in this transformation is to ensure that we meet healthcare needs and establish specialized sectors that add meaningful value: industries that empower our people, stimulate growth, and secure self-reliance in biopharmaceutical production.

My vision is to build a healthier future, champion groundbreaking innovation, and position Saudi Arabia as a global leader in biotechnology and life sciences.

My Academic Foundations

My academic journey has been defined by resilience and determination, pushing through challenges that tested both my resolve and vision. It was more than a collection of degrees and honors; it was a relentless pursuit of excellence during times of uncertainty. From my earliest days studying in the UK, through programs at Harvard and executive roles at global organizations, I faced obstacles that shaped me into a leader. Every step demanded discipline, adaptability, and courage. Instead of following a straightforward path, I navigated setbacks and complexities, gaining a deeper appreciation for healthcare as a dynamic, ever-evolving field with profound potential to transform lives.

The journey began in 1986 at King Saud University, a premier institution in Saudi Arabia. Drawn to biotechnology, then undergoing rapid change, I pursued a Bachelor in Applied Medical Sciences. The late 1980s were a period of intense progress and high expectations, and immersion in molecular biology, genetic engineering, and clinical biochemistry distinguished me academically. But I also found myself bridging disciplines, moving across traditional boundaries between science, medicine, and industry. That grounding was critical in giving me the vocabulary and confidence to operate in each.

After earning my undergraduate degree in 1992, I began a clinical internship in 1993, rotating through four major hospitals in Riyadh. This period exposed me to the fast-paced realities of emergency medicine, the precision required in surgery, and the complexities of pathology and administration. The demanding rotations went beyond academic requirements; they forced me to confront the realities of patient care and hospital management, shaping my perspective on medicine as a complex, interconnected system. It was during these testing times, amidst the daily pressures of healthcare, that my

vision for impactful leadership began to crystallize.

That vision grew stronger at King Faisal Specialist Hospital and Research Center, where I participated in the Saudi Career Development Program from 1993 to 1995. The program was designed to cultivate future leaders, and the expectations were high. Working alongside some of the nation's top medical professionals, I was exposed to advanced technologies, collaborative teams, and strategic planning under pressure. Involvement in quality improvement and policy development sharpened my understanding of how individual clinical decisions connect to institutional outcomes, and confirmed my conviction that the Kingdom's healthcare future required systematic industrial underpinning, not just clinical excellence.

Driven to deepen my knowledge, I went to the University of Birmingham in the UK in 1996 for a Master of Science in Healthcare Management. The curriculum covered health economics, policy analysis, organizational behavior, and strategic leadership. What set the experience apart, and made it especially challenging, was fieldwork in South Africa with South Field University during a period of significant social and political upheaval. My research on healthcare delivery in constrained environments taught me that resilience in medical systems is as much institutional as technical, and that lessons from other emerging economies could apply to the Kingdom. I graduated with distinction in 1997, sharpened as a systems thinker.

I undertook my PhD at the University of Hull from 1997 to 2001, researching the Saudi healthcare system: its inefficiencies, workforce challenges, and policy gaps. In parallel, I led sustained research into vaccine localization and biotechnology in the Kingdom. The dissertation did more than identify problems; it offered actionable solutions rooted in global best practice and adapted to Saudi Arabia's context. Completing this research required stamina and persistence, especially as I balanced academic demands with real-world engagement. It was more than an academic milestone. It was a call to action, positioning me as a scholar and a strategist, and gave me the analytical grounding for the institution-building that would follow.

Despite decades of achievement, my thirst for learning never faded. In 2024, I earned a postgraduate diploma in Leadership Principles from Harvard Business School and a Doctor of Business Administration (DBA) from SBS Swiss Business School. These programs were demanding, requiring ethical leadership, strategic vision, and organizational change. My motivation was never about collecting titles; it was about gaining practical skills to guide complex organizations, shape policy, and inspire future leaders. The training directly informs how I run my portfolio today.

Throughout my academic career, I conducted substantial research in healthcare services and spent three challenging years investigating vaccine localization and biotechnology in Saudi Arabia. These research projects required perseverance and creativity, further demonstrating my commitment to making a meaningful impact.

Today, my academic journey stands as a testament to education's power to transform lives. Every degree, research project, and professional accomplishment was earned through hard work and tenacity. My story suggests that true leadership is forged in adversity, built through learning, service, and steadfast commitment to positive change. By sharing it, I hope to inspire others to see that visionary leadership is shaped by perseverance and courage, and to build the lives, careers, and institutions they aspire to.

My Professional Journey

When I joined the KSA Research, Development, and Innovation Supreme Committee in 2021, chaired by HRH Crown Prince and Prime Minister Mohammed bin Salman, I brought years of experience navigating the opportunities and challenges of Saudi Arabia's scientific sector. The role marked a turning point: a chance to help drive national strategy from the inside. The stakes were high. Vision 2030 identified biotechnology as a cornerstone of our future, but the reality on the ground was stark: the Kingdom lacked the scientific and industrial base to deliver that vision.

I spearheaded a three-year initiative to assess Saudi Arabia's biotech sector, working with researchers, industry leaders, and policymakers. Our findings were sobering: the ecosystem lacked essential elements in R&D, clinical trials, specialized training, and industrial engineering. These deficiencies were more than technical; they were systemic, impeding innovation, delaying product development, and perpetuating reliance on foreign suppliers for critical medicines.

Rather than dwell on these limitations, I saw a roadmap for transformation. I envisioned a fully integrated biotech ecosystem, anchored in policy and in robust institutions, skilled talent, and strategic partnerships. The vision fuelled a new wave of ventures that extended my earlier work with SAUDIBIO and led to the creation of the Vaccine Industrial Company (VIC), Biotech Industrial Engineering Company (BIOERA), the Biotech Innovations Company for R&D, the Biotechnology Training Institute (BTI), ANIVAX for veterinary biotechnology, and Dr. Khaled Al-Mosa Consulting.

The first major milestone was the founding of SAUDIBIO, which became the cornerstone of Saudi Arabia's modern biotechnology sector. Building on that foundation, I established the Biotech Industrial Engineering Company (BIOERA), one of the Kingdom's first specialized biotech enablers. BIOERA was designed as more than a business; it served as

a comprehensive solutions provider, offering ten core services to investors and developers building biotech manufacturing facilities from the ground up: site selection, regulatory compliance, equipment sourcing, and workforce planning among them. Adapted to Saudi Arabia, BIOERA quickly became a pillar of the country's industrial biotech infrastructure.

Infrastructure alone was not enough. Advanced manufacturing capabilities and robust R&D were also essential. This led to the Vaccine Industrial Company (VIC) for human vaccine production and the Biotech Innovations Company for research, development, and next-generation biotech solutions. Together, these organizations expanded our capabilities from building facilities to producing high-value biologics.

Recognizing that state-of-the-art facilities and cutting-edge research require talented, well-trained people, I prioritized international collaboration. I established a partnership with the National Institute for Bioprocessing Research and Training (NIBRT) in Ireland, bringing world-class biotech training to Saudi Arabia, and then adapted the curriculum to fit our regulatory environment, industrial needs, and cultural context.

By 2025, well ahead of the 2030 target, we had delivered 75% of the pillars outlined in the National Biotechnology Strategy launched by HRH Crown Prince and Prime Minister Mohammed bin Salman in January 2024. Our most significant accomplishments included the localization of insulin production, the establishment of advanced biologics manufacturing, the development of cutting-edge vaccines, and notable advances in genome editing, cornerstones of public-health security and economic self-reliance for the Kingdom.

As we built local capacity, it became clear that Saudi Arabia's progress depended on global collaboration. At King Abdulaziz City for Science and Technology (KACST), I led a biotechnology innovation company that became a hub for international partnerships. One of our most impactful collaborations was with Baylor College of Medicine and its Center for Vaccine Development in Houston, providing access to world-class vaccine science expertise.

Our engagement with the University of Oxford's Jenner Institute further elevated Saudi Arabia's biotechnology capabilities. Through a formal Memorandum of Understanding between Biotech Innovations Company (BIC) and Oxford University (Jenner Institute), we established a robust framework for accelerating vaccine development, strengthening national research capacity, and cultivating scientific excellence across the Kingdom.

Together, we committed to co-developing next-generation vaccine platforms, including viral-vector, mRNA, and recombinant protein technologies, and to conducting joint preclinical studies aligned with the highest international regulatory standards. The

partnership established long-term research programs of three to five years, advancing vaccine candidates from early discovery to initial clinical stages, targeting diseases of regional and global significance. This includes the ongoing MERS-CoV vaccine work discussed later in this chapter.

Equally crucial was our investment in human capital. The partnership provided structured knowledge-transfer programs aligned with the Kingdom's biotechnology strategy, hands-on training for BIC scientists in Oxford's laboratories, and capacity-building in clinical-trial design and management to ensure GCP compliance. It also supported joint PhD and postdoctoral positions, building a new generation of Saudi vaccine scientists trained through a dual-institution model.

To further scientific exchange, the MoU established annual workshops, technical sessions, and collaborative publications, overseen by a Joint Steering Committee to ensure alignment with both parties' strategic goals. Through this partnership, we are advancing vaccine innovation while embedding top-tier expertise into Saudi Arabia's biotechnology ecosystem, strengthening our scientific independence and accelerating our journey toward global leadership in life sciences.

I also initiated cancer-vaccine research in partnership with Saudi institutions, moving into one of medicine's most advanced frontiers. Most notably, we prepared a Phase I clinical trial of a Middle East Respiratory Syndrome (MERS) vaccine, funded by the Saudi National Institutes of Health (SNIH). The trial is scheduled for early 2027 and, if successful, will position Saudi Arabia as a leader in pandemic preparedness and global health response.

As our human and industrial biotech ecosystem matured, I shifted focus to veterinary biotechnology, an often-overlooked but deeply interconnected field. I established ANIVAX, a company dedicated to animal-vaccine research, development, and manufacturing. Through a partnership with Boehringer Ingelheim, the global leader in animal health, ANIVAX accelerates the introduction of advanced veterinary biologics and bolsters regional capabilities. It is the first facility in Saudi Arabia to offer end-to-end production of high-quality animal vaccines, strengthening both national food security and public health.

Animal health is inseparable from human health. By preventing and controlling diseases in livestock and companion animals, we strengthen food security, reduce zoonotic risks, and enhance public health resilience. ANIVAX also advances Vision 2030 by nurturing local talent, reducing dependency on imports, creating high-value jobs, and elevating Saudi Arabia's profile in global health innovation.

Looking back, I see more than a series of projects: I see a movement and a transformation. This chapter of my journey has been about building something enduring fueled by vision, collaboration, and unwavering execution. I am confident this is only the beginning.

Highlights of My Leadership and Accomplishments

Over my career, I have focused on building what did not yet exist: the scientific, industrial, and commercial foundations required for Saudi Arabia to compete in global biotechnology. Driven by the conviction that the Kingdom could lead regionally in advanced life sciences, I established multiple companies that together form the first integrated biotechnology value chain in Saudi Arabia. This ecosystem spans research, development, manufacturing, and commercialization, and is designed to be both nationally anchored and globally connected.

At each stage, I have concentrated on national challenges, scalable solutions, and expert teams dedicated to world-class standards. Every achievement marks a purposeful step toward a resilient biotechnology sector in Saudi Arabia: founding startups, forging strategic alliances, and developing industrial capability in line with Vision 2030. My efforts have laid foundations for a new generation of Saudi scientists, entrepreneurs, and investors in biotech.

My leadership in the private and public sectors reflects a commitment to advancing Saudi Arabia's biotechnology ecosystem. I have played a central role in founding and steering innovative companies, launching impactful initiatives, and implementing strategic programs that have shaped the Kingdom's scientific, industrial, and commercial life. Throughout my career, I have specialized in the localization of biotechnology, translating global advances into domestic capability: insulin and biologics, vaccines, gene editing, and veterinary biotech, each matched to a Saudi institution capable of delivering it at scale. Across public-sector appointments and developing platforms for the local production of essential medical products. My expertise also extends to business development, where I have forged strategic partnerships with leading multinational firms, built high-value business units, and created opportunities for local talent, all while driving the Kingdom needs, with Saudi talent, to Saudi quality.

SAUDIBIO (2010) Insulin Manufacturing

Founder and Chairman

- Established the first and only insulin manufacturing facility in Saudi Arabia
- Strategic partnership with Novo Nordisk,
  the world's leading insulin producer

SAUDIBIO (2020) Cancer Therapeutics

- Led the localization of **oncology and cancer therapeutics.**
- Partnership with Sandoz–Novartis

Vaccine Industrial Company

- Established in response to the urgent need for domestic vaccine manufacturing, highlighted by the COVID-19 pandemic, to ensure Saudi Arabia's self-sufficiency and rapid response capabilities.
- Spearheading the development of the Middle East's largest human vaccine production facility, designed to meet both national and regional demands.
- Formed a strategic partnership with CSL Seqirus to advance pandemic readiness, ensuring robust infrastructure and supply for emergency situations and comprehensive protection for the nation during future pandemics.

Biotechnology Innovation Company for R&D

- Established a national R&D engine for vaccines, biologics, and gene therapy.

Partnerships include:

Baylor College of Medicine (USA)

- Vaccine development and R&D

Oxford University (The Jenner Institute) (UK)

Vaccine development and gene therapy innovation

KACST

- Joint research labs and national talent development

Saudi NIH

- Funded clinical trials phase-1 for MERS vaccine

KAIMRC

- Clinical trial site collaboration

BIOERA, Industrial Engineering & Biotech Facility Development

- Leads turnkey engineering solutions for advanced biopharmaceutical plants.
- Consortium includes: Keyplants Modules, Zyme Biotech, Podtech clean rooms, Valgenesis, AskGXP, Jadwa Contracting, Shahin Engineering

ANIVAX Company, Animal Vaccine Manufacturing

- Localizing veterinary vaccines, especially Foot and Mouth Disease
- Strategic partnership with Boehringer Ingelheim, the world's largest animal vaccine company

Blood Plasma Fractionation Initiative

- Leading national efforts to localize plasma-derived medicinal products.
- Collaboration with CSL Plasma and the Ministry of Health

Dr. Khaled Al-Mosa Consulting Firm

- Partnered with NIBRT (Ireland) to establish the first Middle East training hub for bioprocessing.
- Provides advanced training for Saudi professionals in biotechnology and biomanufacturing.

Integrated National Biotechnology Framework

I established a biotechnology ecosystem spanning every stage, from initial scientific discovery through large-scale industrial production and market introduction. Rather than build standalone companies, I created an interconnected value chain that strengthens national resilience, drives innovation, and positions Saudi Arabia as a global competitor. Each organization fulfils a specific, strategic function within the broader system, ensuring that Saudi Arabia benefits from capability across the full biotech spectrum.

Biotechnology Manufacturing

- Insulin
- Oncology therapeutics
- Human vaccines
- Animal vaccines
- Plasma-derived products

Research, Development & Innovation

- Clinical trials infrastructure
- Gene therapy platforms
- Vaccine discovery and development
- National research partnerships

Talent Development

- Establishing the first regional training center
- Developing specialized programs in bioprocessing and cell therapy

Industrial Engineering & Facility Development

- Turnkey solutions for advanced biomanufacturing plants
- Global-local engineering consortium

Healthcare Leadership (Public & Private Sectors):

Private Sector Leadership (2005–2010)

In the initial phase, I established a medical -services company and several state-of-the-art medical and surgical centers to raise the quality of specialized healthcare and improve access to world-class clinical services within the Kingdom. Each facility was developed with a distinct objective: to close essential gaps in the national healthcare system, introduce innovative medical technologies, and foster sustainable capabilities that enable Saudi clinicians and scientists to thrive. Through these centers, my focus has been on merging innovation with patient care, making it possible to meet complex medical needs locally with exceptional expertise and safety. The established centers include:

Medicine & Technology Group

Eye World Surgical Center

Saudi Surgeons Day Surgery Center

Public Sector Leadership (1992–2005)

From 1992 to 2005, my journey in public -sector leadership was marked by a steadfast commitment to advancing Saudi Arabia's healthcare system. In those formative years, I held several key roles within national institutions, driving initiatives focused on improving clinical services, enhancing operational efficiency, and developing local talent. My work helped shape the country's medical sector and laid groundwork for sustainable growth and a more competitive sector.

King Faisal Specialist Hospital & Research Center, Saudi Career Development Program Participant

Security Forces Hospital, Director of Local & International Recruitment

King Khaled Eye Specialist Hospital, Director of Ambulatory Care Services

Al-Iman General Hospital, Chief Executive Officer

Reflecting on my professional journey from 1992 to 2026, I am proud to have played a pivotal role in the localization of biotechnology, the transformation of healthcare -services management, and the development of business in Saudi Arabia. My efforts have contributed to a robust national biotech ecosystem, stronger pharmaceutical self-sufficiency, and higher clinical standards across the Kingdom. By integrating visionary leadership, entrepreneurial acumen, and a steadfast commitment to innovation, I have helped position Saudi Arabia as a rising force in the global life-sciences arena.

Chapter 5

My Role in Pioneering Biotechnology Manufacturing in the Kingdom of Saudi Arabia

In March 2021, His Royal Highness the Crown Prince and Prime Minister appointed me to serve as the Private Sector Representative on the Kingdom of Saudi Arabia's Supreme Committee for Research, Development, and Innovation, which is chaired by His Royal Highness at the Council of Economic and Development Affairs. This prestigious appointment stands as national recognition of my pioneering role in advancing the Kingdom's scientific and industrial transformation.

مجلس الشؤون الاقتصادية والتنمية

Council of Economic and Development Affairs

I stand at the forefront of Saudi Arabia's biotechnology revolution, driven by a commitment to localize biomanufacturing and raise the Kingdom's healthcare capabilities. As an entrepreneur, investor, and researcher, I have shaped the trajectory of biotechnology manufacturing in Saudi Arabia for over three decades. My mission has been to pioneer breakthroughs in medicine, build self-reliant biotech capability, and strengthen healthcare infrastructure. By founding key enterprises across the value chain and forging strategic partnerships with global leaders, I have laid the foundations of a self-reliant, world-class biotechnology industry in the Kingdom.

With more than 34 years of leadership from 1992 to 2026, I have been honored to be recognized as the Godfather of Biotechnology Manufacturing in Saudi Arabia, a title bestowed by HE Dr. Hussein A. Gezairy, former Regional Director of the WHO Eastern Mediterranean Region, former Saudi Minister of Health, and Founder of the College of Medicine at King Saud University. (Chapter 4). My work reflects a lifelong dedication to healthcare, research, and industrial innovation. By integrating practical experience with scientific rigour, I have helped position the Kingdom as a rising force in global biotechnology.

In March 2021, I was appointed by His Royal Highness Crown Prince and Prime Minister, Prince Mohammed bin Salman, to serve as a As a member of this Supreme Committee, representing the private sector. Chaired by His Royal Highness and operating under the Council of Economic and Development Affairs and the Council of Ministers,

powers shaping our national innovation agenda.

As a certified senior consultant, I possess extensive expertise spanning biotechnology manufacturing, research and development, healthcare management, and business development. By combining scientific knowledge with entrepreneurial insight, my credentials and professional journey demonstrate a strong commitment to establishing a robust and innovative biotech ecosystem within the Kingdom.

A distinguished group of organizations under my leadership, SAUDIBIO, Vaccine Industrial Company (VIC), BIOERA, Biotech Innovations Company for R&D, Biotechnology Training Institute (BTI), ANIVAX, and the Dr. Khaled Al-Mosa Consulting Firm, stands at the forefront of Saudi Arabia's biotech sector. Together, they form an integrated value chain spanning research, manufacturing, engineering, training, and advisory, each built to address a specific national priority and collectively positioning the Kingdom as a regional leader in biotechnology.

In January 2024, HRH Crown Prince Mohammed bin Salman introduced the National Biotechnology Strategy, a landmark initiative reflecting Saudi Arabia's unwavering dedication to scientific innovation, the localization of biotechnology industries, and the leverage of national capabilities for global leadership. Guided by the Crown Prince's vision, the strategy aims to create a healthier future, establish specialized industries with added value, and secure the Kingdom's independence in biopharmaceutical production. This transformative blueprint underscores Saudi Arabia's determination to position the Kingdom as a regional biotech hub by 2030 and a global leader by 2040, with four pillars: vaccine sovereignty, biomanufacturing, genomics, and plant optimisation.

Under my stewardship, Saudi Arabia is steadily advancing toward pharmaceutical self-sufficiency and emerging as a rising force in global medical innovation. This progress is exemplified by the portfolio of pioneering companies I have established across the Kingdom, each contributing to our growing leadership in biotechnology, healthcare, and industrial development.

Localization of Biotechnology Manufacturing

I spearheaded the localization of biotechnology manufacturing, introducing cutting-edge global technologies to Saudi Arabia. This initiative positioned our nation as a hub for critical medical production, including:

- Insulin for diabetes management
- Vaccines for infectious disease prevention
- Cancer therapies tailored to regional needs

- Biologics and biosimilars for chronic conditions
- Advanced cell and gene therapies
- Research & Development (R&D) programs driving innovation in biotechnology.
- Clinical trials to validate new therapies and ensure global regulatory alignment.
- Biotech training initiatives to build a skilled national workforce.
- Animal vaccines to strengthen veterinary health and safeguard food security.

SAUDI Biotechnology Manufacturing Company (SAUDIBIO)

When I founded SAUDIBIO in 2010, I envisioned a future where Saudi Arabia would no longer rely on imported biologics to meet its healthcare needs. Headquartered in Riyadh, SAUDIBIO has since become the Kingdom's first and only GMP-certified biotech manufacturing facility, a distinction earned through strategic foresight, rigorous compliance, and an unwavering commitment to excellence. This mission is especially critical in a nation where nearly 20% of adults live with diabetes, and a substantial share of patients depend on, SAUDIBIO has been transformative for the Saudi biopharmaceutical sector, driving the local production of insulin pens and vials, introducing advanced biologics, and laying the groundwork for a self-sufficient national biotechnology industry.

Our state-of-the-art facility in Sudair Industrial & Business City (MODON) reflects the Kingdom's industrial ambition. Designed by the Swedish firm KeyPlants and equipped with precision machinery from Groninger and Bosch, the plant embodies a modular, scalable approach to biopharmaceutical production. Certified by the SFDA and praised by Novo Nordisk for meeting the highest global standards, it is among the most advanced biologics facilities in the region.

Over the years, we have built a robust portfolio of high-impact biologics, each developed and manufactured with meticulous care to preserve bioactivity, ensure dose precision, and maintain cold chain integrity.

Novo Nordisk Portfolio

Our strategic partnership with Novo Nordisk has enabled the localization of several cornerstone therapies in diabetes and hematology:

- Recombinant human insulin, produced locally in multiple formats, vials, Penfill® cartridges, and FlexPen® disposable pens, tailored to diverse patient needs and ensuring accessibility, accuracy, and ease of use. Localizing insulin production marked a decisive shift away from import dependency, directly supporting Vision 2030's goals of pharmaceutical self-sufficiency and chronic disease mitigation.
- Mixtard® 30 Penfill®, a biphasic insulin formulation that combines basal and prandial

coverage in a single injection, simplifying treatment regimens and improving glycemic control for individuals with type 1 and type 2 diabetes.

- FlexPen®, originally developed by Novo Nordisk and now produced locally by SAUDIBIO, represents a milestone in biopharmaceutical localization. This prefilled, disposable insulin pen embodies precision, safety, and convenience, while its domestic production strengthens chronic disease management and industrial resilience.
- Novoseven®, a recombinant coagulation factor VIIa, manufactured through aseptic fill-finish operations under our partnership with Novo Nordisk, providing life-saving therapy for patients with bleeding disorders.

Sandoz Portfolio

In parallel, our collaboration with Sandoz, one of the world's leading generics and biosimilars companies, with a global presence in more than 100 countries, has expanded access to advanced biologics:

- Adalimumab biosimilar, a monoclonal antibody targeting TNF-α, addressing a wide range of autoimmune conditions including rheumatoid arthritis, Crohn's disease, and juvenile idiopathic arthritis.
- Rixathon®, a biosimilar of rituximab, offering effective treatment options for hematological malignancies and autoimmune disorders.

As the first biotech company in Saudi Arabia, SAUDIBIO integrates product registration, regulatory compliance, and ethical sales across the Middle East and North Africa (MENA) region. With a dedicated team of 250 professionals, we anchors enabling biotech innovation throughout the region.

In October 2023, SAUDIBIO entered a transformative chapter when Lifera, Public Investment Fund (PIF) company, acquired a 70% stake in the company. This strategic move catalyzed the expansion of domestic insulin production and advanced several national healthcare objectives, including:

- Bolstering Saudi Arabia's capacity to manufacture essential therapeutics
- Strengthening strategic collaborations with leading global pharmaceutical companies
- Enhancing local manufacturing infrastructure and fortifying supply chain resilience
- Promoting the localization of biopharmaceutical expertise and generating high-value employment opportunities

This acquisition, along with Lifera's insulin production agreement with Novo Nordisk, aligns with PIF's broader strategy to secure critical drug supplies and establish Saudi Arabia as a regional hub for biotechnology. It supports our national ambition to lead in

precision medicine, genomics, and advanced therapeutics, positioning the Kingdom at the forefront of innovation in the Middle East.

By 2027, SAUDIBIO aims to quintuple our biologics capacity, reaching an annual output of 100 million pens and vials. This expansion will include GLP-1 injectables and advanced biosimilars; all produced in accordance with EU GMP Annex I and SFDA standards.

SAUDIBIO's mission extends beyond manufacturing. Guided by patient impact, integrity, teamwork, and community care, we aim to improve lives through high-quality biotech products and advance Vision 2030. Under my stewardship, SAUDIBIO has become more than a pharmaceutical company; it is a strategic pillar of national health resilience, industrial diversification, and scientific advancement.

With continued policy support and visionary governance, I believe SAUDIBIO is poised to anchor a new era of biotech sovereignty across the Gulf, offering a replicable blueprint for regional localization and public-private collaboration.

Figure 5.1
SAUDIBIO's Licensed Manufacturing and Supply Collaboration with Novo Nordisk

Vaccine Industrial Company (VIC)

In response to the global COVID19 pandemic, I launched the Vaccine Industrial

Company (VIC) in 2022 with a clear and urgent vision: to build Saudi Arabia's first human vaccine manufacturing facility and transform the nation's approach to vaccine production. At that point, Saudi Arabia stood out among G20 countries for lacking domestic vaccinemanufacturing capabilities, a gap identified in national biotechnology strategies, pandemic response reviews, and international assessments by the World Health Organization (WHO) in Geneva and the World Bank in Washington, D.C. Both organizations demonstrated the importance of establishing regional vaccine production as a fundamental element of global health security and resilience against pandemics.

From the outset, my vision was to build more than a factory: the largest vaccine manufacturing complex in the MENA region, a national asset capable of positioning Saudi Arabia as a biotechnology leader by 2030. VIC was designed to close critical gaps exposed by the pandemic, strengthen the health-security infrastructure, and ensure that the Kingdom would never again depend on external suppliers for essential vaccines. Through this initiative, we set in motion a new era of sovereign manufacturing capacity, scientific excellence, and regional leadership in advanced biopharmaceutical technologies. Born out of the urgent lessons of the pandemic, VIC was envisioned as a cornerstone of resilience, ensuring that the Kingdom would never again be dependent on external supply chains for critical vaccines. Today, VIC stands as the largest facility has been engineered for flexibility from day one, with lines capable of producing seasonal influenza vaccines in normal times and pandemic-response vaccines at scale when required. That dual-mode design is the spine of the Kingdom's new pandemic-readiness posture.[^24]

Strategically designed to elevate Saudi Arabia's position in global vaccine development, VIC represents a pivotal advancement in both industrial infrastructure and healthcare resilience. Our facility is equipped with cutting-edge technologies and adheres to stringent international standards, positioning the Kingdom as a regional leader in vaccine innovation and supply.

The creation of VIC is a significant milestone on our path to healthcare self-sufficiency. By producing essential vaccines locally, we reduce dependence on global supply chains and strengthen preparedness for public-health emergencies. The facility can manufacture a wide range of vaccines, including those targeting pandemic-potential infectious diseases, and is built to scale production rapidly in response to emerging threats.

To achieve worldclass quality and operational excellence, VIC has deliberately cultivated alliances with some of the world's most respected manufacturers and technology innovators. Among these, one partnership stands out as a defining milestone: a landmark tripartite agreement uniting VIC, CSL Seqirus, and the Saudi Ministry of Health. CSL

Seqirus, one of the world's largest influenzavaccine producers and a pioneer in cellbased


On this day, December 16, 2018 in Riyadh, Saudi Arabia
Saudi Biotechnology Manufacturing Company (hereinafter referred to as SaudiBio) and Novo Nordisk A/S & Novo Nordisk HCAG (hereinafter referred to as Novo Nordisk) has affixed signatures on the

License & Manufacture and Supply Agreements

for local manufacturing of Novo Nordisk products in the Kingdom of Saudi Arabia in the facility of SaudiBio.

في هذا اليوم، السادس عشر من ديسمبر ٢٠١٨
الرياض، المملكة العربية السعودية

قامت شركتي نوفو نوردسك
والشركة السعودية لصناعات التكنولوجيا الطبية الحيوية (سعودي بايو)

بالتوقيع على
اتفاقية التصنيع المحلي

من أجل تصنيع منتجات نوفو نوردسك في المملكة العربية السعودية
في مصنع شركة سعودي بايو

For SaudiBio:

For Novo Nordisk:

Dr.Khaled Almosa
Founder & Vice President

vaccine technology, brings a transformative approach to vaccine development. Unlike traditional eggbased methods, cellbased platforms enable faster production timelines and improved safety profiles, placing them at the forefront of modern immunization science.

This collaboration is not merely a manufacturing partnership; it is a strategic pandemic-readiness agreement designed to secure the Kingdom's ability to produce up to 70 million doses during a global health emergency. It marks a pivotal moment in Saudi Arabia's healthcare evolution. Together, the three parties are laying the foundation for localized production of seasonal influenza vaccines and rapid-response pandemic vaccines, with full technology transfer and capability-building at each step.

By combining CSL Seqirus's global expertise with VIC's emerging manufacturing infrastructure, the partnership directly advances the ambitions of Vision 2030: achieving pharmaceutical selfsufficiency, diversifying the industrial base, and reinforcing Saudi Arabia's position as a rising biotechnology leader.

Beyond the technical and industrial benefits, these partnerships bring advanced know-how, regulatory sophistication, and international best practice into the Kingdom's growing life -sciences ecosystem. Progress was made tangible in a national milestone: the first cell-based vaccine officially registered with the Saudi Food and Drug Authority (SFDA), a transformative step in the Kingdom's journey toward vaccine self-sufficiency.

The achievement validates years of institutional build-up and demonstrates that a Saudi facility, run by Saudi scientists, can meet the highest international regulatory standards. In doing so, the collaboration not only reinforces national immunization programs but also contributes to broader public health efforts across the Middle East and North Africa.

Key Provisions of the Agreement

The memorandum of understanding is structured around several core articles that define the scope and intent of the collaboration.

Article One: Components of the Memorandum

- The preamble and all annexed documents form an integral part of the memorandum. Together, they guide its interpretation and implementation, ensuring clarity and alignment among all parties.

Article Two: Scope of Cooperation

- The agreement outlines two primary domains of cooperation, seasonal influenza and pandemic preparedness, each with its own set of commitments.

Cooperation on Seasonal Influenza

- Localization of vaccine manufacturing to establish domestic production capabilities.
- Exploration of pathways for including seasonal influenza vaccines in the Ministry of Health's official medicines and vaccines list.
- Sharing epidemiological data on influenza patterns and circulating strains.
- Alignment with national immunization guidelines and adherence to safetymonitoring requirements.
- Joint development of publicawareness campaigns to promote seasonal influenza vaccination.
- Creation of educational materials tailored for highrisk populations.
- Codevelopment of workshops and training programs focused on influenza prevention and best practices.

Cooperation on Pandemic Preparedness

- Assessment of national requirements for pandemic and prepandemic influenza vaccines across relevant departments.
- Exchange of expertise related to pandemicpreparedness projects, strategic stockpiles, and pharmaceutical security.
- Discussion of an Advance Purchase Agreement (APA) to secure manufacturing readiness and reservation capacity for pandemic vaccines.
- Exploration of including prepandemic vaccines within the national strategic

stockpile.

- Commitment to establishing a commercial partnership, including reservation volumes, following the signing of the memorandum, with the goal of finalizing all pandemicrelated contracts by 12 December 2025.

Figure 5.2

Vaccine Industrial Company (VIC) Industrial Plant Allocated by MODON, Hosting the Largest Human Vaccine Facility in the MENA Region

Under my leadership, VIC is more than a manufacturing hub; it is a symbol of Saudi Arabia's growing influence in global health innovation. It reflects our strategic investment in biotechnology as part of the Kingdom's broader Vision 2030 goals. Through VIC, we are building a resilient healthcare ecosystem, fostering scientific advancement, and improving the well-being of our people.

Figure 5.3
Signing of the Pandemic Response MoU Between MOH, CSL, and VIC, October 2025

Establishment of Biotechnology Value Chain

Throughout my career, I have been deeply committed to building a comprehensive biotechnology industry value chain in Saudi Arabia, one that fosters innovation, drives economic growth, and ensures national self-reliance in life-saving medical technologies. To achieve this, I founded multiple pioneering companies, each designed to address a critical segment of the biotech ecosystem.

These enterprises span the full spectrum of biotechnology development, from research and clinical innovation to manufacturing, regulatory compliance, and regional distribution. Together, they form an integrated framework that supports the Kingdom's strategic goals under Vision 2030 and positions Saudi Arabia as a rising global leader in medical science and industrial biotechnology.

Biotechnology Innovation Company (BIC)

I founded the Biotechnology Innovation Company (BIC) in 2023 to elevate Saudi Arabia's capabilities in biotechnology science and translational research. The venture grew from a strategic collaboration with Baylor College of Medicine and King Abdulaziz City for Science and Technology (KACST), reflecting my ambition to position the Kingdom as a regional leader in biotech innovation. BIC's remit spans discovery science, preclinical development, and clinical translation, all aligned with national priorities.

BIC is a dynamic platform for high-impact R&D focused on novel therapeutics, vaccines, and diagnostic technologies. One of our flagship initiatives is a Phase I clinical trial program for Middle East Respiratory Syndrome (MERS), a viral disease of regional concern. Funded by the Saudi National Institutes of Health, the trials are a historic milestone for a Saudi biotechnology company, showing the Kingdom's ability to lead on infectious-disease research with clear regional and global significance. The work aligns Saudi capability with international scientific priorities.

Our partnership with Baylor College of Medicine, an internationally recognized leader in biotechnology research, enables us to advance biologics and vaccine development at the frontier of the field, including clinical trials for MERS-CoV vaccines, a priority in the Kingdom's infectious-disease preparedness. This work complements national efforts, including the first Phase I human trial of a MERS vaccine. Together, these programs accelerate the Kingdom's translational pipeline and strengthen its standing in the international research community, drawing top-tier investigators and collaborators to Saudi-led programs.

Beyond infectious disease research, BIC is actively engaged in broader scientific domains, including genomics, immunotherapy, precision medicine, and training.

BIC training programs aims at bridging skills in biotechnology. In 2025 BIC conducted a training program dubbed as "From Gene to Vaccine: A Practical Training on mRNA Based Vaccine Development at KACST". The first of its kind in KSA.

The four-week training workshop combined knowledge-based lectures with hands-on lab practice, allowing participants to first grasp key concepts and then apply them in real-world scenarios. This blended approach enhanced understanding, built confidence, and equipped participants with the skills needed for advanced tasks and professional growth.

Figure 5.4

From Gene to Vaccine: Practical Training on mRNA Based Vaccine Development at KACST training- 2025.

These efforts align with the goals of Saudi Vision 2030, promoting scientific excellence, economic diversification, and improved health outcomes for our population.

Under my leadership, the company continues to empower local talent, foster global partnerships, and reinforce the Kingdom's role in shaping the future of healthcare innovation, both regionally and internationally. This includes advancing gene therapy programs and vaccine development in collaboration with Oxford University, further strengthening Saudi Arabia's position at the forefront of nextgeneration biomedical innovation.

BIOERA Biotech Industrial Engineering and Project Management Company

I founded BIOERA Biotech Industrial Engineering and Project Management Company in 2023 with a clear purpose: to accelerate the growth of Saudi Arabia's biotechnology sector by transforming visionary concepts into world-class infrastructure. BIOERA is a globally recognized firm that specializes in the design, development, and execution of advanced biotech facilities, each built to meet the highest international standards.

BIOERA's mission is to bridge scientific ambition and industrial execution. I have cultivated a network of global and regional partners, including KEYPLANTS, ZYME BIOTECH, SHAHIN ENGINEERING CONSULTANCY, PODTECH, and JADWA CONTRACTORS. Together, we bring multidisciplinary expertise in engineering, bioprocessing, construction, and project management to deliver turnkey solutions across the biotechnology lifecycle, from facility design and construction to commissioning and operational readiness.

These companies operate across the GCC, the United States, Europe, and India. BIOERA's reputation is built on agility, innovation, and an unwavering commitment to quality. The firm has played a central role in developing state-of-the-art manufacturing plants, research centers, and training institutes, each tailored to the evolving needs of the biotechnology industry. Our projects are designed to support scalable production, ensure regulatory compliance, and enable rapid technology transfer, critical capabilities for any nation seeking to build a resilient and self-sufficient biotech ecosystem.

Biotechnology Training Institute (BTI)

In 2024, recognizing the urgent need for specialized biotech talent, I established the Biotechnology Training Institute (BTI) in strategic partnership with the National Institute for Bioprocessing Research & Training (NIBRT), a globally renowned center of excellence based in Ireland. BTI is the first and only dedicated biotechnology training institute in Saudi Arabia, purpose-built to supply the skilled workforce required by our growing biotech sector. The partnership brings NIBRT's internationally accredited curriculum to Saudi Arabia, directly addressing a core gap in the Kingdom's biotech ambitions.

I created BTI with a clear mission: to equip Saudi professionals, students, and industry personnel with the technical expertise and practical skills needed to thrive in the fast-moving biotech sector. Our training programs are modeled after NIBRT's internationally accredited curriculum and cover critical areas such as upstream and downstream processing, fill-finish operations, quality control, regulatory compliance, and Good Manufacturing Practice (GMP) standards.

To ensure our trainees are truly industry-ready, BTI features advanced simulation labs and pilot-scale production facilities that mirror real-world biomanufacturing environments. This immersive approach allows participants to gain hands-on experience with the latest technologies and equipment, preparing them to contribute immediately to biotech operations within Saudi Arabia and beyond.

BTI plays a vital role in supporting the Kingdom's Vision 2030 goals by fostering human capital development, reducing reliance on foreign expertise, and accelerating the localization of biotech industries. It also serves as a regional hub for knowledge exchange, hosting workshops, certification programs, and collaborative research initiatives that bring together academia, industry, and government stakeholders.

ANIVAX Company (Veterinary Biotech)

As part of a lifelong mission to build a fully integrated biotechnology ecosystem in the Kingdom, I have led the establishment of several biotech enterprises. These ventures were born out of a commitment to addressing critical gaps in our national healthcare

and pharmaceutical sectors, laying the groundwork for a resilient, innovative life sciences industry that serves our people and our future. Through our **partnership with Boehringer Ingelheim**, we have further strengthened this foundation by bringing world-class expertise in animal health and advanced biologics into the Kingdom, accelerating our progress toward a fully sovereign and globally competitive biotech ecosystem. industry. Each company was designed to fulfill a specific function within the larger value chain, so that the whole is greater than the sum of its parts. Together, they provide the Kingdom with end-to-end capability, from discovery through manufacturing to commercialization.-

To further advance this strategic vision, I founded ANIVAX in 2025, a pioneering company dedicated exclusively to the research, development, and manufacturing of animal vaccines. ANIVAX represents a significant leap forward in Saudi Arabia's biotech evolution, positioning our Kingdom as a regional leader in veterinary pharmaceutical innovation and excellence.

What sets ANIVAX apart is our unwavering commitment to end-to-end manufacturing capabilities. We are building the first facility of its kind in Saudi Arabia capable of executing the entire vaccine production life-cycle, from initial formulation and packaging to fill-and-finish operations. This ensures not only the highest standards of quality and operational efficiency but also strengthens our national self-reliance.

A core element of ANIVAX is a fundamental belief: animal health is intrinsically linked to human health. By preventing and controlling diseases in livestock and companion animals, we contribute to safer food systems, reduce the risk of zoonotic disease transmission, and enhance public health resilience across the board.

This transformative initiative is more than a business venture; it is a strategic pillar in support of Saudi Vision 2030. Through ANIVAX, we are:

- Cultivating local scientific and technical expertise
- Reducing our dependence on imported pharmaceutical products
- Creating high-value employment opportunities in the biotech sector
- Strengthening Saudi Arabia's position in global health innovation

ANIVAX stands as a bold testament to our nation's commitment to advancing biotechnology and safeguarding both public and veterinary health through localized, world-class solutions. I am proud to contribute to this journey and to help shape a healthier, more self-sufficient future for our Kingdom.

Dr. Khaled Al-Mosa Consulting Firm

I established the Dr. Khaled AlMosa Consulting Firm as a specialized advisory platform dedicated to advancing strategic management, industrial development, and professional training across the healthcare, pharmaceutical, and biotechnology sectors. The firm was built to bridge global expertise with Saudi Arabia's national ambitions, supporting government entities, investors, and industry leaders as they navigate the complexities of biotech manufacturing, regulatory systems, and industrial localization.

Our services extend beyond training. The firm provides end-to-end consulting : biotechnology strategy development, industrial -engineering advisory, feasibility and market assessments, operational -excellence programs, regulatory and compliance guidance, investment and partnership structuring, and the design of advanced manufacturing ecosystems. We also support clients in areas such as supply-chain optimization, technology transfer, workforce development, and the establishment of biotech industrial clusters, ensuring that every project is aligned with international standards and national priorities.

One of our flagship initiatives is NIBRT Saudi, a biotechnology training institute modeled after the internationally renowned National Institute for Bioprocessing Research and Training (NIBRT) in Ireland. This collaboration was created to deliver worldclass, industryaligned training tailored to the needs of Saudi Arabia's rapidly expanding biotech sector.

Through this partnership, we introduced specialized curricula and handson training modules in bioprocessing, sterile manufacturing, quality assurance, GMP compliance, and regulatory frameworks, equipping Saudi professionals with the skills required to operate and lead advanced biomanufacturing facilities.

By integrating strategic consulting, industrial engineering expertise, and highimpact training, the Dr. Khaled AlMosa Consulting Firm plays a central role in building a sustainable and competitive biotechnology ecosystem in the Kingdom. Our work supports Saudi Arabia's broader goals of industrial localization, economic diversification, and healthcare innovation, empowering national talent, strengthening biopharmaceutical resilience, and enabling the Kingdom to shape its own future in advanced therapeutics and life sciences.

PART III: THE MISSION

Chapter 6

Challenges and Opportunities in Establishing a Sustainable Biotechnology Manufacturing Industry in Saudi Arabia

Saudi Arabia's biotechnology sector is at a pivotal stage of development. The Kingdom has made remarkable strides in localizing biomanufacturing and advancing vaccine sovereignty, but the journey toward a fully sustainable biotechnology industry presents both formidable challenges and transformative opportunities. Addressing regulatory frameworks, talent development, supply-chain resilience, and global partnerships will be essential to overcoming barriers, while Vision 2030, strategic investments, and innovation ecosystems will create new pathways for growth.

The Kingdom of Saudi Arabia (KSA) stands at a pivotal juncture in its drive for economic diversification and healthcare innovation, with biotechnology manufacturing as a strategic priority. As the nation accelerates its Vision 2030 agenda, the development of sustainable biopharmaceutical capabilities, particularly in vaccines, has become central to long-term goals of self-reliance, economic growth, and public-health resilience. Global crises such as the COVID-19 pandemic exposed the vulnerabilities of import-dependent healthcare systems and revealed the urgency of domestic vaccine production.

Healthcare in KSA

According to the WHO World Health Report 2000 (the most recent global health-systems ranking of its kind), the Saudi healthcare system ranks 26th of 190 systems globally, ahead of many international peers. The ranking reflects investment in infrastructure, workforce, and access. The next decade of investment, particularly in biotechnology and biomanufacturing, will determine whether the Kingdom rises further in the global hierarchy.

Despite these achievements, the Saudi healthcare system faces significant challenges: a shortage of drugs and vaccines, gaps in the laws, regulations, and policies of the Ministry of Health (MOH), and limited cooperation with other sectors of the economy. Although many Ministry of Health facilities offer services free of charge, access remains uneven across regions, and the population's healthcare needs continue to outpace domestic capacity. These gaps are most acute in biologics and vaccines, where domestic production remains limited and the Kingdom relies heavily on imports.

The estimated cost of healthcare worldwide in 2017 was USD 7.8 trillion (WHO, 2019), with annual growth projected at 5.4% between 2017 and 2022. KSA is the leading spender on healthcare in the Middle East, with approximately USD 40 billion in spend per year. Much of this expenditure flows to imported drugs and vaccines, highlighting the opportunity cost of healthcare worldwide (excluding the US) is USD 677 per person; however, in Saudi Arabia, it is more than USD 1,120 per person, which is 66 percent more than the broader economic diversification agenda. Localization of biotechnology manufacturing is the medical sector is the third subsidized sector, following the military and educational sectors, with funding of over USD 46 billion in 2019. See Figure (3.1), from International Trade Administration 2019, as shown in Figure (6.1) below. Local manufacturing is the single most leveraged intervention, because it addresses supply security, industrial capability, and export potential simultaneously.

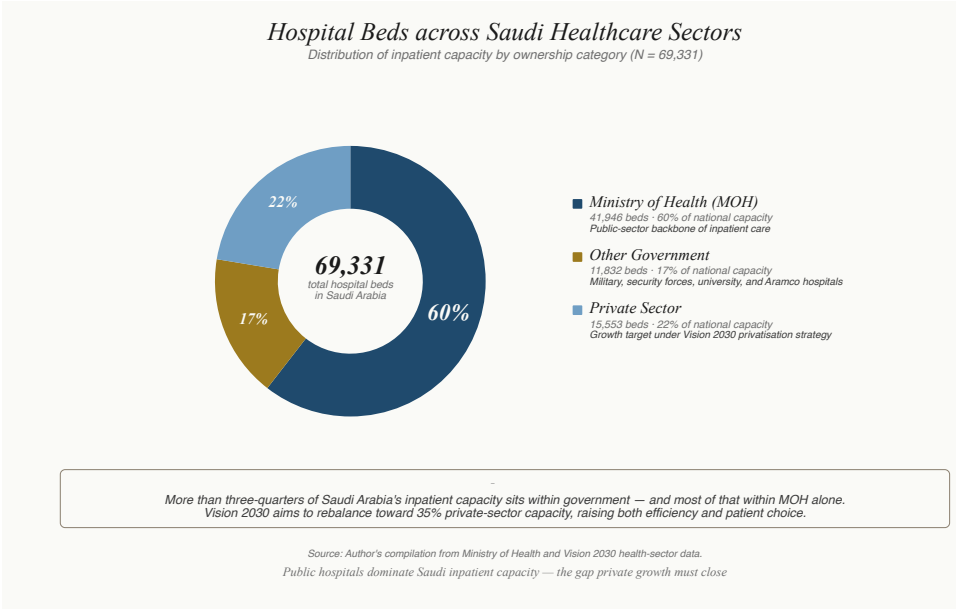

Figure 6.1

Beds in Various Sector of KSA Healthcare System

Note. Adapted from MOH, 2010, p. 10.

The KSA economy has historically depended on oil revenue, being the world's largest producer and exporter (KSA Profile, 2011). Recently, KSA has introduced programs to diversify, and today it produces and exports a range of industrial goods (KSA Vision 2030, 2017). The Kingdom is also investing heavily in non-oil sectors, including healthcare services (Saudi Version 2030, National Transformation Program, 2020). The first public health department was established in Mecca in 1925 based on a royal decree from King

Abdulaziz. This department was responsible for sponsoring and monitoring free healthcare for the population and pilgrims through establishing several hospitals and dispensaries. While it was an important first step in providing curative health services, the national income was not sufficient to this diversification strategy, positioned to secure long-term health outcomes while creating high -value jobs. Because the Kingdom's demographic profile, disease burden, and cultural continuity are distinctive, a domestic biotechnology industry, designed for Saudi Arabia's specific needs, will deliver benefits that imported products cannot. Vision 2030 recognises this explicitly, placing biotechnology central to its industrial and healthcare transformation.

The next crucial advance was the establishment of the Ministry of Health in 1951 under another royal decree. Twenty years later, the 5-year development plans were introduced by the government to improve all sectors of the nation, including the Saudi health care system, and since then, substantial improvements in health care have been achieved in Saudi Arabia.

Vaccine Manufacturing

Vaccination is one of the most efficient methods for preventing and controlling dangerous and occasionally fatal viral diseases (World Health Organization (WHO), Report 2020, p. 266). Mass vaccination, surveillance, and campaigns have decreased morbidity and death from several infectious diseases, including SARS-CoV-2, and have helped eradicate diseases like smallpox.

Vaccines are biological substances created by modifying genetic material of living organisms, such as cultures of yeast, bacteria, insect cells, or animal cells. As biological compositions, vaccines are designed to boost and prime the immune system to fight against illness or infection by making use of the highly developed mammalian immune system's capacity to identify, react to, and recognize pathogens.

Vaccines differ from small-molecule medications in many ways, in terms of development, production, regulatory restrictions, and patent structure.

Unlike chemically identical generic medications, most vaccines made with the same active ingredients are effectively new entities. Vaccines have eradicated or contained serious diseases including poliomyelitis, Haemophilus influenzae type b (Hib), rotavirus enteritis, hepatitis A and B, measles, mumps, rubella, varicella, and tetanus. The list of pathogens against which effective vaccines exist is long and growing, and the public-health and economic impact is among the largest of any class of medical intervention.

Table 6.1 Emerging Viral Infectious Diseases

Note. Adapted from Excler et al., 2021, p. 595.

Year	Name	No of deaths	Comments
1918	'Spanish influenza'	In the range of about 50 million to 100 million	1918: H1N1; other pandemics in 1957–1958 (H2N2), 1968 (H3N2) and 2009 (H1N1)
1931	Rift Valley Fever	Overall CFR < 1%; ~50% for hemorrhagic fever	Contact with blood or organs of infected animals and mosquito-borne; several outbreaks in 1977, 1997–1998
1937	West Nile fever	CFR ~5%	Mosquito-borne; worldwide outbreaks (most recent 1999–2010, USA)
1967	Marburg hemorrhagic fever	~470; very high CFR (24–88%, WHO)	Contact with African green monkey; numerous outbreaks in Africa 1969–2018
1969	Lassa fever	~5,000 deaths annually; CFR 1–2%; Nigerian CFR 25%	Contact with rodents or contaminated food or items; mostly in West Africa (Nigeria 2018)
1976 2020	Ebola hemorrhagic fever	15,266 cumulative (WHO, 2024); CFR 75%	First identified in 1976; first major outbreak in 2013–2016 in West Africa and in 2018 in Democratic Republic of Congo; 29 regional epidemics in 2020 in West and Central Africa
1981	HIV/AIDS	~37 million	Ongoing pandemic
1996	Avian flu	High CFR (60%)	H5N1 and H7N9 viruses from poultry; several outbreaks worldwide; last outbreak in China in 2018
1999	Nipah fever	<1,000.very high CFR	Outbreaks in Malaysia, Singapore, Bangladesh, and India
2002	SARS	813; CFR ~ 10%	Contained, did not turn into pandemic
2009	H1N1; H7N9 'swine flu'	284,000.CFR 2.9–9%	Pandemic
2012	MERS	935; CFR 34.4%	Major outbreak in 2012–2019; ongoing (camels, humans); detected in 27 countries but mostly in Middle Eastern countries
2014	Chikungunya	Rare	Mosquito-borne
2015	Zika	Unknown	Mosquito-borne
2019–	COVID-19 (SARS-CoV-2)	>7 million confirmed; ~14–18M excess (WHO, 2024);	2019–ongoing

WHO Vaccination and Immunization Report (2020, p. 266) estimates that immunizations prevent between 2-3 million deaths annually. Monitoring, pandemic preparedness programs, government and non-government cooperation, national policies, and current technology and platforms for vaccine production and distribution are among the many variables that affect capacities to respond to threats quickly.

Although technologies and systems for manufacturing vaccines have been developed over time to address limitations and reflect technological improvement, the worldwide need for vaccines is increasing. Several factors drive this demand: a growing global population, rising life expectancy, greater recognition of the value of immunization, the threat of pandemic disease, and the emergence of new pathogens. Meeting this demand requires both expansion of existing production capacity and investment in demands for vaccines, there is a vital need for nations around the world to intensify effort through the collaboration of government and private sector to manufacture vaccines to meet the local and international needs. new platform technologies capable of rapid scale-up.

Vaccine manufacturing serves to facilitate levels of revenue and capital investment in healthcare facilities and systems that are in proportion to KSA economic status and are appropriately distributed to reflect domestic primary healthcare (KSA-MoH-VRO, 2017, p. 113).

In the Kingdom of Saudi Arabia (KSA), economic diversification has become a top priority. The manufacturing sector has grown substantially in recent years, geared towards a central role in realizing Saudi Vision 2030 and is expected to become the country's largest economic driver in line with the Sustainable Development Goals (SDGs) adopted in 2015 (KSA Vision 2030, p. 29).

SARS-CoV-2 forced large-scale vaccination of the Saudi population. Because no domestic vaccine-manufacturing capability existed, WHO-approved vaccines had to be imported, generating substantial cost and logistical pressure on the national supply chain. The episode revived the imperative for locally manufactured vaccines and provided the world had to be imported, creating additional medical costs and logistics challenges (WHO, 2020, p. 241). Hence, successful local vaccine manufacturing business in KSA is crucial for the National Biotechnology Strategy that followed.

KSA is the largest country on the Arabian Peninsula and operates a free healthcare system for all residents (KSA-MOH-VRO, 2017, p. 113). The Ministry of Health is the primary provider, via a network of 287 government hospitals and 2,257 primary healthcare institutions. This system faces structural pressures: a rapidly growing population, a high burden of non-communicable disease, and significant reliance on imported medicines

and vaccines. Strengthening domestic biotechnology manufacturing directly addresses the last of these pressures, reducing cost and Interior, as well as organizations like the National Guard and ARAMCO, are responsible for financing and delivering healthcare services to their employees and their families. securing supply.

Other government agencies currently operate 50 hospitals in the Kingdom. The private health sector operates 167 hospitals, 3005 medical complexes, 49 private doctor clinics, and 174 laboratories (KSA Ministry of Health Annual Statistical Report, 2021, p. 2), as shown in Table (6.2).

Table 6.2 KSA Health Services Sector Statistical Report

Note. Adapted from KSA Ministry of Health Annual Statistical Report, 2021, p.2.

Public Health Service Providers	No. of hospitals	No. of hospital beds	No. of doctors	Population served
Ministry of Health (MOH)	287 (56.9%)	45180 (57.48%)	50065 (52.5%)	All Saudi nationals and expatriates working in government services
Other Government Sectors	50(9.9%)	13989 (17.79%)	20234 (21.2%)	
Armed Forces Medical Services		5689	8242	Employees and their families
National Guard Services		2669	4751	Employees and their families
Ministry of Interior		855	1100	Employees and their families
King Faisal specialist hospital & research center		1817	1859	Referred Saudi Nationals
Royal Commission Hospitals		455	498	RCJY's Employees
ARAMCO Hospitals		424	760	ARAMCO Employees
Ministry of Human Resources and Social Development		2080	147	University Students and Employees
Private Health Sector	167 (33.1%)	19427 (24.71%)	25037 (26.3%)	Saudi Nationals and Expatriates
Total Hospitals and Beds	504 (100%)	78596 (100%)	95336 (100%)	

Saudi nationals and foreign workers alike are exposed to known and emerging viral diseases. Several factors compound the risk: high-density urbanisation, demographic shifts, modernization that favors individual mobility, climate change, ecosystem

disruption, and the constant flow of pilgrims, migrants, and travellers across the Kingdom's borders. Together, these factors require national capability in surveillance, response, and, critically, vaccine manufacture.

During the emergence of the Spanish flu in 1918, as per estimates, the global population was approximately 1.8 billion (UN World Population Prospects, historical estimates). As per recent estimates, the global population has been anticipated to reach around 9.9 billion by the year 2050, which would mark an increase of more than 25 percent from the prevailing global population of 7.8 billion as recorded during 2020 (Worldometer, 2023).

The novel SARS-CoV-2, the virus responsible for COVID-19 in 2019, spread across the world in under six months. It caused high mortality among the elderly and those with comorbidities, triggered a healthcare pandemic, and disrupted the global economy. Beyond its direct health impact, the only measure of control was restricted to an array of mitigation strategies like wearing masks, avoiding large gatherings, and self-distancing, which was not only imperfect but also had its own limitations (WHO Vaccine and Immunization Report, 2020, p. 189).

As more than 100 million individuals worldwide were infected and deaths occurred across nations, it became widely acknowledged that vaccine development, alongside existing countermeasures, was the best option to control the COVID-19 pandemic (WHO Vaccine and Immunization Report (2020, p. 189). Therefore, factors that drive policymakers and researchers to maintain vigil and reevaluate their steps towards surveillance and management of threats from infectious diseases that might emerge in the future while reassessing the global mechanisms to control similar pandemics need to be facilitated.

Throughout the millennia, the emergence of new infectious diseases has been recognized long before the causative agents were discovered. Despite advances in therapeutics, diagnostics, and vaccines, global travel and increased international interdependence have compounded the difficulty of containing such diseases (WHO-GHO, 2019, p. 17). Emerging infectious diseases (EIDs) are now identified as major threats to global stability and to human health (IFPMA, 2019, p. 15).

A review of emergent pandemic diseases across history illuminates how coronavirus epidemics, and the SARS-CoV-2 pandemic in particular, emerge and propagate. As human societies grow in size and complexity, opportunities for pathogens to cross between species and populations multiply. Contemporary patterns of urbanisation, global travel, and intensive animal husbandry accelerate those dynamics. Pandemic preparedness, therefore, is not a one-off exercise; it requires sustained investment in

surveillance, research, and manufacturing capacity. Countries that build domestic vaccine-manufacturing capability will be better placed to respond to future pandemics on timelines that matter. KSA's national vaccine-manufacturing program is a direct response to this lesson. By establishing end-to-end capability, including cell-based influenza vaccine production and pandemic-response platforms, the Kingdom positions itself to protect its population rapidly in future emergencies, and to contribute to regional and global response capacity.

Amid concerns about transmission during the 2013--2016 Ebola outbreak in West Africa, the World Health Organization (WHO Ebola Situation Report, 2020) stressed the urgency of accelerating the development and assessment of candidate vaccines. To ensure that manufacturers could respond quickly to emerging threats, WHO called for investment in vaccine platforms capable of rapid redeployment against new pathogens. The lesson was reinforced by COVID-19: vaccine-manufacturing capacity is a national security asset. Countries without domestic capability face delays and tested Ebola vaccines for defense purposes within non-human primates. However, this earlier work was not prepared for clinical trials at the time of the epidemic nor deemed commercially viable to facilitate its development.

Vaccines have long been the keystone for managing outbreaks of infectious disease (WHO, 2020, p. 189). They are among the most reliable means of reducing the risk of an epidemic or pandemic. The faster a vaccine can be deployed, the more lives can be saved and Immunization Report (2020, p. 189). As is evident, the standard cycle for vaccine development is not appropriate to tackle explosive pandemics such as COVID-19 (WHO Ebola Situation Report, 2020, pp. 110--112; IFPMA, 2019, p. 15).

New vaccine platform technologies can sharply reduce the standard development cycle, enabling multiple vaccines to be developed, tested, and manufactured in parallel. Several technical platforms now exist or are in the process of development to tackle emergent infectious viral diseases. Two vaccines for COVID-19 have been evidenced to be developed with the help of Messenger Ribonucleic Acid (mRNA, viral-vector, recombinant-protein, inactivated-virus, and DNA-based approaches. Each platform offers distinct advantages, and a domestic manufacturing base must be capable of operating across more than one to ensure resilience.

The emergency use authorization (EUA) framework introduced by the US FDA and the European Medicines Agency's conditional marketing authorisation have streamlined accelerated review. There are clear costs to such acceleration, including post-market surveillance burdens and the risk of late-emerging safety signals, but the COVID-19 experience demonstrated that the trade-off is acceptable when the alternative is

uncontrolled disease.

Several governments, with support from NGOs and charities, invest in vaccine manufacturing to improve health outcomes (IFPMA, 2019, p. 15). Such investment has reduced morbidity and mortality rates associated with impactful vaccination programs, with a blend of direct and indirect safeguards, which has led to a drop in the existence of diseases and costs related to healthcare. Such noticeable reductions have major implications for the growth of the economy, with minimum amounts being spent as costs are avoided with a smaller number of medical tests, treatments, and procedures and less time off from work by patients.

Cost-effectiveness analyses consistently show that vaccination is a high-return investment: many programs cost less than US$50 per life saved (IFPMA, 2019, p. 15). Returns on investment for vaccines are among the highest in public health. The economic case goes beyond direct healthcare savings. Vaccination prevents illness, disability, and death: the hearing loss that follows pneumococcal meningitis, the limb amputation that can follow meningococcal disease, the lost years from rotavirus and measles. Beyond these direct consequences, it averts the productivity losses that cascade through schooling, employment, and family care responsibilities. For KSA, where healthcare expenditure and chronic-disease burden are both substantial, investment in a domestic vaccine-manufacturing base produces economic, health, and strategic returns simultaneously. The scale of that triple return justifies the long-horizon, capital-intensive nature of biomanufacturing investment, and helps explain why Vision 2030 places biotechnology among its most strategic industrial priorities.

The COVID-19 pandemic served as a reality check on how fragile global vaccine supply can be and how little deep manufacturing expertise existed in many countries, including KSA. The government responded by scaling up healthcare provision, including rapid procurement of approved vaccines, and has since moved to reduce long-term dependence on external suppliers by investing in domestic manufacturing. The VIC program, in collaboration with CSL Seqirus, is the direct outcome of that shift. Building cell-based influenza and pandemic-response vaccine capability within the Kingdom ensures that in any future public-health emergency, Saudi Arabia will be able to protect its population as well as a large geographical area, none of these other nations have succeeded in healthcare development at an extensive national scale in a short time span. See Figure (6.2).

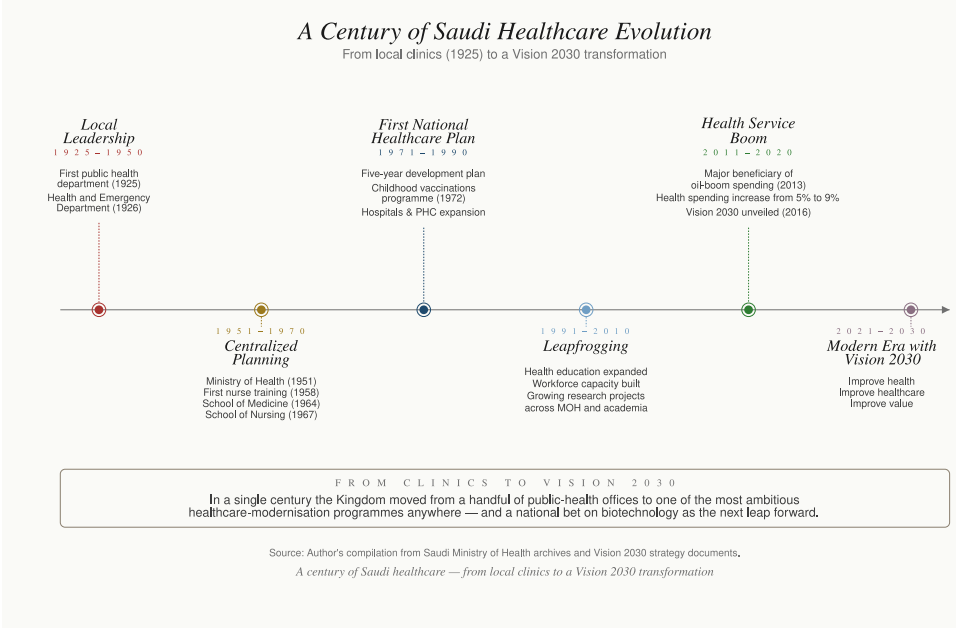

Figure 6.2

Evolution of the Health System in Saudi Arabia (1925–2030)

Note. Adapted from Young et al., 2021, p. 95.

Despite the massive enhancements within the KSA healthcare system, there are still challenges at the primary healthcare system, such as population growth, high costs of healthcare, emergent infectious diseases, chronic ailments, inequitable access, and a healthcare system that is highly centralized. During the outbreak of the COVID-19 pandemic, KSA was prompt to order vaccine supplies, wherein the first batch of vaccines reached in February 2021 (KSA-MoH-VRO, 2017, p. 213).

Vaccines were distributed in phases. The first phase prioritized healthcare workers, who faced the highest infection risk. The second phase covered frontline workers such as military and security personnel, then expanded to those with chronic conditions, the elderly, and finally the general adult population. Children and adolescents followed once safety and efficacy data for those age groups became available. The phased approach allowed the Kingdom to optimise limited initial supply and to concentrate protection where it mattered most, and it also served as a stress test of logistics, communications, and cold-chain capability at national scale, lessons that now inform the architecture of KSA's domestic vaccine program.

Vaccine manufacturing is intricate, with significant challenges across the safe and effective production lifecycle (IFPMA, 2019, p. 31). Complexity is amplified by the

analytical demands of biological process characterization, the variability of biological starting materials, and the regulatory requirement for batch consistency. Mastering these challenges requires a combination of capital investment, technical depth, and time, none of which can be shortcut.

Based on the annual reports as presented by the United Nations International Children's Emergency Fund (UNICEF) between the periods of 2015-2019, there is an indication that most of the goods that were obtained from diverse nations were either biologicals or vaccines (UNICEF, 2015, 2017, 2019).

GAVI, the Vaccine Alliance, was established in 2000 as a public-private partnership to improve vaccine access for children in lower-income countries. Its partners include governments, the WHO, UNICEF, and the private sector. Beginning with six vaccines from five suppliers across three regions, GAVI now operates at substantial scale and offers a model of how vaccine access can be coordinated across borders, manufacturers, and funding sources.

Within the developing countries around the world a voluntary public health-driven alliance of vaccine manufacturers known as DCVMN - "Developing Countries Vaccine Manufacturers Network" was formed a collaborative network of 48 vaccine manufacturers from 17 countries that supports local production to improve access to affordable vaccines.

Between 2012 and 2018, the number of DCVMN manufacturers supplying GAVI markets rose from 4 to 10, and DCVMN accounted for 55% of total doses delivered to GAVI. During the COVID-19 pandemic, only a handful of nations had domestic vaccine-manufacturing capacity at relevant scale, and the imbalance generated the supply-shortfall and price-distortion problems that defined global access in 2020–2021.

Local production of vaccines would need interested nations to work towards the transfer of technology, its assimilation, capacity building, and innovation. Interventions on vaccine capacity building specifically could assume diverse forms that encompass detailed consultations, online learning options, technical support, in-person and web-based training, skills-based courses like mentoring and coaching, and guidance materials in the form of knowledge products.

Through all of these efforts, KSA was not among the nations contributing to global vaccine production. During the COVID-19 pandemic, the Kingdom relied entirely on acquisition of vaccines manufactured and marketed elsewhere. That extreme dependence cannot be sustained in the next pandemic. The case for domestic manufacturing capability is now both economic and strategic, and it has the full backing of Vision 2030.

The vaccine market in low- and middle-income countries (LMICs) is dominated by

foreign manufacturers, creating logistics and delivery challenges, storage complications, and risks to viability (El-Chaarani, 2019, p. 7). These immediate challenges reinforce the case for domestic manufacturing. Local production shortens supply chains, reduces cost, and improves responsiveness. For KSA specifically, a domestic base also enables tailoring to local disease burden and population genetics, areas in which the Kingdom's distinctive profile warrants direct attention from nationally-owned R&D, rather than reliance on vaccines optimised for other populations.

During the COVID-19 pandemic, vaccination demand rose sharply as the disease spread, met by an unprecedented response in research and development that accelerated multiple vaccine platforms to approval within a year of the virus being identified. This necessitated the requirement for scaling up production at a faster pace than is usually known in the domain of pharmaceutical development. Furthermore, the challenge of the COVID-19 pandemic was further aggravated by massive single year, an achievement without precedent in vaccine history. The scientific validation of mRNA and adenoviral-vector platforms has transformed the field, compressing development timelines and opening new options for rapid response to future pathogens. For KSA, participating in the next generation of vaccine components and manufacturers of vaccines aimed at collective supply targets of around 14 billion COVID-19 vaccines by the end of 2021, which was three to four times larger than the anticipated annual global demand for all vaccines prior to COVID-19 (IFPMA, 2019, p. 24).

In KSA the first case of COVID-19 was reported on 2 March 2020. Cases peaked on 17 June 2020, with 4,919 new infections recorded in a single day. By 13 January 2021, 363,328 cases had been laboratory-confirmed, with 6,246 fatalities. Robust steps were undertaken by KSA-MoH to restrict the spread of the disease, which included restrictions on travel, mandatory use of masks, and lockdowns. During the COVID-19 pandemic, KSA was confronted with several issues related to The Kingdom mounted a coordinated national response combining public-health measures, testing infrastructure, and a rapid vaccination program, drawing on imported vaccines approved by the SFDA. While the response was effective, it also reinforced the strategic case for domestic vaccine delivery and operations, communication, patient experience, vaccine quality assurance, vaccine education, supply chain, and clinical care. Since there are no locally manufactured vaccines for COVID-19 in the country, a highly integrated process that involved ensuring a consistent track of vaccine supply was maintained. However, several challenges continue to emerge (KSA-MoH Report, 2020).

Prior to VIC's establishment, KSA was the only G20 country without domestic vaccine manufacturing capacity (International Monetary Fund, WTO, WHO, WITS, team

analysis, 2022, p. 6).

KSA has depended largely on other countries for its vaccine requirements. The Kingdom's biopharmaceutical manufacturing footprint is limited: there are 19 pharmaceutical organizations operating domestically, and only a small subset have the technical capability for biological products. The gap is now being addressed through a combination of public investment, joint ventures, and the build-out of GMP-certified facilities such as SAUDIBIO and VIC.

In KSA, several organizations are establishing start-ups for vaccine manufacturing, supported by a government investment of approximately US$3.4 billion directed at local manufacturing capacity. Other organizations are pursuing joint ventures with established international manufacturers to accelerate the transfer of platform technologies. The combination of direct government investment, policy support, and joint-venture activity is designed to compress the normally long development cycle for a domestic vaccine industry. Within a decade, KSA aims to move from near-total import reliance to a position where the Kingdom manufactures core seasonal and pandemic-response vaccines domestically, exports to the region, and serves as a center for vaccine R&D on diseases of particular regional relevance.

One way through which the KSA government is considering localization of vaccine manufacturing is through the establishment of partnerships and joint ventures between global vaccine manufacturers and local organizations as an outcome of routine immunization and disease outbreaks. Reputed multinational companies have an enhanced understanding regarding complex manufacturing processes, entry barriers arising from high technology, research and development, and cost associated with vaccine production (Biopolis Biomedical Research Initiative, 2021, p. 22). Alliance with organizations such as DCVMN with headquarters in Switzerland is among the ways through which vaccine manufacturing business can be achieved.

Pharmaceutical Manufacturing Industry in KSA

In KSA, more than 82% of national pharmaceutical companies do not manufacture biological products. Fewer than 14% manufacture more than ten biological products for the Saudi market. More than 80% do not manufacture biosimilars. The structural under-development of the biological-products segment is the single largest gap in the Kingdom's pharmaceutical capability, and it is the gap that the National Biotechnology Strategy is designed to close.

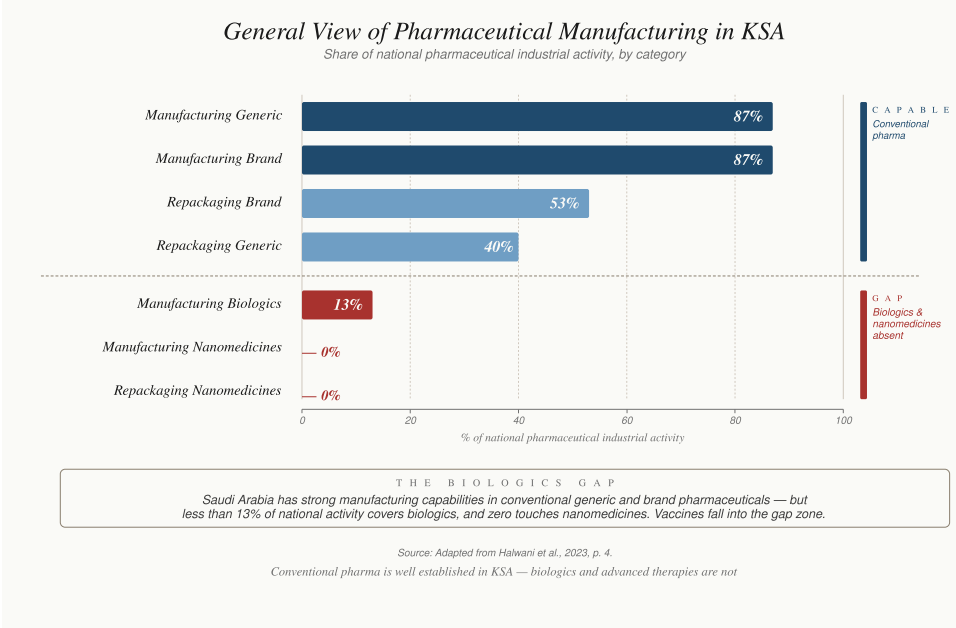

Figure 6.3

General View of Pharmaceutical Manufacturing in KSA

Note. Adapted from Halwani et al., 2023, p. 4.

The Saudi pharmaceutical market is worth USD 8.3 billion. Forecasts from the Pharmaceuticals Export Promotion Council of India (Pharmexcil, 2020) project an upward growth pattern, making KSA the largest pharmaceutical market in the region and a magnet for global manufacturers seeking access. The combination of market scale and policy support gives the Kingdom unusual leverage to negotiate technology-transfer terms favorable to local capability building.

KSA has successfully promoted local pharmaceutical manufacturing development during the last decade to become the leading manufacturer and innovator in the MENA region by accelerating the transition of pharmaceuticals into products with higher complexity. The contribution of KSA to the MENA region is expected to increase 30 percent year by year (IQVIA 2019).

In KSA most pharmaceutical companies started as importers and distributors of drugs, and some have developed into pharmaceutical industries. Locally manufactured products cover only a small amount (i.e., 30%) of the current market demand, with a primary focus on producing generics, which means there is growth potential, but this will require a significant capital investment.

Among drug types, branded drugs are expected to hold the major revenue share in 2027, driven by continued launches of branded medicines in the Kingdom (Coherent Market Insights, 2021). For instance, in December 2015, SAJA Pharmaceuticals announced that it signed a contract with Novartis AG to launch SAJA, the first antidiabetic drug (Jalra and JalraM ^met^), as a second brand of Novartis AG blockbuster (Galvus and Galvus ^met^). However, the expansion of local pharmaceutical production by foreign firms is likely to intensify competitive pressure on smaller domestic companies, which may struggle to match the cost efficiencies of international players. Although the pharmaceutical market in KSA has grown steadily in recent years, most domestic pharmaceutical companies continue to concentrate on the production of generic drugs. In contrast, the major worldwide manufacturers focus on developing and launching pharmaceutical brands in the Saudi market and the limited domestic capability to produce biologics and advanced therapies, which remain under patent protection. As Saudi manufacturing matures, the mix will shift: locally produced biologics and vaccines will capture share from imports, and domestic players will move into higher-margin branded territory through licensing, local innovation, and partnership structures. The trajectory mirrors that of other emerging pharmaceutical markets, and is accelerated by the focused policy support under Vision 2030. The end-state is a market in which Saudi Arabia's pharmaceutical expenditure increasingly captures domestic value rather than flowing abroad.

Factors that Impede Biotechnology Manufacturing Business

The COVID-19 pandemic, which disrupted every segment of the global economy partly because no readily available vaccine existed, demonstrates the case for sustained investment in pharmaceutical R&D. Vaccination remains one of the most cost-effective public-health interventions available, and the absence of domestic R&D capability translates directly into delayed access in a crisis.

One of the biggest advances in medical research history is vaccination against disease, and it is now regarded as essential for improving life expectancy, reducing mortality at a reasonable cost, and spurring economic growth.

The World Health Organization (WHO) estimates that licensed vaccines save two to three million lives annually, and that number would rise by at least six million if every child received vaccinations in accordance with the recommended schedule.

Globally, 19.5 million infants remain vulnerable to vaccine-preventable diseases due to inadequate access to basic immunizations, primarily in low- and middle-income countries where equitable distribution remains a persistent challenge.

The process of manufacturing vaccines is fraught with difficulties, such as adequate

production facilities, machinery, lead times, product portfolio management, life cycle management, intellectual property (IP), process development, and maintenance in general.

Sustaining a long-term vaccination life-cycle within a market requires a robust and reliable production infrastructure, supported by uninterrupted access to raw materials over multiple decades.

In 2023, I conducted empirical research to investigate factors that impede successful biotechnology manufacturing business in KSA as imperatives for healthcare sustainability.

The following section reveals critical insights into the multifaceted challenges hindering biotechnology manufacturing in the Kingdom.

(a) Research and Development (R&D) Capability

The manufacture of an effective vaccine is complicated; hence, extensive research and development (R&D) must be established, and this includes facilities, technology, and skills.

Lack of adequate R&D for vaccine manufacturing has been recognized as a challenge for local manufacturers in the developing countries.

In terms of R&D, the main challenges to vaccine manufacturing include:

- Inadequate R&D capacity to support technology transfer.
- Lack of experience R&D staff.
- Resource prioritization at the company level.
- License negotiation skills and training.
- Evaluation and assessment of quality of technologies.

The great majority of vaccines that are presently available were created using conventional research techniques; therefore, the next generation of novel vaccines will be far more difficult, challenging, expensive, and risky to manufacture because of the complexities associated with the targets set for vaccine development, which demand significant financial investment and expertise, making R&D capability indispensable.

For any pharmaceutical organization, the spending on research and development (R&D) can be influenced by multiple factors, which are controlled mainly by the expected revenues, expenses, and policies that are required to produce and market vaccines and other drugs (Hollis, 2019; Austin, 2006).

Several factors contribute to the overall cost of vaccine research and development. These include timeline, costs, sectoral affiliation (i.e., public, or private sectors with commercial

or non-commercial orientations), the licensure track record of vaccine developers, the licensure track record of vaccines for a specific disease, and the complexity of platform technology. Vaccine portfolios have different industrial challenges that manufacturers must scale through in the process of development. See Table (6.3). In this case, a well-established research and development strategy is of paramount importance to effectively achieve a successful vaccine manufacturing business.

Table 6.3 Classes of Vaccines and the Industrial Challenges Associated

Note. Adapted from Smith et al., 2011, pp. 428–438.

Classes of Vaccines	Vaccine Active Component	Main Manufacturing Challenge
Oral Polio vaccine	Live-attenuated viruses x3	Maintaining phenotypic and genotypic stability of each of the 3 strains
Rabies	Inactivated cell culture grown virus (e.g., on Vero cells)	Ensuring complete inactivation while maintaining immunogenic potency and avoiding reactogenicity. Appropriate BSL containment of live virus steps.
Acellular Pertussis	Purified proteins from B. pertussis	Consistency of production, detoxification of components. Stability and
Multivalent Pneumococcal conjugate vaccines	Multivalent Pneumococcal conjugate vaccines	Multivalent Pneumococcal conjugate vaccines
Hepatitis B Vaccine	Recombinant protein	Consistency of manufacturing, with reproducible immunogenicity andMinimal host protein contaminant profiles
Japanese Encephalitis (JE)e.g., Immuno Jev	Vectored vaccine	Need to demonstrate absence of potential for reversion or genetic rearrangement. Robustness of process. Freeze drying process and stability of product.

In KSA, local drug producers have strong capability in conventional dosage forms (tablets and capsules) within the generics segment, but cannot produce non-conventional forms such as biological and plasma-derived products. An innovative drug development scheme focused on biologics would close the most strategically important capability gap, and would unlock the higher-margin segments of the pharmaceutical market, which would require a well-established R&D capability and patent protection through reliable intellectual property policies. This scheme will improve the return on investment in R&D for developed vaccines and other essential drugs.

Despite the government's financial support for R&D in general, most of the research projects that are related to pharmaceutical development are scattered and have no true outcome, majorly due to a lack of new domestic 'branded' medicines.

The limited returns on R&D investments can be attributed to several structural and operational barriers, including a shortage of skilled personnel, insufficient technical expertise, inadequate research infrastructure, restrictive regulatory frameworks that constrain market access, and the growing impact of patent cliffs where drug patents expire or lose commercial viability.

The inadequacy of R&D in vaccine manufacturing stems from ineffective collaboration strategies among local vaccine producers, academic institutions, research centers, and pharmaceutical companies, particularly in the joint development of novel pharmaceutical products that can be patented and manufactured domestically.

There is an unprecedented need to manufacture and distribute enough safe, effective vaccine to immunize large populations and protect the global community from the continued threat of morbidity and mortality from severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2). Moreover, the global demand for vaccines, coupled with the geographically diverse nature of pandemics, necessitates multiple effective vaccine strategies. Collaborative research and development efforts among biotechnology and pharmaceutical firms are therefore critical, as many are advancing distinct and complementary vaccine platforms to address varied epidemiological challenges coronavirus 2 and its successors. Meeting this need requires not only manufacturing capacity but the regulatory, logistical, and clinical infrastructure to deliver vaccines into arms at speed.

Vaccine portfolios across many pharmaceutical companies have contracted over recent decades, primarily due to the substantial cost and extended timelines of vaccine development relative to other therapeutic products. However, the pandemic response and the commercial success of COVID-19 vaccines have revived corporate interest, and investment in vaccine platforms has risen materially. For an emerging manufacturing nation such as baculovirus-based recombinant vaccines, virus-like particles, viral vectors, and RNA or DNA vaccines. With the global population projected to reach approximately 10 billion by 2050, an estimated 90 percent will reside in developing countries. This demographic shift is an opportunity: international partners are more open to technology transfer, licensing, and joint-venture structures than at any point in the past twenty years. The VIC-CSL Seqirus partnership and the BIC-Baylor collaboration both exemplify how the Kingdom is converting that window into durable national capability.

KSA has significantly intensified efforts to advance domestic vaccine manufacturing, as reflected in the expansion of infrastructure and investment in research institutions. However, despite these commendable strides, considerable progress is still required before national entities can consistently produce vaccines that meet the highest international

standards of quality and efficacy (Alzahrani & Harris, 2021).

A persistent barrier to advancing vaccine-production capacity is limited private-sector investment in industrial infrastructure. The Kingdom continues to lack state-of-the-art manufacturing facilities capable of producing vaccines rapidly and at scale. A second constraint is the shortage of qualified professionals with the requisite expertise in vaccine development and production processes (see Figure 6.4). Progress toward a robust vaccine manufacturing ecosystem has also been impeded by restricted access to the cutting-edge technologies essential for modern biopharmaceutical innovation. Finally, the high cost of conducting research and developing novel vaccine technologies remains a critical challenge that must be addressed.

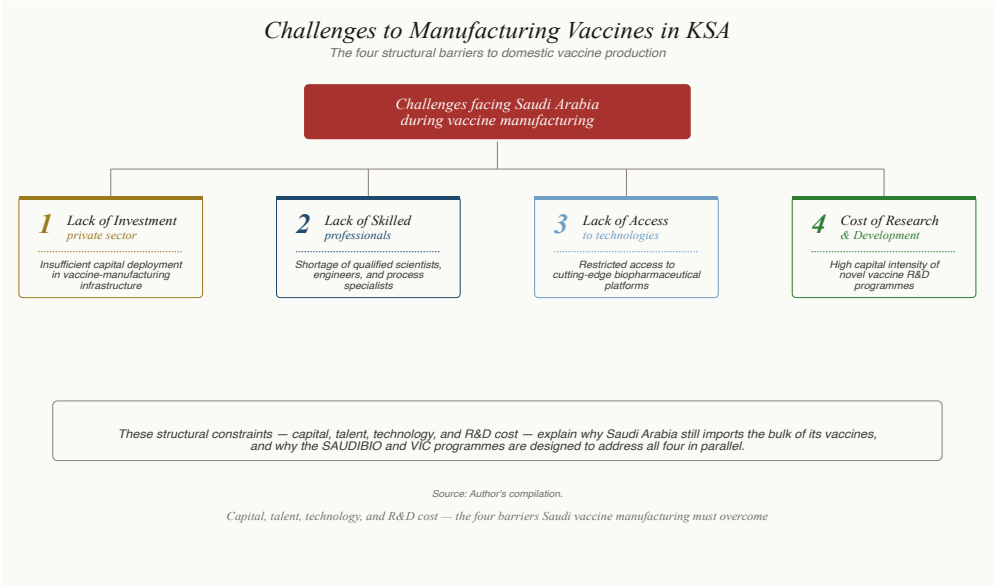

Figure 6.4

Challenges to Manufacturing Vaccines in KSA

Note. Author's compilation.

Despite its considerable wealth, KSA remains heavily dependent on imports, primarily from the United States and European nations, for public vaccination programs, often at substantial financial cost. This reliance has exposed vulnerabilities, not only during COVID-19 but also during earlier outbreaks such as hepatitis, when vaccine shortages were reported. It is therefore imperative for KSA to establish domestic vaccine-manufacturing capabilities to enhance national health security and reduce dependence on external suppliers.

As the Saudi population grows, establishing local vaccine-manufacturing facilities to

meet future healthcare demand becomes a national imperative. One viable pathway is the Contract Development and Manufacturing Organization (CDMO) model, which enables modular engagement and shared infrastructure across multiple pharmaceutical clients, reducing capital intensity for any single product line and accelerating time to market.

PricewaterhouseCoopers GmbH (2019) recommends that pharmaceutical companies may engage Contract Development and Manufacturing Organizations (CDMOs) to support one or more phases of vaccine or pharmaceutical product research and production. The CDMO model integrates diverse healthcare strategies, including tools and systems that enable healthcare professionals to more effectively interpret and capture clinical data, thereby enhancing patient outcomes.

The model is also highly relevant to the health sector, as it offers a structured framework for healthcare data management. This facilitates improved accuracy and efficiency in medical record-keeping and enhanced the overall quality of patient care. Additionally, it enables healthcare organizations to more effectively analyze and leverage clinical data to optimize operational performance and patient outcomes.

The adoption of CDMO modalities is well-suited to the health sector broadly, and to vaccine localization efforts, as it encompasses the full spectrum of pharmaceutical processes, from drug discovery and development to commercialization, including marketing and sales. See Figure (6.5).

In the pharmaceutical industry, the CDMO model operates as an integrated framework that supports modular engagement across the drug development life-cycle. It offers consolidated access to diverse technologies and enables collaboration among multiple pharmaceutical entities under a single operational umbrella. This model supports the identification and coordination of various CDMO partners, allows for volume-specific production planning, accommodates smaller batch manufacturing, and provides an efficient mechanism for pooling specialized professional expertise.

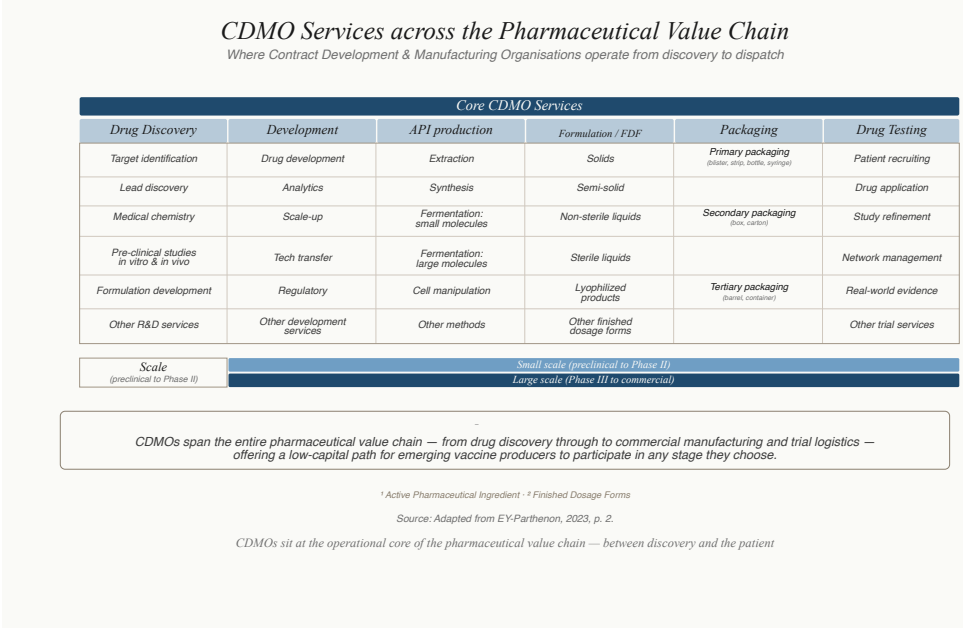

Figure 6.5

Modalities for Manufacturing Categories for CDMOs

Note. (Adapted from EY-Parthenon, 2023, p. 2).

The implication of CDMO models has helped numerous developed and developing countries such as Brazil, Morocco, South Africa, South Korea, and Italy. Furthermore, it has been foreseen that leading global CDMOs have covered all major vaccine technology platforms and have also helped to be key technological transfer centers See Table (6.4).

Table 6.4 Top CDMOs Manufacturing Organizations and Sales Revenue (2020)

Note. Adapted from Bown & Bollyky, 2022, p. 476.

Firms, categorized by revenue	Headquarters
US$3B – 5B	
Lonza	Switzerland
Catalent	United States
Thermo Fisher Scientific (Patheon)	United States
US$1B – 3B	
Fareva	France
Recipharm	Sweden
Wuxi AppTec/Bio	China
Siegfried	Switzerland
Delpharm	France
US$0.75 – 1B	
Cambrex	United States
Albany Molecular Research (AMRI)	United States
Vetter	Germany
Aenova Group	Germany
Boehringer-Ingelheim	Germany
Fujifilm Diosynth Biotechnologies (FDB)	Japan
US$0.5 – 0.75B	
Ajinomoto	Japan
Almac Group	United Kingdom
Baxter Biopharma Solutions	United States

According to Fitch Solutions (2023, p. 3), a strong corporate governance structure is essential if KSA is to overcome the historical impediments to the production and manufacturing facilities for local vaccines. Accordingly, implementing an effective corporate governance structure might facilitate the dissemination of information to the public, government, and other relevant authorities in KSA on the availability of local vaccines and the significance of having local vaccine manufacturing. Effective governance enables disciplined capital allocation, transparent decision-making, and accountability across the public-private interface. These attributes are required for sustained, multi-decade investment in capability building.

Per the World Bank (2022), Saudi health expenditure peaked at 6.26% of GDP in 2017 before declining to 5.69% by 2019. Approximately 25--35% of the national health budget addresses non-communicable diseases such as cardiovascular disease, diabetes, and

obesity. While vaccination programs have significantly reduced the incidence of vaccine-preventable diseases (VPDs) like poliomyelitis, measles, and pertussis in developed nations, vaccine hesitancy remains prevalent among a substantial segment of the Saudi population.

In 2022, approximately 20% of Saudi parents expressed vaccine hesitancy and 17% of the general population indicated reluctance toward influenza vaccination. These figures suggest a persistent gap in public awareness of the benefits of vaccination programs and their role in preventing vaccine-preventable diseases (VPDs). This widespread hesitancy, rooted in limited social awareness, has emerged as a significant barrier to advancing national vaccine manufacturing initiatives.

The combination of low healthcare budgets and insufficient pharmaceutical R&D infrastructure has materially constrained vaccine-manufacturing capability, resulting in dependence on foreign producers such as Pfizer–BioNTech and Moderna during the COVID-19 pandemic.

Per the WHO (2022), the manufacture of quality vaccines requires international standardization across quality -control testing, materials, and production process. Therefore, vaccine manufacturing requires setting the overall manufacturing procedure from start to finish, keeping in mind that the field of vaccine technology is ever evolving. Hence, R&D infrastructure elements such as manufacturing procedures, testing tactics, standards, and reagents Vaccine manufacturing must be specified end-to-end, with consistency maintained from raw material to finished product. This is one of the most demanding regulatory disciplines in industry, and competence in it is the gateway to global market access.

These requirements include implementing “hoc pharmaceutical quality systems” for quality assurance and processes, implementing various quality controls at each stage, and establishing a sufficient infrastructure that separates all activities to ensure vaccine purity, identity, safety, sterility, and efficacy (WHO, 2023).

Accelerating vaccine manufacturing requires all producing companies to uphold rigorous quality-control standards and operational best practices. Enhancing production capacity also requires the integration of up-to-date technological advancements, an urgent challenge for developing nations such as the Kingdom of Saudi Arabia (KSA). Addressing these gaps is critical to ensuring scalable, efficient, and high-quality vaccine output that meets both national and global health demands.

Furthermore, biotechnology can help with the manufacture of vaccines, starting with the design and exploration processes. This calls for an effective R&D development for

the enhancement of every step of the vaccine production process, which involves the presence of immunogenic and antigenic components to ensure the vaccine's overall efficacy when it enters the recipient's body.

In R&D for vaccine manufacturing, the EU has a robust industrial infrastructure and a long history of conducting R&D and producing vaccines. More than 80% of vaccine doses from the top research manufacturers are produced in Europe and exported internationally (Vaccines Europe, 2017). Leading authorities on vaccines have formed the Innovation Partnership for a Roadmap on Vaccines in Europe (IPROVE), whose mission is to chart the best ways for Europe to invest in the science and technology required for vaccine innovation.

The EU's research funding program, the 7th Framework Program (FP7), began in December 2013. It brought together more than 130 public and private stakeholders from academia, public health institutes, regulators, industry, and small and medium-sized enterprises to determine and prioritize the gaps and challenges to be addressed to bolster innovation in vaccines and vaccination in Europe.

The seven issues that shaped the IPROVE consultation were: vaccine R&D; manufacturing and quality control; infrastructure; therapeutic vaccines; the needs of small and medium-sized businesses; vaccine acceptance ; and training requirements. The framework remains a useful diagnostic for Translational Medicine. Currently, Europe is well-positioned to spearhead the development of the upcoming vaccine generation due to the many centers of expertise in vaccination and related fields that are already established. Furthermore, there are additional non-governmental organizations (NGOs) operating globally that support the development of vaccine -manufacturing program, including KSA's, and provides a structure for assessing where investment and policy attention are most needed.

Table 6.5 List of NGOs Supporting R&D Vaccine Development

Note. Adapted from Kumraj et al., 2022, pp. 11-12.

Name	Task Description
Bill & Melinda Gates Foundation (BMGF)	The Bill & Melinda Gates Foundation's Vaccine Development and Surveillance team invests in expertise and platform technologies that make vaccines faster, better, and more affordable. Its goal is to accelerate the development and commercialization of vaccine technologies. The Foundation's model demonstrates how patient capital, deployed strategically, can shift the economics of vaccine development for diseases that markets alone would not address.
Gavi, the Vaccine Alliance (GAVI)	GAVI, a public-private partnership, helps in vaccinating half of the world's children against some of the world's deadliest diseases. It also drives improving global health security by supporting health systems, as well as funding global stockpiles for Ebola, cholera, meningitis, and yellow fever vaccines.
Clinton Health Access Initiative, Inc. (CHAI)	The CHAI is a global health organization that works toward saving lives and reducing the disease burden in LMICs. It partners with other organizations to strengthen the capabilities of governments and the private sector to create self-sustained high-quality health systems.
International Vaccine Access Center (IVAC)	Based at the Johns Hopkins Bloomberg School of Public Health, IVAC has served as a trusted partner for governments, international agencies, research groups, and non-profit organizations seeking to advance access to life-saving immunizations for all people. It accelerates equitable access to vaccines through the generation, synthesis, and use of evidence to inform decision-making and action.
Coalition for Epidemic Preparedness Innovations (CEPI)	CEPI, a Norwegian Association, is an innovative global partnership between public, private, philanthropic, and civil society organizations CEPI accelerates the development of vaccines to prevent emerging infectious diseases and enables equitable access to these vaccines for people during outbreaks.
International Vaccine Institute (IVI)	The International Vaccine Institute (IVI) is a nonprofit international organization established in 1997 under a United Nations Development Program initiative. Headquartered in Seoul and hosted by the Republic of Korea, IVI has 36 member countries and the WHO as treaty partner. It is one of the few organizations dedicated specifically to vaccines for developing countries, and its model has direct relevance for any nation building a domestic vaccine R&D function.
Netherlands Vaccine Institute (NVI)	NVI facilitates in the development and transfer of vaccine technology to vaccine manufacturers in both developing as well as developed countries.
The COVID-19 Vaccines Global Access Facility (COVAX)	COVAX is co-led by CEPI, GAVI, and WHO, alongside key delivery partner UNICEF. COVAX aims to accelerate the development and manufacturing of COVID-19 vaccines as well as ensure fair and equitable access of these vaccines to every country across the globe.

(b) Cost of Investment and Revenue for Vaccine Manufacturing

Vaccine manufacturing is an elaborate process, typically requiring 10 to 15 years from initial discovery through Phase III efficacy trials. Industry conventions place the financial requirement at \$0.5 to \$1 billion per successful vaccine, with high attrition between phases. These timelines and costs are why platform-based approaches that compress the cycle are now central to national vaccine candidates successfully reach the market. This high-risk, high-cost market has led to a decline in investor participation, thereby exacerbating the productivity gap within global vaccine development efforts. strategies, KSA's included.

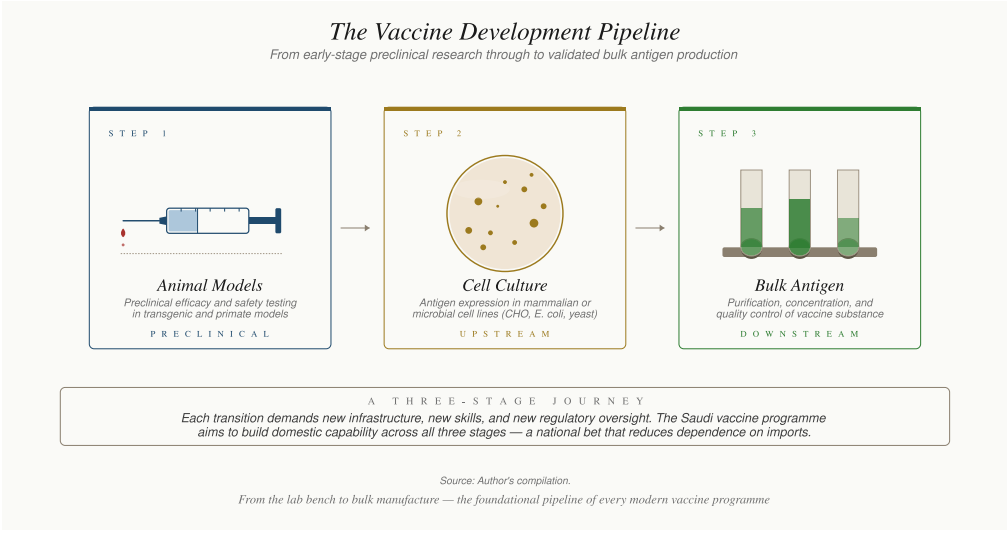

Figure 6.6

Traditional Process of Vaccine Development

Note. Adapted from Sharma et al., 2020, p. 4.

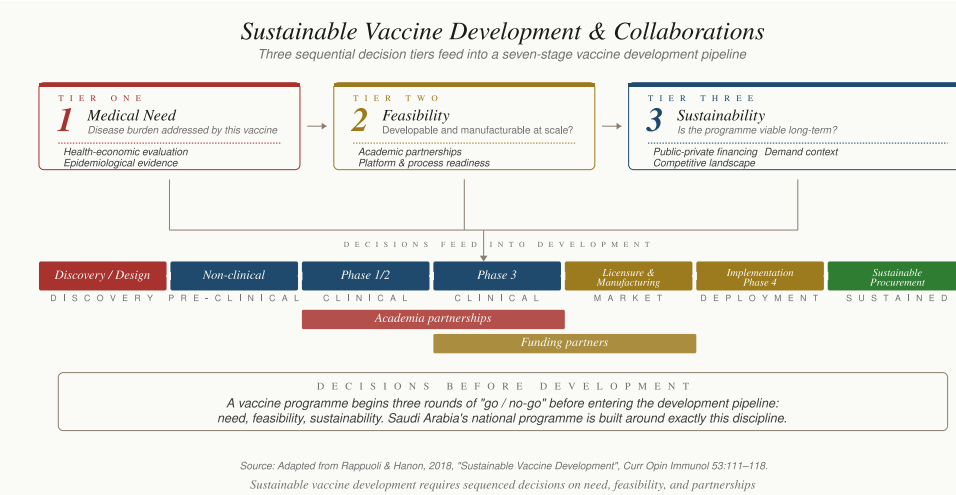

Figure 6.7

Sustainable Vaccine Development and Collaborations

Note. Adapted from Rappuoli & Hanon, 2018, p. 112.

The fundamental objective of an entrepreneurial business is to make profit to sustain the business and facilitate business operations in general. Therefore, profit remains a fundamental principle and concurrently the objective of contemporary business despite the emergence of social entrepreneurship, which aims at social value creation and quality of life improvement. Profit is therefore indispensable to the attainment of other objectives.

Vaccine manufacturing demands substantial financial investment and is characterized by a high attrition rate. Development programs that advance from initial discovery through to licensure typically require prolonged timelines and considerable capital, with an estimated failure rate of approximately 94% on average. This reflects the inherent risk and complexity of vaccine innovation, particularly in resource-constrained settings.

In as much as addressing domestic, regional, or worldwide infectious disease crises is an essential aim of the vaccine manufacturing industry in terms of public health, the inherent risks in the development of vaccines in most cases often exceed the potential return on investment that is made in the production of vaccines.

Therefore, there is a possibility that entrepreneurs and shareholders will not consistently approve the necessary investments or undertake the necessary actions necessary to commence vaccine manufacturing.

From a business perspective, entrepreneurs are more likely to take strategic action when they possess a clear understanding of market demands, technical opportunities,

and operational challenges. In this context, perceived market insights serve as a critical decision-making lens, compelling entrepreneurs to evaluate their readiness and willingness to engage with complex scenarios, such as those presented by vaccine manufacturing initiatives.

There is a notable correlation between entrepreneurs' perceived ability to tackle challenges and the technical feasibility of products and services. When entrepreneurs recognize that they possess substantial knowledge about addressing a specific market gap, this awareness often catalyzes further action and reinforces their confidence in pursuing innovative solutions. Conversely, as market gaps widen, businesses may encounter greater operational difficulties and heightened ambiguity, which can undermine strategic clarity and increase uncertainty in decision-making.

Therefore, cost of investment versus revenue generation is a paradox that constantly prompts attention and consideration for entrepreneurs. An organization's net profit is directly influenced by its expense management practices. When operational costs are effectively controlled, profitability tends to increase. Conversely, careless, or excessive spending can erode profit margins. Therefore, fluctuations in operational expenses have a significant impact on net profit, rising costs typically lead to reduced profitability, while cost reductions can enhance financial performance.

Operational expenses refer to the commercial costs incurred in support of routine business activities aimed at achieving predefined organizational goals. These expenses encompass a wide range of expenditures directly related to sustaining and optimizing business operations in pursuit of strategic objectives. Importantly, operational costs exert a direct influence on net income, higher operational expenses typically reduce profitability, while efficient cost management can enhance financial performance.

Pharmaceutical enterprises is central to advancing healthcare sector reform, serving not only as indicators of corporate and economic development but also as strategic contributors to national health outcomes. Operating within a highly complex and regulated industry, successful investment in pharmaceutical ventures necessitates a coordinated effort among diverse stakeholders, including government bodies, private investors, research institutions, and regulatory agencies, to ensure sustainable establishment and growth.

There are approximately forty licensed pharmaceutical manufacturers in KSA holding Good Manufacturing Practice (GMP) certification. Notable among them are Tabuk Pharmaceuticals Company, Jazeera Pharmaceutical Industries (JPI), and the Saudi Pharmaceutical Industries and Medical Appliances Corporation (SPIMACO). Historically, many of these enterprises began by repacking finished dosage forms,

importing pharmaceutical products, and participating primarily in distribution activities. Their roles have evolved over time in alignment with national health and industrial development goals (see Figure 6.8).

At this level of pharmaceutical business engagements, these organizations have experienced an increase in their return on investment (ROI) based on the recorded growth rate of 14 billion Saudi Riyal (SAR) in 2012 to 28 billion SAR in 2016 and 40 billion SAR in 2023, indicating a favorable pharmaceutical business in KSA.

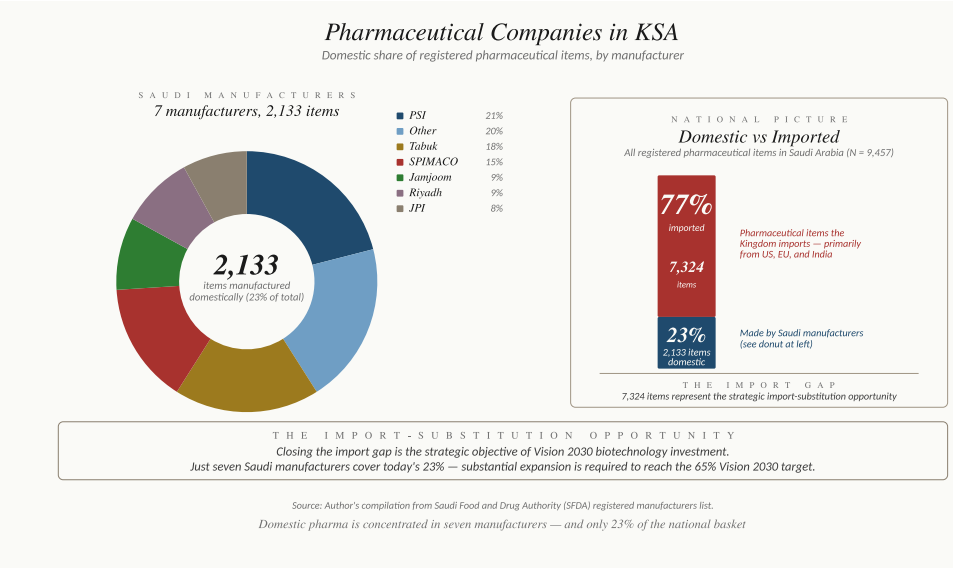

Figure 6.8

Pharmaceutical Companies in KSA

Note. Adapted from Alshehri et al., 2023, p. 608.

In view of the Saudi Vision 2030, local research institutes, such as King Abdulaziz City for Science and Technology (KACST), King Abdullah University of Science and Technology (KAUST), and King Abdullah International Medical Research Center (KAIMRC), have started to concentrate on pharmaceutical research, development, and innovation (RDI). These research facilities have been tasked with carrying out R&D projects related to vaccine manufacturing to increase interest in the vaccine manufacturing business (Oxford Business Group, 2018).

While research institutes in KSA possess the capacity to undertake a range of R&D initiatives related to drug development, a persistent challenge lies in translating these scientific outcomes into commercially viable products. Bridging this gap often necessitates

strategic support from regional pharmaceutical industries, which can provide the infrastructure, regulatory alignment, and market access required to scale innovations from the laboratory to the marketplace.

(c) Infrastructure for vaccine manufacturing

The development and growth of the manufacturing sector of every economy depends on its infrastructure. In general, the importance of infrastructure as a major driver of growth and development of the economy has been emphasized by classical and neoclassical schools of thought such as Adam Smith (1723-1790); David Ricardo (1772–1823); Thomas Robert Malthus (1766-1834); John Stuart Mill (1806-1873); and Karl Marx (1818-1883), to name a few.

Critical Infrastructure Networks (CINs) refer to the interconnected assets, systems, and networks that are essential to a nation's security, economic stability, public health, and safety. These infrastructures underpin the continuous functioning of key societal operations and are vital for the reliable maintenance of business activities across sectors. See Figure (6.9).

Therefore, efficient development of the manufacturing industry in every economy depends on its infrastructure, and infrastructure is a major driver of economic growth.

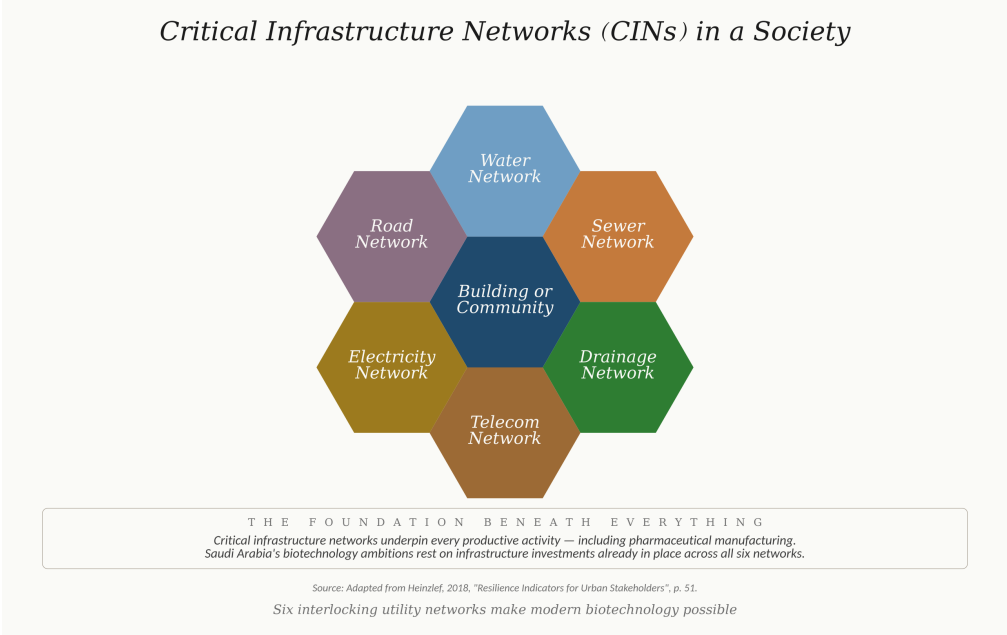

Figure 6.9

Critical Infrastructure Networks (CINs) in a Society

Note. Adapted from Heinzlef, 2018, p.51.

Infrastructure Monitor (2022, p. 22) highlights that public and private infrastructure investment strengthens economic resilience and promotes sustainable development performance. Public infrastructure investment, which consists of highways, airports, mass transit, etc., is modeled as important sources that generate external economies and facilitate private sector productivity and growth.

Core infrastructure also includes resources provided by the public sector, such as roads, railroads, ports, electrical, and communication infrastructure (Diewert 1986, p. 12). Public infrastructure is typically classified as a non-marketable asset, given that its services are often provided free of charge or at subsidized rates. This highlights the strategic importance of infrastructure as a foundational element in industrial development, enabling economic activity, facilitating service delivery, and supporting long-term national growth.

Empirical studies have reflected the critical role of infrastructure in manufacturing -sector performance. One study examined production elasticity relative to public capital stock and found a positive correlation between infrastructure investment and output. Complementary evidence shows that investment in roads, power, water, and digital infrastructure investment significantly contributes to productivity growth. In the context of Spain's private sector, research revealed that a 1% increase in public capital led to a 0.055% rise in private production. However, a broader investigation using the trans log production function across more than 1,500 counties in 50 U.S. states indicated that while infrastructure investment positively influences output, its impact on productivity remains limited. These findings suggest that infrastructure is a necessary but not sufficient condition for sustained productivity gains in downstream industries. For biotechnology manufacturing specifically, infrastructure requirements are particularly intense: reliable utilities, specialized logistics (cold chain), digital connectivity, and skilled-labour availability are prerequisites. KSA's Vision 2030 infrastructure program directly addresses these requirements, and purpose-built industrial cities such as Sudair and SPARK provide the spatial and utility foundations on which biotech facilities can be deployed at competitive cost.

In recent years, KSA has undertaken a series of major infrastructure projects aligned with the Vision 2030 agenda for economic diversification and growth (see Table 6.6). This accelerated pace of infrastructure development is fostering increased investment, job creation, and broader economic expansion. For companies to capitalise on these opportunities, particularly in the vaccine-manufacturing sector, a clear understanding of the operational and financial implications is essential. Assessing these implications is critical to strategic alignment, resource optimisation, and long-term viability within the

evolving industrial landscape.

Table 6.6 Notable Infrastructure Projects in KSA

Note. Compiled by the Author.

Projects	Description
King Salman International Airport	A new hub for international travel based in Riyadh.
The Riyadh Metro	One of the largest urban transport projects in the world.
The Red Sea Project	A massive tourism, leisure and residential development planned for the western coast of Saudi Arabia.
The Makkah Public Transport Program	A comprehensive system designed to reduce congestion in the holy city of Makkah.
The Riyadh-Dammam Expressway	A major highway project that is expected to reduce travel times between the two cities.
Al Widyan	A new city located in the north of Riyadh is being built with an eye towards encouraging economic growth.
Al Widyan	
Jabal Omar Development Project in Makkah	A massive urban project, which aims to develop the area into one of the most luxurious residential, business and leisure districts in the Middle East.

In a report by Global Infrastructure Hub (2023, pp. 3-6), it indicated that KSA has been putting up major economic changes as part of its Vision 2030 strategy. See Table (6.7).

Reforms have made it easier to establish a business, obtain building permits, access financing, resolve insolvency, and streamline procurement and licensing. These changes are boosting competition, stimulating new market entrants, and accelerating private-sector growth. For biotech specifically, the reform program reduces friction at exactly the points (capital deployment, facility build, regulatory approval) where speed determines whether a national capability gets built within the openness of procurement procedures. Even though the COVID-19 outbreak may have a long-term impact on the amount of government debt, KSA is still in a strong position to finance future infrastructure projects and carry out its reforms, which are aimed at facilitating business establishments such as vaccine manufacturing organizations (KSA Vision 2030 window.

Table 6.7 Ease of Doing Business in KSA

Note. Adapted from Global Infrastructure Hub, 2023, pp. 3-6.

Components	Rate
GDP	779.3 USD billion
GDP growth rate	0.2%
GDP per capita growth rate	-2.9%
Gini coefficient	42.2 (0-100 worst)
Gross Government Debt	23.0% of GDP
Inflation rate	-1.1%
Summary credit rating	76.0 (0-100 best)
Unemployment rate	5.9%
Urbanization ratio	84.0% of total population
Road connectivity	100.0 (0-100 best)
Quality of road infrastructure	5.2 (1-7 best)
Efficiency of train services	4.5 (1-7 best)
Efficiency of air transport services	5.4 (1-7 best)
Efficiency of seaport services	4.8 (1-7 best)
Electricity access	99.4% of population
Electricity supply quality	8.1% of output lost
Exposure to unsafe drinking water	9.5% of population
Reliability of water supply	5.8 (1-7 best)
Digital Adoption Index	0.7 (0-1 best)
Mobile-broadband subscriptions	111.1 per 100 population
Fixed-broadband Internet subscriptions	5.6 per 100 population

(d) Technical Knowledge for Vaccine Manufacturing

The vaccine industry is about know-how, both explicit and tacit. Explicit knowledge can be codified or written down, stored in documents or databases, and is relatively straightforward to transfer from one person to another via training. However, transferring tacit knowledge, intuitive knowledge, and know-how rooted in context, experience, practice, and values is much more difficult.

Vaccine manufacturing extends beyond explicit knowledge, such as standardized protocols and documented procedures, and relies heavily on tacit, experience-based expertise. Tacit knowledge is acquired through repeated practice and contextual learning, often under the guidance of seasoned professionals. For instance, much like an individual's inability to replicate a gourmet dish from a top-tier restaurant despite having the recipe, the nuanced skills required in vaccine production cannot be fully transferred

through documentation alone. Instead, they emerge through hands-on engagement, iterative refinement, and mentorship within a controlled manufacturing environment.

Specific scientific and biotechnical engineering expertise is required to be able to understand the production process and interpret any deviations encountered along the way, and to pass on this understanding to other personnel.

The initiation of vaccine manufacturing begins with the establishment of bulk antigen production, which serves as the foundational step in the bioprocessing chain. This process culminates in the distribution of the final, use-ready vaccine product. In this context, technology transfer partnerships play a pivotal role by designating local partners to undertake specific stages of the manufacturing workflow. Such collaborations facilitate capacity building, enhance local technical expertise, and support the broader goal of vaccine localization within KSA.

Backward integration is a widely adopted strategy in industrial development, particularly within technology-transfer and localization frameworks. A local partner typically begins by distributing finished products and gradually acquires the technical capability to undertake earlier stages of production. Over time, the partner moves upstream, from packaging and final formulation to bulk manufacture and ultimately R&D. The strategy is well-suited to the Kingdom's current trajectory and underpins the SAUDIBIO and VIC programs.

The earlier a facility initiates vaccine production, the greater the technological barriers it faces in achieving successful outcomes. These initial stages, such as bulk antigen synthesis, cell culture, and upstream bioprocessing, are inherently more complex and technically demanding than downstream activities like formulation and packaging. As a result, early-phase manufacturing requires advanced infrastructure, specialized expertise, and rigorous quality control systems to ensure product integrity and regulatory compliance. See (Figure 6.10).

Given the intricacies of vaccine manufacturing, technology transfer is essential and demands a high level of technical expertise and contextual knowledge. In countries with a sizeable pharmaceutical sector but regulatory standards below international benchmarks, recruitment from the local pharmaceutical talent pool can present limitations. Even when individuals with pharmaceutical experience are available, they require targeted training to move beyond conventional paradigms and adopt the vaccine-specific mindset of "treating the process as the product." This conceptual shift is critical, as vaccine production depends on process fidelity, reproducibility, and rigorous quality control embedded throughout the manufacturing lifecycle.

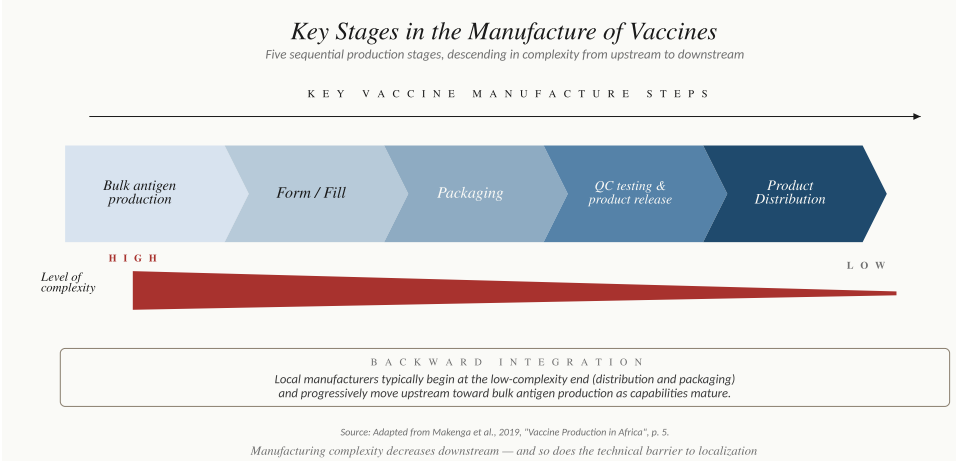

Figure 6.10

Key Stages in the Manufacture of Vaccines

Note. Adapted from Makenga et al., 2019, p. 5.

A high level of technical expertise is indispensable in vaccine manufacturing due to the inherent complexities of the process. For example: Antiviral vaccines fall into two main groups:

(1) Gene-based vaccinations transfer host cell-produced protein antigens encoded in gene sequences. Live virus vaccines, recombinant vaccine vectors, and nucleic acid vaccines are a few examples of these.

(2) In vitro-produced whole-inactivated viruses, single viral proteins or subdomains, or viral proteins packaged into particles are examples of protein-based vaccinations. Because they can be more readily adapted to platform manufacturing technologies, where upstream supply chains and downstream procedures are the same for each product, recombinant vaccine vectors and nucleic acid vaccines are most suited for speed. Understanding the vaccine antigen's atomic structure and the vaccine's preservation of the targeted epitopes are necessary for precision.

Therefore, the ability to hire, train, and maintain quality personnel to maintain the process and quality systems is a challenge even for highly experienced manufacturers. Technical competence is essential, as is knowledge of the latest technologies and global regulatory requirements. Globally, there is a scarcity of personnel with the requisite skills and expertise needed by the vaccine industry.

Vaccine production requires deep scientific knowledge and persistent curiosity to

understand and detect the subtle signals a biological process may send that are not detectable in release data. Experienced workers use caution when considering changes in processes or facilities or when responding to process or equipment failure. Sustaining vaccine manufacturing requires developing a strong base of scientific, technical, product-specific manufacturing, and quality control system knowledge.

Countries such as Switzerland, India, Brazil, and China, with large populations and sound technical and scientific education systems, have succeeded in creating a new and growing cohort of technicians and skilled workers suited for the highly detailed work of vaccine manufacturing. New market entrants in other geographies may underestimate the difficulty of developing this type of knowledge based in tandem with a comprehensive training system.

In KSA, human -capital intensity remains low relative to developed economies, producing a scarcity of technicians and scientists in manufacturing. Researchers have argued that flexibility in production processes, and the capacity to absorb new technologies are directly related to the stock of indigenous human capital (Kumraj et al., 2022; Badreldin & Atallah, 2021). Labor costs vary significantly depending on a deep technical workforce. Closing this gap is the explicit purpose of the Biotechnology Training Institute (BTI) and the partnership with NIBRT, both of which feed directly into the operational pipeline of SAUDIBIO and VIC.

Most expatriate staff will require higher total compensation and benefits than local employees, increasing the overall cost of labor and decreasing local employment opportunities. However, specialists are needed in setting up a new vaccine manufacturing facility; hence, hiring foreign experts to work in key facility positions is often necessary as local skilled workers will require significant training, which may include being sent abroad for months at a time, compounding the challenges towards successful vaccine manufacturing.

Appropriate efforts to recruit, train, and retain a skilled local workforce, combined with recognition, promotion pathways, and innovation opportunities, are essential to counter brain drain and support the long-term sustainability of developing-country vaccine manufacturers.

(e) Government Support for Vaccine Manufacturing

The COVID-19 pandemic caused several nations, including KSA, to face vaccine scarcity in protecting their citizens. Mitigating future challenges of this nature requires industry experts and government to act in coordination to improve vaccine manufacturing and distribution, removing bottlenecks in both supply and access to vaccine portfolios.

Furthermore, this involves the participation of the government agencies tasked with regulation and evaluation of the quality, safety, and effectiveness of all vaccines before usage; hence, the support of the government is crucial in the production and manufacturing processes.

A 2015 WHO survey indicated that vaccine availability had grown, access had improved, and costs had declined as a result of technology transfer to lower-income nations. The report also noted that it is not always economic to establish local vaccine production operation. Instead of seeing vaccine production only as a business, what is important is to consider vaccine manufacturing as public health security. The formulation of a national vaccination policy might help determine when to consider local manufacturing. Hence, a sizable local or regional, particularly for small markets, because of the scale and capital intensity of vaccine manufacturing. For KSA, market size, government commitment, and regional export potential shift that calculus decisively: scale is sufficient, capital is available, and regional demand supports sustained utilisation of domestic facilities. The economics work because the Kingdom is building for more than its own population.

Empirical evidence demonstrates that sustained political backing is essential for a nation to produce vaccines domestically, which should be supported by a strong regulatory infrastructure, policy coherence, incentives, government facility investment alongside commercial capital, other support projects, such as the provision of affordable land, human resource capacity building for making available skill development, and a supportive business atmosphere. These are ways the government can support an effective vaccine manufacturing business.

Long-term viability of vaccine manufacturing depends on government assistance; proper rules to access capital given to vaccine manufacturers are considered major factors that facilitate the growth of any national vaccine manufacturing business.

Although private access to capital has increased because of overall economic development, vaccine manufacturers have identified the need for capital investment to ensure successful cGMP compliance and adoption of new production technology as a particular challenge that governments should take into consideration and support.

KSA is the only G20 nation (prior to VIC) without a national infrastructure for the manufacture of vaccines. Therefore, the government had to take the lead in encouraging local pharmaceutical firms to manufacture vaccines by providing funding through the Saudi Industrial Development Fund (SIDF).

In this context, the SFDA must play a significant role in aligning public and private pharmaceutical actors, since the principal cause of under-performance in vaccine

manufacturing is limited bioprocessing expertise.

(f) Partnership Opportunity for Vaccine Manufacturing

It is a common understanding that vaccines are not the best products for revenue generation because vaccines are intricate biological products with challenges in their design, testing, long duration of production, and huge cost, which in most cases are not attractive to investors. In this case, forming alliances and partnerships is a vital strategy by which the private and public organizations can circumvent these challenges and achieve effective vaccine manufacturing business.

According to the World Economic Situation and Prospect, United Nations (WESP-UN) Report (2019), one notable alliance is the Developing Countries Vaccine Manufacturers Network (DCVMN), which is an association of corporate vaccine manufacturers in developing nations around the world working with international agencies such as WHO, UNICEF, PAHO, and GAVI to expedite access to necessary vaccine manufacturing.

As further emphasized by WESP-UN (2019), the mission of association is to safeguard all people from infectious illnesses, both known and unknown, through increasing access to high-quality vaccines on a worldwide scale and acknowledging the necessity of international collaboration in science, technology, and the economy.

In a study conducted by the Global Burden of Disease Collaborative Network (GBD) (2017), findings describe the proactive measures taken by DCVMN members to lessen the worldwide burden of infectious disease and their dedication to vaccine manufacturing as well as the alliance ability to generate employment. See Figure (6.11). Furthermore, findings highlighted the contributions made by the corporate members specifically focused on vaccine research and development, considering new innovations in vaccines and their impact on the battle against infectious diseases.

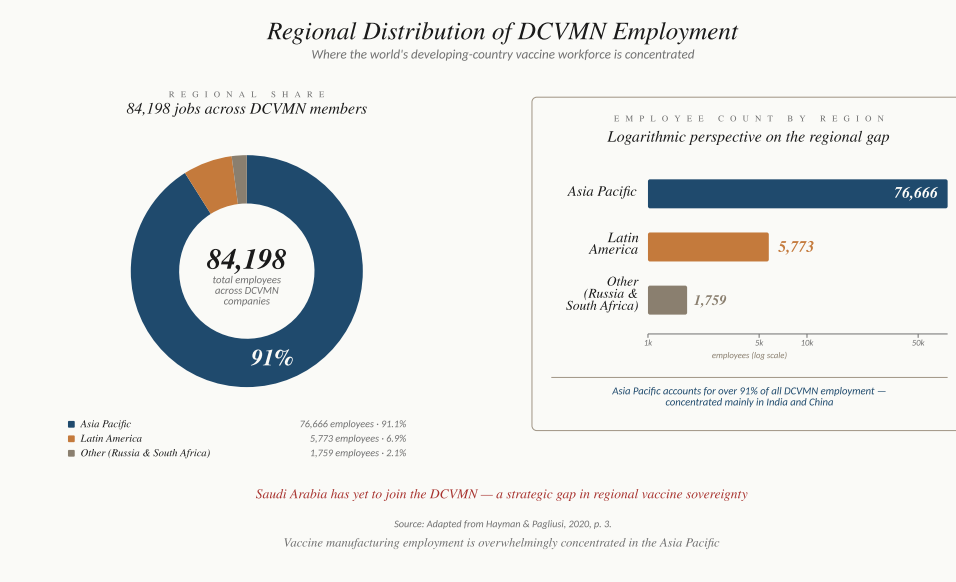

Figure 6.11

Regional Distribution of Employment Provided by DCVMN

Note. Adapted from Hayman and Pagliusi, 2020, p. 3.

There has been a considerable increase in the quantity of vaccines from DCVMN members attaining WHO pre-qualification and certification during the last five years, indicating a reliable system for the world's supply of vaccines as well as showing how manufacturers and developing nations have advanced to fulfill strict regulations, quality control, and production standards.

Studies have shown that members of DCVMN can now offer more than 3.5 billion vaccine doses yearly due to partnership and cooperation. Strategic partnerships have further demonstrated enhanced capabilities in producing targeted antigens, including those required for multivalent vaccines.

DCVMN members have also been able to supply up to 170 nations with vaccines against 50 different diseases spread across nearly 200 products. Considering that DCVMN members have started vaccine manufacturing capacity of over 3.5 billion doses yearly, this indicates the reliability of the association's role in facilitating vaccine manufacturing to maintain the domestic need of its member organization as well as for the global demand of vaccine products.

In KSA, local pharmaceutical businesses have not been benefiting from partnering with international organizations to develop their local competence through knowledge

and expertise exchange to mitigate challenges that arise frequently while creating infrastructure for vaccine manufacturing and financing biotechnology research.

Global access to safe, efficacious, and reasonably priced vaccines is a prerequisite for sustainable vaccine manufacture. Companies therefore need strong business plans and incentives to produce vaccines. Owing to the difficulties and expenses involved in developing, producing, and distributing vaccines, it is difficult for businesses to stay in business, and as a result, facilities close and organizations leave the field of vaccine manufacturing for other lucrative business ventures.

Researchers have emphasized the benefits of partnership: increased manufacturing capability, the creation of innovative higher-quality vaccines, broader vaccine accessibility, simpler licensing procedures, access to capital, reduced labour-intensity, and shared risk. The benefits accrue to both partners when the structure is well-designed, with clear technology-transfer milestones and efficiency. Similarly, public-private partnerships (PPPs), known as \"product development partnerships\" (PDPs), work to create innovations and goods for underserved markets, which is crucial for developing vaccines that lack strong commercial challenges. However, it has been noted that PPPs have some disadvantages that are worthy of consideration, such as stifling of innovation, private sector rent-seeking, high transaction and establishment costs, higher capital costs, challenges with relationship management, poor risk distribution, lower value-for-money (VfM), and restricted competitive behaviors.

These concerns justify requests from different sectors for ways to close the gaps and address the fundamental issues of PPP design: how to forge effective alliances between public and private actors; how to develop and assess suitable incentive systems; how to foster learning across projects; and how to build governance frameworks that combine the best of relational and contractual approaches.

(g) Government Regulations and Policy

Regulatory law and policies are the fundamental tenet that guides the vaccine manufacturing business to ensure that every vaccine manufactured is safe, effective, and consistent throughout a vaccine's life cycle.

Government agencies are the final authority on whether a new vaccine manufacturing organization will obtain approval to manufacture a product as well as the decision to be a partner in steering and guiding the manufacturer to comprehend the regulatory obstacles necessary to achieve necessary permits to start a manufacturing activity. Specifically, products for export must attain WHO prequalification (PQ) status, and one of the criteria for this process is for the local regulatory body to be highly functional to

meet WHO qualification requirements.

Generally, regulations for vaccine manufacturing are specific; hence, manufacturers must adhere to all national regulatory authority (NRA) standards, as well as those of the nations in which they plan to distribute or sell their vaccine and adapt to any changes in laws. These specifications include the yearly reporting of production information (such as data trends, change management, stability reviews, and critical investigations of any process failures or unexpected patterns) and the regular monitoring of adverse event data.

Per WHO Pre-Qualification (2020), a manufacturing facility must undergo routine and unannounced regulatory inspections to verify compliance with current Good Manufacturing Practice (cGMP), maintenance of facilities and equipment, process and quality systems, and documentation integrity. The inspection regime is intentionally rigorous: facilities that meet WHO PQ standards are accepted for procurement by major international agencies, which is the gateway to multi-country export markets.

Procurement groups such as the Pan American Health Organization (PAHO) may accept approvals from certain NRAs, such as the FDA and EMA, or the WHO PQ. Pre-Qualification (PQ) is a highly structured and systematic process aimed at ensuring the quality of vaccines. It involves ensuring that the policies and practices of the manufacturing company produce a product that not only satisfies international quality standards but also complies with the programmatic requirements of the national immunization program and WHO use recommendations (WHO Pre-Qualification (2020).

A company exporting internationally must maintain numerous licenses, one for each market in which the product is authorised, and is subject to almost constant inspection by various national regulatory authorities (NRAs). Producers must also have procedures for handling problems that develop during regular production, as well as any new safety or field-use concerns that emerge after the product is in widespread use. Manufacturers seeking to market their products through channels such as the UNICEF Supply Division, which procures hundreds of millions of doses on behalf of its constituents, must meet WHO Pre-Qualification (PQ) requirements in addition to the standard licensing process.

As a requirement, the approval of new vaccines must go through a precise regulatory process. There are four main components to the approval procedure. See Table (6.8).

Table 6.8 Vaccine Approval Process

Note. Adapted from Gomez et al., 2013, p. 3.

Item No	Principal elements
1	Preparation of preclinical materials for proof-of-concept testing in animal models, manufacture of clinical materials according to current GMP (cGMP), and toxicology analysis in an appropriate animal system.
2	Submission of an investigational new drug application (IND) for submission to FDA for review.
3	Testing for safety and effectiveness through clinical and further nonclinical studies (phase 1 to 3 clinical studies).
4	
5	Submission of all clinical, nonclinical, and manufacturing data to the FDA and EMA in the form of a Biologics License Application (BLA) for final review and licensure.

The development and functioning of local regulatory authorities, while outside the influence of any manufacturer, materially shape any manufacturing project and should be a vital consideration when planning vaccine manufacturing. Local regulators are responsible for granting initial licenses to manufacturers; delays or problems at that stage can lead to termination of the entire project. A well-functioning regulatory authority with strong scientific knowledge in vaccine technology can provide support and guidance on both facility operation and the registration of products for global markets.

One critical barrier to sustainably manufacturing vaccines relates to rigorous regulatory procedures for vaccine manufacturing. Although low prices of vaccine, production uncertainty, and limited capabilities to expand to new markets are also identified, nonetheless, a rigorous and ever-changing list of laws and regulations is frequently being cited by manufacturers as a factor that impedes vaccine manufacturing.

In KSA, laws and regulations governing medicine and vaccine manufacturing are administered by the Saudi Food and Drug Authority (SFDA). The SFDA is responsible for regulating, registering, and approving pharmaceuticals in Saudi Arabia, monitoring efficacy, safety, and quality across the lifecycle. The SFDA's authority and capability have grown substantially over the past decade, and its alignment with international regulatory benchmarks is essential to the Kingdom's biotechnology ambitions.

Table 6.9 SFDA Regulatory Process

Note. Adapted from SFDA, 2020, p. 12.

Process	Description
Validation process:	In this process, the SFDA will validate and evaluate the drug file in terms of the completeness and accuracy of all information according to the SFDA generic medicine market authorization requirements and procedure. At this stage, the manufacturer must provide samples of the product for testing in a further step.
Assessment process:	In this process the product file will be assessed by two groups: quality and efficacy groups in the SFDA. The product file can proceed to the next step only after being recommended for approval and successfully passing the quality and efficacy assessment; otherwise, it will be rejected
Pricing process:	The pricing unit according to the SFDA pricing rules will determine the price of the product
Testing process:	The drug samples received from the drug company will be sent to the laboratory for testing.
Inspection process:	In this process, the SFDA will check the product manufacturing line to ensure compliance with current good manufacturing practice (GMP). It must hold a valid certificate from the Saudi MOH or SFDA; otherwise, an inspection team will be sent to check the line before granting the approval.
Product licensing:	This is the final stage in which the product will be granted marketing authorization (MA) based on reviewing all the reports (quality and efficacy assessment reports, pricing report, testing report, GMP inspection report and company registration) by the SFDA registration committee.
Appeal process:	The company has the right to appeal within 30 days of the final decision by the SFDA.

The SFDA enforces stringent regulations and a rigorous product-registration process, intended to guarantee the efficacy, safety, and quality of medications. It has been noted that Saudi Arabia's laws and regulatory system are among the strictest in the Middle East, which in many cases has been a hindrance to manufacturers. Table 6.10 sets out the SFDA regulatory process and drug-review timelines that must be followed for the manufacture and marketing of medicines and vaccines.

Table 6.10 SFDA Drug Review Timelines

Note. Adapted from SFDA, 2020, p. 13.

Drug Type	SFDA Timelines (working Days)
Human Generic	155
Human New Drugs registered in SRA	280
Human New Drugs not registered in SRA	405
Human Biologics registered in SRA	280
Human Biologics not registered in SRA	405
Radiopharmaceuticals	280
Veterinary Generics	165
Veterinary New Drugs registered in SRA	260
Veterinary New Drugs not registered in SRA	385
Veterinary Biologics registered in SRA	260
Veterinary Biologics not registered in SRA	385
Herbal & health products	155

Research indicates that the KSA encounters several obstacles in obtaining dependable and economical vaccines since there are insufficient production facilities in the domestic market. As a result, the country depends mostly on foreign markets to get efficacious vaccines.

The SFDA, which oversees the nation's pharmaceutical operations, is prioritizing vaccine manufacturing through systematic review of current regulation and policy to streamline approval. The Saudi government has expanded regulations and policies aimed at supporting pharmaceutical and biotechnology industries in the development of local vaccine manufacturing as well as to facilitate partnerships with multinational corporations and bolster vaccine manufacturing, and the policy environment is now materially more favorable than at any prior point in the Kingdom's history.

Chapter 7

Building a Sustainable Biopharmaceutical Sector in Saudi Arabia: Strategies for Local Manufacturing and Innovation

PIF and the Rise of SAUDI Biotechnology: Sovereign Investment as a Catalyst for Health and Economic Resilience

The Public Investment Fund (PIF) is a defining force in Saudi Arabia's economic environment, particularly in biotechnology, a sector now recognized as central to healthcare resilience and industrial diversification. Under Vision 2030, PIF has emerged as a strategic enabler of national ambition, deploying capital, governance, and international partnership to build industries the Kingdom requires but did not previously possess.

Established in 1971 by royal decree, PIF is Saudi Arabia's sovereign wealth fund and one of the largest in the world, with assets of approximately US$940 billion as of end-2024 (PIF Annual Report 2024). Its mandate is broad: to drive economic transformation, cultivate new industries, and deliver sustainable returns for future generations. In biotechnology, PIF plays the role of both investor and architect, backing flagship platforms such as Lifera, SAUDIBIO, and VIC, and ensuring that sovereign capital, regulatory support, and strategic direction move in coordinated fashion to accelerate the Kingdom's life-sciences industry.

PIF's strategic blueprint is deeply intertwined with the goals of Vision 2030, Saudi Arabia's comprehensive roadmap to reduce oil dependency and foster a knowledge-based economy. The fund's mission encompasses:

- Driving economic transformation through targeted investments in emerging and high-impact sectors
- Creating new industries and opportunities that stimulate innovation and entrepreneurship.
- Investing in long-term, sustainable projects that yield enduring national benefits.
- Facilitating job creation and nurturing a skilled workforce across diversified domains

Domestically, PIF has launched a constellation of landmark projects that exemplify its commitment to national development:

- *NEOM:* A $500 billion futuristic city powered entirely by renewable energy, envisioned as a hub for innovation and sustainability.
- *Qiddiya:* A sprawling entertainment and sports megaproject near Riyadh, designed to redefine leisure and cultural engagement.

- *Red Sea Global:* A luxury tourism initiative encompassing over 50 pristine islands, aimed at positioning Saudi Arabia as a premier global destination.
- *Roshn Group:* A national real estate developer focused on modern, integrated residential communities.
- *Diriyah Company:* A heritage and cultural tourism enterprise centered around the historic Diriyah site, celebrating Saudi Arabia's rich legacy.

Internationally, PIF has extended its influence through strategic stakes in globally recognized entities:

- *Uber:* A 5% stake valued at $3.5 billion, reinforcing its footprint in the mobility and tech sectors.
- *Live Nation:* A 5.7% stake worth $500 million, supporting entertainment and live events.
- *Jio Platforms (India):* A 2.3% stake valued at $1.5 billion, tapping into digital infrastructure and telecommunications.
- *Newcastle United FC:* Full acquisition of the English Premier League club, symbolizing cultural diplomacy and global brand engagement.

The fund's economic impact is both profound and expansive. With over US$940 billion in assets under management, more than 220 portfolio companies, and upwards of 1.1 million jobs created directly and indirectly, PIF's reach spans 13 strategic sectors, including energy, tourism, entertainment, technology, and manufacturing.

Within this dynamic ecosystem, biotechnology occupies a central and increasingly prominent role. PIF's investments in biotech are not merely financial, they are foundational. They support the Kingdom's National Biotechnology Strategy, which emphasizes:

- Biopharma resilience through localized production and reduced dependency on global supply chains
- Technology transfer to ensure the adoption of cutting-edge manufacturing and research capabilities.
- Workforce development to cultivate a new generation of scientists, engineers, and healthcare professionals.

By channelling capital into biotech infrastructure, research, and partnerships, PIF is building a self-sustaining biotechnology ecosystem. This includes support for companies such as SAUDIBIO, which combines national ambition with international standards. Through these investments, PIF is accelerating the localization of critical medicines and strengthening the Kingdom's position in regional and global biotech markets.

PIF is more than a financial institution; it is a strategic architect of Saudi Arabia's future. Its biotechnology role reflects a broader commitment to health sovereignty, industrial diversification, and global competitiveness. As Vision 2030 unfolds, PIF will remain at the forefront, converting aspiration into measurable outcomes in the life sciences.

Lifera: PIF's Vanguard in Biopharmaceutical Sovereignty

Lifera, a wholly owned subsidiary of the Public Investment Fund (PIF), represents Saudi Arabia's strategic leap into the future of biopharmaceutical innovation. Conceived as a national instrument to fortify healthcare resilience and catalyze economic diversification, Lifera is more than a company; it is a mission-driven enterprise designed to transform the Kingdom into a regional and global leader in biotechnology.

Central to Lifera's mandate lies a dual mission:

- To enhance biopharma resilience by localizing the production of critical medicines, thereby reducing dependency on global supply chains, and ensuring national health security.
- To advance the National Biotechnology Strategy through the development of cutting-edge infrastructure, strategic partnerships, and the cultivation of a highly skilled workforce.

This mission is deeply aligned with the broader goals of Vision 2030, which seeks to reposition Saudi Arabia as a diversified, knowledge-based economy. Lifera's emergence as a biopharmaceutical powerhouse is a direct reflection of PIF's commitment to building sovereign capabilities in high-impact sectors.

Strategic Pillars and Key Initiatives

Lifera's operational blueprint is anchored in four transformative pillars:

Contract Development and Manufacturing Organization (CDMO)

Lifera is being developed into a commercial-scale CDMO, offering end-to-end manufacturing services for biologics, vaccines, plasma therapeutics, monoclonal antibodies, and cell and gene therapies. Its ambition is to rival global CDMO leaders by delivering sterile drug products and advanced therapeutics on scale.

Multi-omics Capacity

Lifera is investing in high-throughput platforms for genomics, proteomics, and metabolomics to support clinical research, population health initiatives, and precision medicine. These capabilities are foundational to Saudi Arabia's long-term strategy in personalized healthcare and biotechnology innovation.

Technology Transfer

Through strategic alliances with global biopharma leaders such as Novo Nordisk and Sanofi, Lifera facilitates the transfer of proprietary technologies, manufacturing know-how, and regulatory expertise. These partnerships accelerate localization and elevate the Kingdom's technical competencies.

Workforce Development

Lifera is committed to nurturing a world-class biopharma workforce. Through specialized training programs, employment pathways, and academic collaborations, it aims to build a talent pipeline equipped to lead the next generation of biotech innovation.

Lifera's comparative advantage lies in its strategic positioning within the MENA region, its sovereign backing by PIF, and its alignment with national policy frameworks. It is uniquely equipped to serve both domestic and regional markets, while also contributing to global supply chains.

National Impact and Global Ambitions

Lifera is more than a corporate entity; it is a national instrument of transformation. Its initiatives are designed to:

- Empower the private sector through partnerships, technology transfer, and infrastructure enablement.
- Attract international expertise and foster cross-border collaborations.
- Develop a high-caliber workforce capable of sustaining long-term innovation.
- Anchor Saudi Arabia's leadership in precision medicine, genomics, and advanced therapeutics.

As a biopharmaceutical arm of PIF, Lifera embodies the Kingdom's vision for health sovereignty, economic diversification, and scientific excellence. Its emergence signals a bold pivot toward self-sufficiency, resilience, and global competitiveness in biotechnology.

Lifera vs. Global CDMO Leaders: Strategic Comparison

As Lifera positions itself as a Contract Development and Manufacturing Organization (CDMO) of national and regional significance, it enters a competitive market dominated by long-established global players. To contextualize Lifera's emergence, the following comparative table outlines key features across leading CDMOs:

Table 7.1Key Features Across Leading CDMOs

Feature / Focus Area	Lifera (Saudi Arabia)	Lonza (Switzerland)	Thermo Fisher (USA)	Catalent (USA)	WuXi Biologics (China)
Ownership & Mission	PIF-backed; national biotech strategy; regional health resilience	Public company; global CDMO with biologics and small molecule focus	Public company; diversified life sciences and CDMO services	Public company (until 2024); focused on drug delivery and biologics	Public company; biologics-focused CDMO with global reach
Geographic Focus	MENA region; expanding global partnerships	Europe, North America, Asia	Global footprint with facilities in EU, US, Singapore	North America, EU, Asia	China-centric with global expansion
Core Capabilities	Biologics, sterile injectables, genetic testing, vaccine manufacturing	Mammalian cell culture, microbial fermentation, API production	Sterile injectables, gene therapy, protein analysis	Oral, injectable, inhaled drug delivery; biologics	End-to-end biologics development and manufacturing
Innovation Edge	Multi-omics, AI-driven drug discovery, rare disease diagnostics	Advanced biologics platforms, cell & gene therapy	Next-gen protein analysis, ultra-cold storage, AI integration	Proprietary delivery technologies	Integrated platforms for antibody and cell line development

Strategic Insights and Positioning

Based on the comparative analysis above, several key differentiators and strategic implications emerge:

1. Lifera's Differentiator

Unlike its global counterparts that evolved from commercial ventures, Lifera is uniquely state-backed and mission-driven. Its foundation is rooted in national priorities, health sovereignty, chronic disease management, and pandemic preparedness. This gives Lifera a policy-aligned mandate that prioritizes public health outcomes over commercial scale.

2. Innovation Focus

Lifera's emphasis on multi-omics, AI-driven diagnostics, and rare disease genomics

positions it at the forefront of precision medicine, particularly for MENA populations. These capabilities are not only technologically advanced but also culturally and regionally tailored, addressing genetic diversity and disease prevalence specific to the region.

3. Global CDMO Landscape

Established leaders such as Lonza and Thermo Fisher offer unmatched scale, diversified portfolios, and decades of operational experience. However, their focus often centers on servicing global pharmaceutical pipelines, which may not always align with regional health priorities or localization efforts.

4. Strategic Positioning

While Lifera does not yet compete on volume or revenue, it is carving out a distinct niche in localized biomanufacturing, genetic testing, and vaccine sovereignty. These areas have gained strategic urgency in the post-COVID era, where supply chain disruptions and health equity challenges have underscored the need for regional self-sufficiency.

Lifera's rise as a CDMO powerhouse is a sovereign strategy, not simply a commercial undertaking. With PIF as anchor and Vision 2030 as framework, Lifera has accelerated Saudi Arabia's biopharmaceutical independence. Its acquisition of 70% of SAUDIBIO consolidates the Kingdom's first GMP-certified biotech facility under a Saudi-owned platform with the capital, governance, and partnership network to scale it. The combination extends beyond insulin and established biologics into a broader portfolio: vaccines. Through this strategic integration, Lifera is redefining the contours of biopharmaceutical leadership in the Middle East. Its trajectory demonstrates how nations can harness targeted investment, innovation, and advanced therapies, each anchored in domestic manufacturing capability and positioned to serve both the Kingdom and the wider region.-

Charting a Sustainable Future for Saudi Biopharma

The transformation of Saudi Arabia's biopharmaceutical sector is a reflection of the Kingdom's determination to achieve health sovereignty, economic diversification, and global competitiveness. Through the strategic vision of the Public Investment Fund (PIF) and the pioneering emergence of Lifera, Saudi Arabia is laying the groundwork for a self-sustaining biotechnology ecosystem rooted in innovation, resilience, and regional leadership.

As the nation accelerates the localization of critical medicines and expands manufacturing capacity, it reduces reliance on global supply chains and fosters a culture of scientific excellence. The collaborative efforts between PIF, Lifera, and strategic partners

reflect a holistic approach that balances commercial performance with strategic outcome: a domestic industry capable of self-supply, regional export, and contribution to global health security.

Looking ahead, the Kingdom's commitment to its National Biotechnology Strategy and Vision 2030 will continue to drive transformative change. Saudi Arabia is positioned not only to meet its domestic needs but to contribute meaningfully to regional and global health security. Through innovation, talent, and forging strategic alliances, Saudi Arabia is charting a course toward a sustainable, inclusive, and resilient biopharmaceutical future, one that stands as a model for emerging economies worldwide development, and strategic partnership, the Kingdom is building enduring capability in one of the most important industries of the twenty-first century.

PART IV: THE LEGACY

Observing Saudi Arabia's rapid progress in vaccine manufacturing has been nothing short of extraordinary.

As I further explore this field, I see a nation rapidly ascending to join the ranks of leading global manufacturers, implementing international GMP standards, and channeling the innovative momentum of Vision 2030. What began as a nascent sector is now becoming a pillar of localization, technological advancement, and enduring resilience.

In my position, I consistently measure our progress against industry leaders such as the United States and European Union. What distinguishes the Kingdom is purposeful strategy: a system built on strict quality assurance, advanced technology, and long-term viability. Rather than merely replicating global models, we adapt them to Saudi Arabia's context, so that domestic capability advances in step with global standards, not in imitation of them.

This chapter begins at the very heart of this remarkable transformation.

Chapter 8

From Absence to Leadership

– The Birth of Vaccine Industrial Company (VIC)

Looking back on the early 2020s, I see that era as a pivotal turning point for Saudi Arabia, a moment when the nation was forced to confront an issue long ignored. Of all the G20 nations, Saudi Arabia was the only one without its own vaccine manufacturing industry. This was not simply a missing piece of our industrial base; it was a strategic vulnerability at the heart of our national health security.

Over the years, most G20 nations had prioritized vaccine sovereignty, investing in scientific research, advanced manufacturing, and comprehensive regulatory systems to protect their populations. Saudi Arabia, by contrast, remained heavily dependent on imported vaccines, a reliance that felt increasingly precarious as international supply chains became more susceptible to disruption and shifting geopolitical dynamics threatened consistent access to lifesaving medicines. The lack of local vaccine production was no longer a distant concern reserved for policy debates: it had emerged as a direct and urgent challenge to national security and public health.

This awareness was sharpened by global events, particularly the COVID-19 pandemic, which highlighted the risks of waiting on international suppliers during a crisis. As vaccine nationalism intensified and countries scrambled to secure doses for their citizens, Saudi Arabia's dependence on external producers became increasingly unsustainable. It brought into sharp focus the need to establish a domestic vaccine manufacturing infrastructure, not only to ensure the availability of essential medicines but also to assert the Kingdom's role in global health security. The imperative was clear: Saudi Arabia had to close this strategic gap, build its own scientific and industrial foundations, and position itself as a leader in biotechnology innovation and resilience.

Then came COVID-19, and the vulnerability we had long tolerated became impossible to ignore. As countries raced to secure doses, vaccine nationalism took hold, and even the strongest alliances strained under the pressure of scarcity. Despite our economic strength and global partnerships, we found ourselves waiting, dependent on the timelines, priorities, and capacities of others. It was a sobering position for a nation of the Kingdom's size and ambition.

For me, that moment crystallised a simple, urgent truth: Saudi Arabia needed to take control of its own vaccine future. We needed an institution capable of transforming

ambition into capability, and capability into sovereignty. That realisation marked the beginning of a journey that would lead to the creation of the Vaccine Industrial Company (VIC), and with it, the Kingdom's first truly domestic vaccine-manufacturing platform.

Vision During Crisis

It was during that turbulence that I made a decision that would redefine the trajectory of my career and, I believed, the future of Saudi Arabia's health security. With decades of experience in biotechnology and healthcare management behind me, I could not ignore the urgency of the moment. The Kingdom needed more than reactive measures; it needed a long-term industrial answer, and someone willing to build it.

My vision did not emerge from impulse or emotion. It was shaped by deliberate analysis, strategic foresight, and a deep understanding of the biopharmaceutical sector. I began by conducting a comprehensive study to uncover the structural barriers that had long prevented Saudi Arabia from entering the vaccine manufacturing arena. The findings were stark:

- Limited specialized infrastructure for biologics
- Shortage of trained workforce in advanced vaccine technologies
- Regulatory frameworks not yet tailored to vaccine production.
- Dependence on imported raw materials and supply chains.
- Lack of global partnerships to transfer knowledge and technology

Each of these obstacles represented a missing piece in the Kingdom's biotechnology ecosystem. Yet, rather than discouraging me, they clarified the path forward. I saw not a list of limitations, but a map of opportunities, each challenge pointing to a strategic intervention that could reshape the nation's capabilities.

As I synthesized the research, a blueprint began to take shape. It outlined not only what needed to be built, but how Saudi Arabia could leapfrog traditional development timelines by aligning with global leaders, adopting cutting-edge technologies, and forging the right international partnerships. This blueprint would become the intellectual foundation for a new era in SAUDI Biotechnology, one defined by ambition, resilience, and scientific sovereignty.

And at the center of that blueprint was the idea that would soon evolve into the Vaccine Industrial Company (VIC).

Founding the Vaccine Industrial Company (VIC)

By 2022, the vision I had been shaping took form. That year, I founded the Vaccine

Industrial Company (VIC): an institution conceived not as a manufacturing plant but as the cornerstone of a new regional biotechnology era. I envisioned VIC as the largest human vaccine manufacturing facility in the Middle East and North Africa, a place where scientific ambition and national resilience would converge. The project which has received a building permit from the Saudi Authority for Industrial Cities and Technology Zone (MODON), will be situated in Sudair City for Industry and Business, covering an impressive 42,000 square meters. Construction is set to begin in, and the first of its kind in the nation. The scale mattered: it would give the Kingdom the capacity to supply its own population in normal times and to respond meaningfully to regional need in a health emergency.

Figure 8.1

Turnkey agreement signed between the Vaccine Industrial Company (VIC) and KeyPlants during a ceremony at the Swedish Embassy in Riyadh, Saudi Arabia.

VIC represented more than closing a gap; it was about reshaping Saudi Arabia's role in global health. My vision was for the Kingdom to be front and center in vaccine innovation, confidently producing, developing, and exporting vaccines alongside the world's leading nations. Establishing VIC was not only a strategic milestone in our biotechnology program but a statement about what kind of country Saudi Arabia intends to be in the next era of global health.

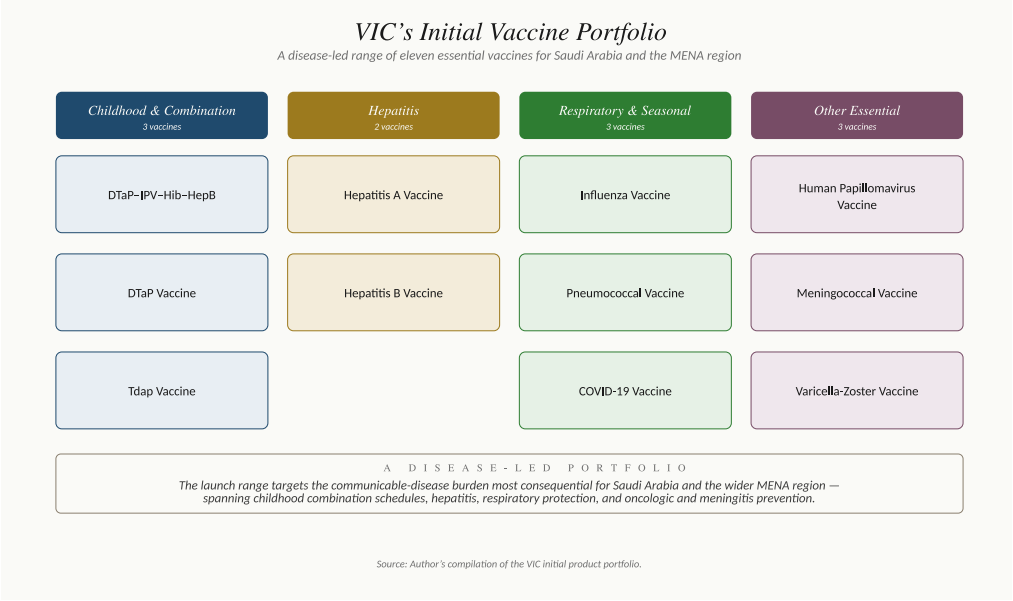

Figure 8.2

The Vaccine Industrial Company (VIC) vaccine portfolio, featuring key immunizations designed to address the primary public health needs of Saudi Arabia and the MENA region.

VIC launches with a comprehensive portfolio of essential vaccines, tailored to the health priorities of Saudi Arabia and the wider MENA region. The initial lineup spans high-impact immunizations, including vaccines for human papillomavirus (HPV), seasonal and pandemic influenza, meningococcal disease, measles-mumps-rubella (MMR), diphtheria-tetanus-pertussis combinations, pneumococcal disease, and rotavirus, among others. Each product has been selected on the basis of burden, strategic importance, and feasibility, with a clear path to domestic manufacture at scale.

covers approximately 70% of the essential vaccines recognized by the SFDA. This breadth highlights VIC's role as a central contributor to the Kingdom's immunization program, supporting public-health priorities through a diverse range of high-impact vaccines across pediatric, adult, and travel-related categories. By maintaining a portfolio that mirrors the majority of SFDA-listed essential vaccines, VIC positions itself as a reliable partner in strengthening national health security and ensuring consistent access to critical immunization solutions.

The mission we set for VIC was both bold and precise:

- Secure vaccine sovereignty by producing seasonal influenza vaccines and

pandemic-response vaccines within the Kingdom.

- Enable regional leadership by supplying high-quality vaccines across the GCC and the broader MENA region.
- Embed global excellence through deep partnerships with international leaders. These collaborations opened doors to cutting-edge technologies and R&D networks across the United States, Europe, and Australia, ensuring that our work aligned with the highest global standards.

Figure 8.3

Land Allocation Ceremony: MODON and VIC Partnership (2023), preceding the subsequent building permit and Q1 2025 construction start.

By forging strategic alliances with global leaders, VIC became an international platform for scientific exchange and collaboration. The partnerships enabled Saudi Arabia to move beyond adopting innovations to participating in their development. VIC contributes actively to new vaccine candidates, to platform improvements, and to the body of clinical evidence that will underpin the next generation of immunization worldwide. That participation, grounded in Saudi capability, is the ambition behind the project.

As VIC's vision materialised, it became clear that we were laying the foundation for far more than a manufacturing site. We were building a future in which Saudi Arabia would

be resilient and self-sufficient, able to respond rapidly to emerging health threats and to support neighboring countries in a crisis. VIC signals that Saudi Arabia takes health sovereignty seriously, and that we are willing to invest at the well-being of our population while fostering regional stability. With a robust infrastructure and a talented workforce, VIC enabled the Kingdom to anticipate and manage public health challenges effectively, reinforcing our leadership in the global fight against disease.

Building a Proven Legacy: SAUDIBIO

VIC did not emerge from a vacuum. Its foundations were laid more than a decade earlier when I founded SAUDIBIO in 2010. At the time, Saudi Arabia had never produced a complex biologic locally, yet the region's escalating diabetes burden demanded a bold response. I believed the Kingdom could rise to that challenge, and SAUDIBIO proved it could.

Producing insulin pens and vials within our borders was a milestone that reshaped my understanding of what was possible. By meeting EU GMP Annex I and SFDA standards, we proved, to ourselves and to the global community, that Saudi Arabia could master the rigorous demands of biopharmaceutical production. Every inspection passed, every batch released, and every patient treated reinforced the case that the Kingdom's biotech industry was ready for bigger things.

Final Vaccine Formulation

There are three fully automated production lines, each line has a sterile room for the final vaccine formulation, including mixing antigens with the appropriate immunity adjuvant and excipients under sterile air and positive pressure to avoid environmental contamination. These lines consist of:

Freeze dried live vaccines

- Technique used to produce live viral vaccines for poultry and livestock.
- The vaccine is mixed with stabilizers and dried in special machines for lyophilization.
- The vaccine can be administered through drinking water or injection.

Inactivated vaccines

- Production under high positive pressure using HEPA filtered sterile air to avoid environmental impacts in the efficacy of the final vaccine.

Diluents for vaccines

- A sterile diluent is used to dissolve the final vaccine to ensure the highest rate of efficacy.

The experience gained at SAUDIBIO became my laboratory for learning. We built regulatory expertise from the ground up, trained a workforce capable of handling sensitive biologics, and scaled operations in a way that aligned with international expectations. These lessons were invaluable. They taught me how to navigate complexity, anticipate challenges, and design systems that could grow without compromising quality.

When the time came to envision VIC, I drew heavily on that legacy. SAUDIBIO had shown me what it took to build a pioneering facility in territory that had never seen one before. VIC would take that knowledge and amplify it, moving from insulin to vaccines, from national impact to regional leadership, and from a single facility to a cornerstone of the Kingdom's biotechnology sector.

In many ways, SAUDIBIO was the proof of concept. VIC became the evolution.

Strategic Impact

As VIC moved from vision to reality, I began to see just how profoundly it would reshape Saudi Arabia's biotechnology sector. For the first time in our history, we could point to a facility capable of producing vaccines at scale, designed, built, and operated within the Kingdom. This achievement was more than symbolic; it represented a structural shift in how we approached health security, industrial development, and global engagement.

The impact of VIC can be understood across three interconnected dimensions:

Healthcare Resilience

VIC gives the Kingdom something it had never possessed before: the ability to secure timely access to essential vaccines without depending on external supply chains. In a world where pandemics can emerge without warning, this capability strengthens our national preparedness and ensures that our population is protected when it matters most.

Economic Diversification

By localizing high-value biopharmaceutical production, VIC contributes directly to the ambitions of Vision 2030. We are creating specialized jobs, nurturing scientific talent, and building an industry rooted in knowledge, innovation, and long-term sustainability. Each step we take reduces our reliance on oil and expands the Kingdom's presence in advanced manufacturing.

Global Competitiveness

With VIC, Saudi Arabia is no longer a passive participant in global health supply chains. We are emerging as a trusted supplier of vaccines across the GCC and the wider MENA region. Through our partnerships and production capabilities, we are embedding the

Kingdom into the global health ecosystem, contributing not only to our own security but to regional and international stability.

As I reflect on these dimensions, I see VIC as a catalyst, one that accelerates the Kingdom's transition into a new era of scientific leadership and industrial sovereignty. And this is only the beginning.

A Foundational Achievement

When I look back on the decision I made during the COVID-19 crisis, I realize it was never just about building a facility or filling a gap in our supply chain. It was about institutionalising excellence, embedding world-class standards, sustainability, and innovation into the DNA of Saudi Arabia's biotechnology sector. VIC was built to endure and to evolve, as the ground on which the Kingdom's next phase of health leadership stands.

For me, VIC represents a commitment to resilience. It stands as proof that Saudi Arabia can design, operate, and sustain advanced biomanufacturing systems that meet the highest global benchmarks. It shows what becomes possible when urgency meets vision, and when vision is backed by rigorous execution.

Together, SAUDIBIO, VIC, and my other enterprises deliver 75% of the Kingdom's four biotechnology transformation pillars, forming the backbone of the emerging bioeconomy. SAUDIBIO addresses the critical need for reliable insulin supply and chronic-disease management. VIC provides vaccine sovereignty and pandemic preparedness. The R&D platforms support innovation in both directions. Collectively, they move the Kingdom from import dependency to domestic capability across the most strategically important categories of medicine.

Both projects share a common thread: they were built on the belief that Saudi Arabia could do more than participate in global health systems, it could help shape them. Through research, experience, and a willingness to challenge long-standing assumptions, we demonstrated that national industries can be reimagined, rebuilt, and elevated to global relevance.

As I reflect on this journey, I see these achievements not as endpoints, but as foundations. They mark the beginning of a new era in which Saudi Arabia stands confidently within the global health ecosystem, innovating, contributing, and leading with purpose.

Strategic Alignment with Vision 2030

From the beginning, I understood that VIC had to be more than a manufacturing

facility, it needed to be a national instrument aligned with the Kingdom's long-term aspirations. The creation of VIC directly advances the pillars of Vision 2030, reinforcing the transformation underway across Saudi Arabia.

Thriving Economy

By expanding into biotechnology, VIC helps diversify the Kingdom's economic base. We are reducing reliance on oil revenues and building a sustainable, high-value industrial sector capable of competing globally.

Vibrant Society

Ensuring timely access to essential vaccines strengthens public health and enhances the quality of life for every resident of the Kingdom. VIC contributes to a society that is healthier, more secure, and better prepared for future challenges.

Ambitious Nation

Through global partnerships, advanced technologies, and a commitment to excellence, VIC positions Saudi Arabia as a leader in biotechnology and life sciences. It reflects the ambition of a nation determined to shape its own future.

VIC also fulfills two of the Supreme Committee for Research, Development, and Innovation's national priorities:

Health & Wellness

By advancing vaccine sovereignty and strengthening healthcare resilience, VIC directly supports the Kingdom's long-term health security.

Economies of the Future

By embedding biotechnology into Saudi Arabia's industrial and innovation ecosystems, VIC contributes to the creation of future-ready industries that will define the next generation of economic growth.

Legacy and Global Positioning

The establishment of VIC is not an incremental step; it is a foundational achievement. For the first time in our history, Saudi Arabia possesses a facility capable of producing vaccines at scale, reducing dependence on imports, and ensuring readiness for future pandemics. This capability fundamentally reshapes our national resilience.

When I compare our progress with global leaders such as the United States and the European Union, I see a Kingdom rapidly closing the gap. VIC embodies world-class standards, nurtures global partnerships, and institutionalizes excellence across every

layer of its operations. Its scale, technological sophistication, and sustainability practices place Saudi Arabia at the forefront of vaccine manufacturing in the MENA region.

Just as importantly, VIC's commitment to workforce development ensures that this progress is not temporary. We are cultivating a generation of scientists, engineers, and specialists who will carry the Kingdom's biotechnology ambitions forward for decades to come.

As I reflect on this journey, I see VIC not only as a facility, but as a symbol of what Saudi Arabia can achieve when vision, strategy, and determination converge. It stands as a cornerstone of our biotechnology future, and a marker of the Kingdom's rising role in the global health ecosystem.

The story of VIC is, in many ways, the story of Saudi Arabia's leap into biotechnology manufacturing. It is a narrative shaped by vision forged in crisis, research turned into action, and leadership that converts vulnerability into strength. When I founded VIC, my goal was not only to close a national gap but to build a platform capable of lifting the Kingdom into regional and eventually global leadership in vaccine science.

Together with SAUDIBIO, VIC is one of the dual flagships of Saudi Arabia's biotechnology evolution. SAUDIBIO addressed the urgent challenge of insulin access and chronic -disease management, proving that complex biologics could be manufactured locally to world-class standards. VIC extends that legacy into vaccine sovereignty and pandemic preparedness, closing the largest remaining gap in Saudi Arabia's biomedical autonomy. Between them, the two companies address a material share of the Kingdom's strategic vision, grounded in research, experience, and a willingness to challenge the status quo, can reshape national industries and redefine a country's role in the global health ecosystem.

As I reflect on this journey, I see VIC and SAUDIBIO as the cornerstones of Saudi Arabia's biotechnology leap. They are not only delivering on the ambitions of Vision 2030, but they are also accelerating the National Biotechnology Strategy ahead of schedule. By institutionalizing excellence, fostering global partnerships, and embedding sustainability into every layer of their operations, these projects ensure that Saudi Arabia emerges as a regional powerhouse in vaccine and biologics manufacturing.

More importantly, they signal the rise of the Kingdom as a global player in life sciences innovation. What once seemed aspirational is now becoming reality: a Saudi Arabia that contributes to global health security, drives scientific advancement, and builds industries capable of sustaining future generations.

And this is only the beginning of what the Kingdom can achieve.

VIC's Foundational Role

When I founded the Vaccine Industrial Company (VIC) in 2022, I knew we were building more than a facility, we were laying the groundwork for a new national capability. VIC became a defining milestone in Saudi Arabia's biotechnology journey, embodying the ambition, scale, and global integration required to secure the Kingdom's health future.

VIC is:

- The first of its kind in Saudi Arabia , a state-of-the-art vaccine manufacturing facility designed to meet the highest international standards and to operate with the precision and reliability expected of global leaders.
- The largest in the Middle East and North Africa (MENA) setting new regional benchmarks for scale, quality, and innovation, and demonstrating that the Kingdom can lead not only in ambition but in execution.
- Globally connected, built on strategic partnerships with CSL Seqirus for cell-based influenza and pandemic readiness vaccines. This collaboration ensures access to cutting-edge technologies, robust knowledge transfer, and integration into global R&D networks.

Through VIC, I sought to create an institution that would not only serve Saudi Arabia's immediate needs but also anchor its long-term scientific and industrial aspirations. It stands today as evidence of what the Kingdom can achieve when vision, strategy, and global collaboration converge.

VIC's Contributions to National Biotechnology Strategy

From the outset, I designed VIC as a strategic national instrument, advancing not only Saudi Arabia's biotechnology ambitions but its wider priorities of resilience, diversification, and global leadership. That intent is reflected in VIC's vaccine portfolio, which spans essential immunizations for the Saudi population and the wider MENA region. The scope, depth, and regulatory rigour of the portfolio includes vaccines for human papillomavirus (HPV), influenza, meningococcal disease, pneumococcal infections, COVID-19, hepatitis A and B, varicella-zoster virus, as well as combination pediatric and adolescent formulations such as DTaP-IPV-Hib-HepB, alongside standalone DTaP and Tdap vaccines. By building a product range that addresses both immediate public-health needs and long-term disease-prevention priorities, mean that VIC is positioned not only to supply domestic demand but to contribute meaningfully to regional health security, bridging the gap between what the Kingdom needs and what the region currently cannot reliably source from elsewhere.

Vaccine Sovereignty

Through VIC, we established end-to-end production of seasonal influenza and pandemic-response vaccines within the Kingdom. This capability ensures that Saudi Arabia can protect its population without relying on external supply chains. In addition, our exclusive rights to next-generation vaccines for Saudi Arabia and the GCC position the Kingdom at the forefront of emerging immunological technologies.

Healthcare Resilience

By reducing dependency on imported vaccines, VIC strengthens the nation's ability to respond swiftly and effectively to pandemics and emerging infectious diseases. This resilience is no longer a theoretical advantage; it is a practical safeguard that ensures continuity, preparedness, and rapid mobilization when the world faces uncertainty.

Economic Diversification

VIC contributes directly to the Kingdom's economic transformation by creating high-value jobs in biomanufacturing, quality systems, engineering, and R&D. It also positions Saudi Arabia as a regional exporter of vaccines, opening new markets and embedding biotechnology into the fabric of the national economy.

Global Competitiveness

By aligning with EU GMP Annex I and SFDA standards, VIC operates at the highest levels of global regulatory compliance. This alignment builds credibility and trust, enabling the Kingdom to participate confidently in international markets and supply chains. It signals to the world that Saudi Arabia is entering the biotechnology sector, and entering it with excellence.

Through these contributions, VIC has become a cornerstone of Saudi Arabia's National Biotechnology Strategy, reinforcing the Kingdom's commitment to health security, economic transformation, and global leadership in life sciences.

Comparative Edge

As VIC matured, it became clear that our ambition was not simply to catch up with global leaders, it was to stand alongside them. When benchmarked against established biotechnology hubs in the United States, the European Union, and Singapore, VIC demonstrates a competitive edge that reflects both the Kingdom's vision and our commitment to excellence.

Scale

VIC is the largest human vaccine manufacturing facility in the Middle East and North Africa, built to a scale comparable with advanced hubs in Europe and Asia. This capacity allows us to serve national needs while supporting regional and global supply chains.

Innovation

By adopting cell-based influenza platforms and pioneering next-generation T-cell vaccine technologies, VIC positions Saudi Arabia at the forefront of modern immunization science. These technologies represent the future of vaccine development, not incremental improvements.

Integration

From the beginning, I ensured that VIC would embed workforce development, sustainability, and long-term capability building into its core operations. This integration creates resilience that extends far beyond a single product line or technology platform. It ensures that VIC can evolve, adapt, and lead for decades to come.

Through these strengths, VIC stands as a symbol of what Saudi Arabia can achieve when strategic vision, scientific innovation, and national ambition converge. It is not only closing the gap with global leaders but also defining a new benchmark for the region.

Strategic Significance

VIC is far more than a manufacturing facility; it is a national cornerstone of Saudi Arabia's biotechnology transformation. It embodies the principles that define the Kingdom's new era: institutionalised excellence, deep global partnerships, and a commitment to turning Vision 2030 from aspiration into measurable outcome. Each element of VIC's design, from its portfolio architecture to its partnership strategy to its regulatory posture, is aligned to those principles.

Founding VIC was one of the most consequential decisions of my career. It required conviction during a moment of global uncertainty and the willingness to build something the Kingdom had never attempted before. The outcome has exceeded my own expectations. VIC has positioned Saudi Arabia as a regional vaccine powerhouse and a rising global player in biotechnology, and it has set the standard for how sovereign industrial capability can be built under Vision 2030.

What began as a response to vulnerability has become a platform for leadership. VIC demonstrates how strategic vision, backed by research, experience, and national ambition, can redefine a country's role in the global health ecosystem. It shows what Saudi Arabia can achieve, and a signal of what is still to come.

Vision of the Vaccine Industrial Company (VIC)

When I founded VIC, I did so with a transformative vision: to establish Saudi Arabia as the regional leader in vaccine manufacturing, research, and innovation, to secure true national sovereignty in healthcare, and to contribute meaningfully to global health security. The vision was never limited to building a facility; it was about redefining what the Kingdom could do in vaccines, and by extension, in biologics, and more broadly still.

VIC's purpose is rooted in the broader ambition of Vision 2030. As Saudi Arabia diversifies its economy, strengthens healthcare resilience, and positions itself as a hub for advanced biotechnology, VIC is one of the most tangible expressions of that national transformation. We set out not only to fill a gap but to redefine the Kingdom's role in global health.

Central toVIC's vision is to:

- Secure vaccine sovereignty by eliminating reliance on imports and ensuring full self-sufficiency in critical vaccine production.
- Lead regional innovation by becoming the largest and most advanced vaccine manufacturing facility in the Middle East and North Africa (MENA), setting new benchmarks for quality, scale, and scientific capability.
- Contribute globally by embedding international standards, fostering strategic partnerships, and supplying vaccines beyond our borders, strengthening global health security while elevating the Kingdom's scientific footprint.
- Empower future generations by nurturing Saudi talent, advancing biotechnology education, and embedding excellence into our institutional culture, ensuring that the Kingdom's progress is sustainable and enduring.

This vision guides every decision we make at VIC. It shapes our partnerships, our technologies, our workforce strategy, and our commitment to excellence. It is the foundation upon which we are building a national capability, one that will serve Saudi Arabia for decades to come.

Mission of the Vaccine Industrial Company (VIC)

From the moment I founded VIC, my mission was clear: to translate vision into action by building a state-of-the-art, life-saving vaccine manufacturing ecosystem, one that seamlessly integrates research, development, production, and distribution. I envisioned VIC not as a single facility, but as a complete engine for national health security and scientific advancement, capable of delivering life-saving impact on scale.

VIC's mission is defined by five pillars that guide every decision we make:

Healthcare Resilience

- Produce a comprehensive portfolio of vaccines, including seasonal influenza vaccines, pandemicresponse cellbased vaccines, nextgeneration Tcell vaccines, and a full range of essential immunizations such as HPV, COVID19, meningococcal, pneumococcal, hepatitis A and B, varicellazoster, DTaPIPVHibHepB, DTaP, and Tdap vaccines.
- Ensure rapid response capabilities for emerging infectious disease.

Industrial Excellence

- Operate facilities that meet EU GMP Annex I and SFDA standards.
- Institutionalize quality assurance, sustainability, and innovation in every process.

Global Partnerships

- Through partnerships with CSL Seqirus, Biological E, Innovax, Sinovac, and other leading global manufacturers, VIC is building the capability to produce a broad spectrum of high-impact vaccines, including seasonal influenza, pandemic-response cell-based vaccines, and next-generation platforms. These collaborations transfer critical know-how and advanced technologies into the Kingdom, converting external expertise into durable Saudi capability.
- Build a global R&D network connecting Saudi Arabia to the United States, Europe, and Asia

Economic Diversification

- Create high-value jobs in biomanufacturing, research, and regulatory sciences.
- Position Saudi Arabia as a regional exporter of vaccines, contributing to non-oil revenue streams.

Vision 2030 Alignment

- Advance the Thriving Economy pillar by localizing pharmaceutical production.
- Strengthen the Vibrant Society pillar by ensuring timely access to life-saving vaccines.
- Embody the Ambitious Nation pillar by embedding excellence and global competitiveness.

These pillars form the backbone of VIC's mission. They ensure that every initiative we undertake, every partnership, every technology platform, every investment in talent, moves the Kingdom closer to true vaccine sovereignty and global leadership in biotechnology.

Strategic Essence

For me, the strategic essence of VIC lies in the harmony between its Vision and its Mission, two forces that guide every decision, every partnership, and every milestone we pursue.

The Vision defines what we aspire to become: a beacon of vaccine sovereignty and innovation for Saudi Arabia and the wider MENA region. It captures our long-term ambition to lead, to inspire, and to secure the Kingdom's place in the global life sciences landscape.

The Mission explains how we turn that aspiration into reality: through excellence in manufacturing, global collaboration, economic diversification, and unwavering alignment with Vision 2030. It is the operational backbone that transforms ambition into measurable progress.

VIC Strategic Partners

From its earliest days, the Vaccine Industrial Company (VIC) was built as a collaborative ecosystem powered by worldclass partners who bring deep expertise across vaccine science, industrial engineering, bioprocessing, and strategic development. These alliances form the backbone of VIC's mission to establish a fully sovereign, globally competitive, and lifesaving vaccine manufacturing powerhouse for the Kingdom of Saudi Arabia.

VIC's strategic network includes leading international organizations such as CSL Seqirus, Baylor College of Medicine, NIBRT, ZymeBiotech, DVS Pharma, KeyPlants, Biological E, Innovax, and Sinovac. Each contributes specialized capability, from advanced cell-based vaccine technologies and modular manufacturing solutions to proven platforms for paediatric, viral, and combination vaccines. The network anchors VIC in the mainstream of global vaccine science and ensures access to the technologies, expertise, and partnerships required to deliver on its mandate.

CSL Seqirus

Technology Transfers Partner

KeyPlants MascoGroup

Engineering Partner - Turnkey modular concept

KACST مدينة الملك عبدالعزيز للعلوم والتقنية

Academic Research & Developments hub

nibrt

Bioprocessing Research and Training Partner

Baylor College of Medicine

Vaccine development, Research & Training

zyme Biotech

Project Management Partner

VIC's strategic partners form a unified ecosystem, one that blends global expertise with national ambition. Together, they enable VIC to deliver on its mission: building a sovereign, innovative, and life-saving vaccine industry that strengthens Saudi Arabia's health security and positions the Kingdom as a biotechnology leader for decades to come.

Chapter 9

The Mission in Action: Diabetes, Vaccines, and Cancer

As I reflect on Saudi Arabia's leap into biotechnology, I recognize that my journey has been driven by a single purpose: to save lives and strengthen the Kingdom's health security. When history looks back on this era of transformation, I hope my name will stand not for personal achievement, but for the systems, institutions, and capabilities that now protect millions of people across the Kingdom and the wider region. Through vision, research, and decisive leadership, I have worked to build a complete ecosystem of biotechnology enterprises, each designed to address critical health challenges, reduce dependency on imports, and secure Saudi Arabia's place as a regional leader in life sciences.

Tackling Diabetes: SAUDIBIO

Saudi Arabia faces one of the highest diabetes burdens in the world. The International Diabetes Federation estimates that approximately 4.3 million adults aged 20–79 were living with diabetes in 2024, rising to more than 5 million when older adults and undiagnosed cases are included, and projected to reach approximately 7.5 million by 2045. For these patients, insulin is not optional; it is the thin line between life and death. Domestic production removes the Kingdom's most dangerous medical dependency.

In 2010, I founded the SAUDI Biotechnology Manufacturing Company, SAUDIBIO, the Kingdom's first multipurpose sterile biologics facility. By producing insulin pens and vials locally, with a projected capacity of 100 million units annually by 2027, SAUDIBIO has ensured that patients across the Kingdom can access lifesaving treatment without interruption.

- Local insulin production ensures uninterrupted access for millions of patients.
- Highcapacity biologics manufacturing reduces reliance on imports.
- National diabetes resilience strengthens longterm public health security.
- This achievement directly addresses one of the most pressing health challenges in Saudi Arabia, and it saves lives every single day.

Securing Vaccine Sovereignty: Vaccine Industrial Company (VIC)

The COVID-19 pandemic exposed a stark vulnerability: despite being a G20 nation, Saudi Arabia had no domestic vaccine-manufacturing capability. During the crisis, the Kingdom administered more than 68 million doses, with 25.43 million individuals fully vaccinated by April 2023 (Saudi MoH; Our World in Data), around 70% of the population. The operational achievement was real; the strategic lesson was equally real. Relying on

others for vaccines in a pandemic is not a position a serious country can accept.

In response, I founded the Vaccine Industrial Company (VIC) in 2022, now the largest human vaccine manufacturing facility in the Middle East and North Africa.

Building on the international partnerships already described, VIC is producing a broad spectrum of high-impact vaccines, including seasonal influenza, pandemic-response cell-based vaccines, and next-generation platforms. The transferred know-how and advanced technologies ensure that Saudi Arabia achieves true vaccine sovereignty and is never again vulnerable to global supply shortages.

- Advanced cellbased platforms strengthen pandemic preparedness.
- Nextgeneration vaccines place Saudi Arabia at the cutting edge of global immunization science.

In short, VIC safeguards millions of lives, not only today, but in every future pandemic.

Advancing Cancer Therapies

Cancer remains one of the Kingdom's most urgent health challenges. In 2022 alone, Saudi Arabia recorded 28,113 new cancer cases and 13,399 cancer-related deaths (GLOBOCAN 2022, IARC). Approximately 76,000 patients were living with cancer within five years of diagnosis (GLOBOCAN 2022 five-year prevalence). For many, access to timely treatment determines survival.

Through SAUDIBIO's expansion into biosimilars and oncology biologics, and through my broader biotechnology ventures, we are now localizing cancer therapies that were once prohibitively expensive or delayed by import dependence. By producing monoclonal antibodies and biosimilars domestically, we are giving thousands of cancer patients access to timely, affordable, and effective treatment.

- Localized oncology biologics reduce treatment delays.
- Affordable monoclonal antibodies expand access for patients across the Kingdom.
- Strengthened cancer care infrastructure improves survival rates and quality of life.

This work is deeply personal to me. Every therapy produced, every patient treated, every life extended: these are the true measures of impact.

Building the Full Ecosystem

My contributions to Saudi Arabia's biotechnology transformation extend far beyond the establishment of manufacturing facilities. From the beginning, I understood that true national resilience required a complete ecosystem, one that integrates research, talent development, industrial capability, and strategic guidance. To build this foundation, I

established several institutions that work together as a unified engine for innovation and health security.

- Biotech Innovations Company for R&D – advancing cutting-edge research in biologics and vaccines, ensuring that Saudi Arabia is not only a manufacturer but a creator of next-generation technologies.
- Biotechnology Training Institute (BTI) – nurturing Saudi talent and building the skilled workforce required to sustain the Kingdom's biotechnology ambitions for decades to come.
- Biotech Industrial Engineering Company (BIOERA) – designing and optimizing advanced biomanufacturing systems, enabling the Kingdom to build, scale, and maintain worldclass biotechnology infrastructure with precision, efficiency, and global competitiveness.
- ANIVAX Company (Veterinary Biotech) – strengthening animal health and food security, recognizing that human health is inseparable from the health of our broader ecosystem.
- Advisory Ventures (Dr. Khaled Al-Mosa Consulting) guides strategic investments, partnerships, and national initiatives to accelerate growth across the biotechnology sector.

In addition to SAUDIBIO and the Vaccine Industrial Company, these ventures collectively form a fully integrated biotechnology ecosystem, spanning research, training, manufacturing, and strategic consulting. This unified approach underpins Saudi Arabia's leap into the life sciences sector and ensures that our progress is sustainable, scalable, and globally competitive.

Alignment with Vision 2030

Every element of this ecosystem directly supports the National Biotechnology Strategy (2024) and advances the pillars of Vision 2030. My work has always been guided by the belief that biotechnology is a national priority with the power to reshape our economy, strengthen our society, and elevate the Kingdom's global standing.

- Thriving Economy: by diversifying into biotechnology and reducing reliance on imported medicines, we are building a resilient, knowledge-based economy.
- Vibrant Society: by ensuring access to insulin, vaccines, and cancer therapies, we are improving quality of life and safeguarding the health of millions.
- Ambitious Nation: by embedding excellence, fostering global partnerships, and driving innovation, we are positioning Saudi Arabia as a rising global leader in biotechnology.

Through these efforts, I am proud to contribute to a future in which Saudi Arabia stands at the forefront of life sciences, innovative, self-reliant, and prepared to meet the health challenges of tomorrow.

Across the institutions I have built, SAUDIBIO, VIC, BIOERA, the Biotech Innovations Company, the Biotechnology Training Institute (BTI), ANIVAX, and the Dr. Khaled Al-Mosa Consulting Firm, I see more than separate achievements. I see a unified, self-reinforcing ecosystem in which each entity addresses a specific challenge while strengthening the others. Together, these institutions create capability across the biotechnology value chain, and that capability is what allows the Kingdom to move from dependence toward resilience.

This is not incremental progress. It is foundational transformation.

Through these enterprises, Saudi Arabia has moved from dependency to sovereignty, from vulnerability to resilience. We have built capabilities that ensure the Kingdom is no longer at the mercy of global supply chains but stands as a regional powerhouse in biotechnology and a rising global contributor to life sciences innovation.

What began as a vision during moments of crisis has become a national asset, one that will protect, empower, and uplift generations to come.

And this journey is only just beginning.

Chapter 10

My Mission: Advancing Biotech Localization to Save Lives

From Vulnerability to Vision: A Personal Call to Protect a Nation's Health

The world was forced to confront a longignored truth: global healthcare systems were fragile, unequal, and deeply unprepared. Nations with domestic manufacturing capabilities protected their populations with timely access to vaccines, while others, regardless of wealth or political influence, waited in uncertainty.

Saudi Arabia, a G20 nation with extraordinary potential, had no vaccine manufacturing facility of its own. To me, this was far more than a technical gap. It was a humanitarian crisis. Millions of lives depended on supply chains we did not control, on foreign factories we did not own, and on geopolitical dynamics we could not influence.

That realization marked a turning point in my life. I chose to act, not merely to build factories, but to safeguard a fundamental human right: the right to health. My mission became unmistakably clear. I would work to ensure that every citizen of Saudi Arabia, and ultimately every person in our region, could access life-saving treatments without dependency or delay.

Creating a Lifesaving Biotechnology Ecosystem for the Future

My work in biotechnology was never intended to culminate in a single company or a solitary breakthrough. From the beginning, I understood that real national resilience demands a complete ecosystem network of interconnected institutions, each solving a different humanitarian challenge and reinforcing the others.

SAUDIBIO (2010)

My journey began with SAUDIBIO, driven by the urgent need to combat diabetes, a disease affecting more than 5.3 million people in Saudi Arabia. Insulin is among the most familiar medicines in modern healthcare, yet for the patient who depends on it, reliable supply is what allows daily life to continue with confidence, dignity, and safety. By producing insulin locally, we set out to ensure that no patient would ever suffer a treatment shortage. The projected annual output of 100 million insulin pens and vials by 2027 is not just a statistic; it represents the protection of millions of Saudis from blindness, kidney disease, and early death.

- SAUDIBIO's commitment to producing insulin and cancer treatments locally.

Vaccine Industrial Company – VIC (2022)

Following SAUDIBIO, VIC was established as the largest vaccine manufacturing plant in the MENA region. VIC produces vaccines for seasonal influenza, pandemic response using cell-based technology, and next-generation vaccines. A vaccine is a form of readiness prepared in advance: protection manufactured before danger arrives, so that a population is not left waiting when a crisis begins. With VIC, we achieved vaccine self-sufficiency for Saudi Arabia's 36 million residents and expanded support to neighboring GCC and MENA countries.

- VIC's contribution to vaccine independence

Biotech Innovations Company for Research & Development

To elevate Saudi Arabia's standing in the global scientific community, I established a dedicated R&D enterprise specializing in biologics, biosimilars, gene therapy, clinical trials, and next-generation medical solutions.

- Advancing research and innovation in biologics, gene therapy, clinical trials, and biosimilar development

Biotechnology Training Institute (BTI)

A thriving ecosystem requires skilled professionals, with Gene Editing advanced as a cross-cutting platform via Biotech Innovations Company. BTI was founded to educate and prepare Saudi scientists and healthcare workers, embedding sustainability and ongoing knowledge transfer within the biotechnology sector.

- Building the next wave of scientific talent

ANIVAX Company (Veterinary Biotech)

Human health goes hand in hand with animal health and food security. ANIVAX boosts our agricultural resilience, protects livestock, and supports the integrity of our food supply systems.

- Safeguarding animal health and food security
- Biotech Industrial Engineering Company – BIOERA
- BIOERA, one of the ecosystem's foundational pillars, was designed to address a vital challenge: building state-of-the-art biotech manufacturing facilities within Saudi Arabia. BIOERA provides ten core services, including site selection, regulatory compliance, equipment acquisition, and workforce planning, offering investors and developers a fully integrated solution. It has become the infrastructure that makes the rest of the ecosystem buildable at scale.
- Building the infrastructure for biotech manufacturing

Advisory Ventures – Dr. Khaled Almosa Consulting Firm

My consulting firm is essential to driving rapid growth, building collaborative partnerships, and ensuring that local and international investments in biotechnology deliver the maximum benefit to society.

- Delivering strategic directions to advance biotechnology

Addressing Humanity's Greatest Health Challenges

My mission focuses on four of the most urgent health challenges facing Saudi Arabia and the world:

1. Diabetes

Localized insulin production means no patient is left behind. Every vial we produce is a life sustained and a family supported.

- Localized insulin as a humanitarian imperative

2. Vaccination

By producing vaccines domestically, we ensure that Saudi Arabia will never again be vulnerable to global shortages. This is not only national security, but also a humanitarian contribution to global pandemic preparedness.

- Building pandemic resilience

3. Cancer

With more than 28,000 new cancer cases annually in the Kingdom, localizing biosimilars and monoclonal antibodies is essential. Affordable, timely therapies directly improve survival and quality of life.

- Expanding access to cancer therapies

4. Genome Editing Therapeutics

Advances in genome editing open the door to treating diseases at their source, correcting genetic errors rather than managing symptoms. By investing in localized development of CRISPRbased and nextgeneration editing technologies, we position Saudi Arabia at the forefront of precision medicine and give patients access to transformative therapies that were once unimaginable.

- Pioneering nextgeneration genetic cures

Vision 2030 and Our Global Responsibility

My work aligns naturally with Vision 2030, which seeks to build a thriving economy, a

vibrant society, and an ambitious nation. Biotechnology is a humanitarian pillar of this vision, not simply an industry. It ensures that economic diversification translates into healthier lives, stronger communities, and global leadership in life sciences.

But my vision extends beyond Saudi Arabia's borders. By building facilities that serve the wider MENA region, I aim to address the global inequity in access to medicines and vaccines. In a world where billions still lack essential treatments, our biotechnology ecosystem stands as a beacon of hope, proof that strategic leadership can transform vulnerability into sovereignty.

My Purpose: Expanding Local Biotech Capacity to Improve and Save Lives

My journey has never been about founding companies for their own sake. It has always been about saving lives. Every insulin pen, every vaccine vial, every cancer therapy we produce represents a human life sustained, a family protected, and a nation strengthened.

By establishing SAUDIBIO, VIC, and the broader biotechnology ecosystem, I have sought to address not only the health needs of Saudi Arabia, but the humanitarian imperative of ensuring equitable access to lifesaving treatments. My mission bridges national needs and global responsibility, localizing biotechnology to save lives and support humanity's future resilience.

Lives Saved Through Local Manufacturing

1. Insulin

When I look at the impact of our insulin localization efforts, I am reminded why I began this mission in the first place. More than 5.3 million people in Saudi Arabia live with diabetes, and for many of them, insulin is not optional; it is the difference between life and death.

The inauguration of our first local insulin manufacturing facility in 2010 was a defining moment for me. For the first time, we ensured continuous access for millions of patients, eliminating the fear of shortages and reducing our dependence on global supply chains.

The impact is profound. By producing insulin locally, we improve affordability, strengthen supply chain resilience, and prevent lifethreatening complications such as ketoacidosis, stroke, and heart failure. In practical terms, this means tens of thousands of lives saved every year, and countless families spared from tragedy.

- Local insulin manufacturing
- supply chain resilience
- preventing diabetic complications

2. Vaccines

Vaccines have always been one of humanity's greatest tools for saving lives. During the COVID-19 vaccination campaign, Saudi Arabia administered over 70 million doses, according to the Ministry of Health and global trackers. By establishing domestic production of critical vaccines, including COVID-19 and seasonal influenza, we have fundamentally strengthened the Kingdom's pandemic readiness and its ability to respond rapidly to emerging threats, reduce mortality, and protect millions of lives from preventable mortality, in this pandemic and the next.[^42]

The longterm impact is staggering. Vaccines prevent diseases such as measles, hepatitis, and influenza, diseases that once claimed countless lives. Over the coming decades, our local production capacity will contribute to saving hundreds of thousands of lives across the Kingdom and the wider region.

- domestic vaccine production
- rapid outbreak response
- preventing infectious diseases

3. Cancer Treatments

According to the World Health Organization's GLOBOCAN 2022 report, published by the International Agency for Research on Cancer (IARC), Saudi Arabia recorded 28,113 new cancer cases in 2022. GLOBOCAN is the world's most widely used and internationally validated source for global cancer incidence, mortality, and prevalence statistics. It compiles data from national cancer registries, health ministries, and epidemiological models to provide standardized, comparable estimates across all countries.

For many patients, timely access to chemotherapy, immunotherapy, and targeted treatments determines whether they survive, or succumb, to their illness.

By localizing the production of cancer therapies, especially for breast, colorectal, and thyroid cancers, we ensure that patients receive treatment without delay and at an affordable cost. This is a humanitarian necessity as much as an industrial achievement.

Early and sustained treatment can increase survival rates by 30–70%, meaning that thousands of lives can be saved every year simply by ensuring that medicines are available when patients need them.

- localized cancer drug production
- timely access to therapy
- improving survival rates

R&D Contributions to Saving Lives

Research and development have become the beating heart of our biotechnology ecosystem. Under Vision 2030, Saudi Arabia has rapidly expanded its clinical trials, scientific research, and biotech innovation capabilities.

Through R&D, we are unlocking breakthroughs that will save lives today and for generations to come. Our work enables:

- personalized medicine for cancer and genetic disorders
- improved drug formulations with fewer side effects
- faster vaccine development for emerging diseases

The impact of this work is immeasurable. R&D accelerates discoveries that can transform the lives of patients with rare diseases, chronic conditions, and complex medical needs. It ensures that Saudi Arabia is not only consuming global innovation, but contributing to it. In many ways, our research efforts represent the future of my mission: a future where science, compassion, and national resilience come together to protect humanity.

When I reflect on the work I have done in biotechnology, I see far more than factories, laboratories, or production lines. I see people, patients, families, communities, whose lives are directly shaped by the decisions we make and the systems we build. My mission has always been rooted in humanity, and every achievement in this sector carries a human story behind it.

Localizing biotechnology is not merely my work; it is my mission to safeguard lives and strengthen humanity's collective resilience in several critical ways by:

- Reducing treatment costs, making lifesaving drugs accessible to lowincome patients. Every time we localize a therapy, whether insulin, vaccines, or cancer treatments, we reduce the financial burden on families. Affordability is not just an economic issue; it is a matter of survival. When a mother can afford insulin for her child, or when a cancer patient can access therapy without delay, we are not just lowering costs; we are giving people a chance to live with dignity.
- Ensuring supply chain stability, especially during global disruptions. The pandemic taught us that dependence on foreign supply chains can cost lives. By producing essential medicines locally, we protect our population from shortages, delays, and geopolitical uncertainty. Stability in healthcare supply is stability in national security.
- Creating local jobs and expertise, strengthening the healthcare ecosystem. Every facility we build becomes a training ground for Saudi scientists, engineers, and healthcare professionals. We are not only manufacturing medicines, but we are also manufacturing knowledge, capability, and national confidence. This growing talent

base ensures that our progress is sustainable for generations.

- Collaborating with global biotech leaders, bringing cuttingedge therapies to Saudi Arabia. Partnerships with international innovators allow us to bring the world's most advanced treatments to our region. These collaborations accelerate technology transfer, elevate our scientific standards, and ensure that patients in Saudi Arabia receive therapies at the same level of excellence available in leading global markets.

As I look toward the future, I recognize that my mission is far from complete. The biotechnology ecosystem we have built is only the foundation. To save even more lives in Saudi Arabia, and to strengthen our role as a regional leader in humanitarian biotechnology, we must continue expanding our capabilities with intention and urgency.

Here are the strategic actions I believe will allow me to deepen and broaden my impact:

Expand local production.

To truly achieve medical sovereignty, we must widen our manufacturing portfolio to include biologics, biosimilars, and treatments for rare diseases. These therapies are often expensive and difficult to access and localizing their production will transform the lives of patients who currently face long waits or prohibitive costs.

- expanding local production

Invest in R&D hubs.

Partnerships with universities, research centers, and global biotech leaders will accelerate innovation within the Kingdom. By strengthening our R&D infrastructure, we can pioneer new therapies, advance precision medicine, and contribute to global scientific breakthroughs.

- investing in R&D hubs

Launch public awareness campaigns.

Saving lives is not only about producing medicines, but also about empowering people with knowledge. Public education on diabetes prevention, cancer screening, and vaccine importance can dramatically reduce disease burden and improve early detection.

- public awareness campaigns

Support clinical trials.

By expanding clinical trial capacity, we can give patients earlier access to innovative therapies while contributing valuable data to the global scientific community. This positions Saudi Arabia as a hub for medical advancement and accelerates the availability of cuttingedge treatments.

- supporting clinical trials

Build regional distribution networks.

To ensure that no patient is left behind, we must strengthen distribution channels that reach underserved and remote areas. Essential medicines should be accessible to every community, regardless of geography or socioeconomic status.

I am reminded that my journey in biotechnology is not a story of what has been accomplished, but a promise of what is still possible. The ecosystems we have built, the medicines we have localized, and the lives we have touched are only the beginning of a larger mission, one rooted in compassion, resilience, and an unwavering belief in the dignity of every human life. My work has taught me that true sovereignty is not measured by wealth or power, but by a nation's ability to protect its people in moments of greatest need. And so, I move forward with a renewed commitment: to continue building, innovating, and serving, until every patient in Saudi Arabia, and every person in our region, has access to the treatments they deserve. This is more than a professional calling; it is the purpose of my life. The future of biotechnology in the Kingdom is bright, and I am honored to play my part in shaping it. The mission continues, and so does the hope it carries.

Epilogue

As I reflect on this chapter of my journey, I see more than a sequence of milestones; I see a vision brought to life through determination, collaboration, and belief in the power of science to transform lives. My mission to localize the production of insulin, vaccines, cancer therapies, and genome-based therapeutics in Saudi Arabia has reshaped our healthcare sector and established the Kingdom as a rising force in global biotechnology.

By 2025, I was humbled to witness the fulfillment of 75% of the strategic objectives outlined in the Kingdom's National Biotechnology Strategy,five years ahead of the Vision 2030 horizon. This achievement was not simply a matter of progress; it showed what becomes possible when national vision meets scientific ambition.

The National Biotechnology Strategy is anchored in four foundational pillars:

- Vaccine Development
- Biomanufacturing
- Genomics
- Plant Optimization

I am proud to have brought three of these pillars, vaccines, biomanufacturing, and gene-editing technologies, to life through the institutions I built and the ecosystems we nurtured.

Saudi Arabia now administers tens of millions of vaccine doses each year across childhood, seasonal, and Hajj-related immunization programs. By establishing the Vaccine Industrial Company (VIC), the largest facility of its kind in the Middle East and North Africa, we have equipped the Kingdom to respond swiftly to public health threats and to reduce dependence on foreign suppliers. During COVID-19, the Kingdom achieved vaccination coverage for nearly 70% of its population, but future resilience demanded autonomy. Today, VIC ensures that in the face of future pandemics, Saudi Arabia will stand prepared, soverei gn, and capable of protecting millions of lives.

For the more than 5.3 million Saudis living with diabetes, local insulin production has saved countless lives. Every vial represents hope restored, families supported, and import dependency replaced with sovereign capability.

Our expansion into biosimilars and monoclonal antibody therapies has brought hope to thousands of families facing cancer. With more than 28,000 new cases annually, timely and affordable access to treatment is a humanitarian imperative, not simply a medical achievement.

These accomplishments mark the fulfillment of 75% of the National Biotechnology Strategy's foundational objectives. This strategy is more than a framework; it is a living commitment. A commitment that Saudi Arabia will chart its own course to lead, to heal, and to innovate with purpose and independence.

Behind every facility, every partnership, and every milestone lies a simple truth: this mission has always been about saving lives. It is about ensuring that no child is denied a vaccine, no patient is left without insulin, and no family faces cancer alone. It is about transforming vulnerability into resilience, dependence into sovereignty, and ambition into reality.

As I look back on this journey, I see more than institutions, strategies, and achievements. I see lives saved, futures secured, and a nation transformed. What began as a vision during a time of global crisis has become a living reality: a biotechnology ecosystem that stands as both a shield for our people and a beacon for the world.

And so, as I reflect on this legacy in motion, I do not see an ending. I see a beginning. A beginning of a future where Saudi Arabia stands as a global leader in biotechnology, where science serves humanity with purpose, and where innovation is unmistakably Saudi.

"I am honored to help save lives in my nation and beyond, and humbled to have been given the title 'Godfather of Biotechnology Manufacturing' by His Excellency Dr. Hussein A. Gezairy."

As Allah, the Exalted says:

"And whoever saves a life, it is as if he has saved all of humanity."

قال تعالى ﴿وَمَنْ أَحْيَاهَا فَكَأَنَّمَا أَحْيَا النَّاسَ جَمِيعًا﴾

– Mā'idah 5:32

By Allah's grace, I stand before you as the driving force behind a transformative mission that has defined my life for over thirty years, a mission rooted in steadfast faith, a profound sense of duty, and unwavering devotion to my homeland. My purpose has been resolute: to safeguard and save countless lives across the Kingdom of Saudi Arabia, and to extend this protection far beyond our borders.

When I embarked on this journey, our nation was almost entirely reliant on external sources for critical medical technologies. Yet I envisioned more for our people. I was convinced Saudi Arabia could achieve self-sufficiency, innovate boldly, and build the scientific infrastructure necessary to secure our future and save lives.

Through relentless dedication, overcoming obstacle after obstacle, I led the establishment of manufacturing plants from the ground up. I championed the training and empowerment of young Saudi scientists, who now stand as leaders in their fields. Under my leadership, we brought life-saving therapies, once deemed unattainable, into reach, including insulin, human and animal vaccines, advanced cancer treatments, plasma-derived products, and pioneering gene therapies.

Each success marked far more than a scientific breakthrough. It meant lives rescued, families preserved, and the fortification of our nation's resilience.

This mission has never been about personal gain. It has always been about service, service to my country, to all of humanity, and to the sacred values entrusted to us by Allah: compassion, responsibility, and the preservation of human life.

As biotechnology continues to reshape our world, my dedication remains unwavering. I will persist in breaking new ground, building new capabilities, and leading efforts to empower every nation, and especially ours, to heal its people and stand strong against every adversity.

"This is my mission. This is my conviction. And, with Allah's continued blessings, I will carry forth this legacy of saving lives for as long as I am able."


وَمَنْ أَحْيَاهَا فَكَأَنَّمَا أَحْيَا النَّاسَ جَمِيعًا

قال تعالى: ﴿ وَمَنْ أَحْيَاهَا فَكَأَنَّمَا أَحْيَا النَّاسَ جَمِيعًا ﴾

"AND WHOEVER SAVES ONE LIFE - IT IS AS IF HE HAD SAVED ALL OF MANKIND"

A VERSE THAT EMBODIES THE NOBLE MISSION GUIDING DR. KHALED AL-MOSA'S LIFELONG DEDICATION TO PROTECTING AND SAVING LIVES ACROSS THE SAUDI NATION AND BEYOND.

APPOINTED IN MARCH 2021 BY DECREE OF HIS ROYAL HIGHNESS THE CROWN PRINCE AND PRIME MINISTER MOHAMMED BIN SALMAN, DR. AL-MOSA SERVES AS THE PRIVATE SECTOR REPRESENTATIVE TO THE SUPREME COMMITTEE FOR RESEARCH, DEVELOPMENT, AND INNOVATION, CHAIRED BY HIS ROYAL HIGHNESS UNDER THE COUNCIL OF ECONOMIC AND DEVELOPMENT AFFAIRS.

WITH MORE THAN THREE DECADES OF SCIENTIFIC, INDUSTRIAL, AND EXECUTIVE LEADERSHIP, DR. AL-MOSA HAS PLAYED A PIVOTAL ROLE IN THE KINGDOM'S BIOTECHNOLOGY TRANSFORMATION. HIS LEADERSHIP IN LOCAL MANUFACTURING, STRATEGIC TECHNOLOGY TRANSFERS, AND THE ESTABLISHMENT OF SOVEREIGN NATIONAL CAPABILITIES IN INSULIN, VACCINES, CANCER THERAPEUTICS, AND GENE THERAPY HAS STRENGTHENED SAUDI ARABIA'S HEALTH SECURITY AND ADVANCED HIS CORE MISSION OF SAVING LIVES WITHIN THE KINGDOM AND FAR BEYOND ITS BORDERS.

HE HAS DRIVEN NATIONAL PROGRESS IN BIOPHARMACEUTICAL DEVELOPMENT, INDUSTRIAL BIOTECHNOLOGY ENGINEERING, AND WORKFORCE DEVELOPMENT ACHIEVING THREE OF THE FOUR PILLARS OF THE NATIONAL BIOTECHNOLOGY STRATEGY LAUNCHED BY HIS ROYAL HIGHNESS THE CROWN PRINCE AND PRIME MINISTER IN 2024, AND LAYING THE STRUCTURAL FOUNDATIONS OF A MODERN, RESILIENT BIOTECHNOLOGY ECOSYSTEM.

GUIDED BY A CLEAR NATIONAL VISION, DR. AL-MOSA CONTRIBUTES TO POSITIONING SAUDI ARABIA AS A GLOBAL BIOTECHNOLOGY HUB BY 2030, CAPABLE OF MEETING ITS OWN CRITICAL HEALTH NEEDS AND SUPPORTING THE BROADER ASPIRATIONS OF VISION 2030 THROUGH SCIENTIFIC INNOVATION AND GLOBAL HEALTH IMPACT.

DR. AL-MOSA IS HONORED TO BE RECOGNIZED AS THE "GODFATHER OF BIOTECHNOLOGY IN SAUDI ARABIA," A TITLE BESTOWED BY H.E. DR. HUSSEIN AL-GEZAIRY, FORMER WHO REGIONAL DIRECTOR, FORMER SAUDI MINISTER OF HEALTH, AND FOUNDING DEAN OF THE COLLEGE OF MEDICINE AT KING SAUD UNIVERSITY.

DR. KHALED AL-MOSA