هيئة تنمية البحث والتطوير والابتكار
Research Development and Innovation Authority

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# Sustainable Environment and Supply of Essential Needs RDI National Priority in Saudi Arabia: Analytical Study

Executive Summary

Innovation Ecosystem in Focus

# Contents

## INTRODUCTION

Based on its geography, the Kingdom of Saudi Arabia has a track record of producing water and food in challenging natural environments. This track record stems from innovative solutions, including well-developed water supply via desalination and arid environment agriculture.

These capabilities have significant potential to improve and help overcome global challenges to meet people's essential needs, particularly as changes to global climate potentially exacerbate water access and harm agricultural output. In addition, Saudi Arabia's natural geography places more significant pressure on specific climate challenges, including reducing surface temperatures, providing lower energy-consuming cooling technology and ultimately achieving a goal of net-zero carbon emissions by the Kingdom.

This study prioritizes the RDI Missions:

- Mission 2.3 Develop technologies in food for sustainable and resilient food systems to achieve more than 50% self-sufficiency by 2040.
- Mission 2.4 Achieve net-zero emissions by 2060.
- Mission 2.5 Decrease the withdrawal of non-renewable water by 90% and the cost of water production by 50% by 2035.

Sustainability and Essential Needs is a complex and constantly evolving technology domain.

This is due to the recent impacts of digital, electrical-related research topics bringing new approaches to traditional processes of providing core outputs to an economy such as food and water.

The sustainability lens applied to conventional mechanical and biochemical processes such as water desalination, agrochemicals and waste management brings efficiency, technology and potential linking of previously parallel processes and technology ecosystems.

Within Sustainability and Essential Needs related research topics, there are specific intellectual property factors to consider:

- Without apparent technical innovations, patentability could impact research topics relying on natural processes (e.g., agriculture or plant breeding).

- Protecting cells, tissues or naturally occurring processes with patent rights is impossible in many jurisdictions. However, it may be possible to protect synthetic innovations that mimic or optimize natural processes. This distinction could be particularly relevant in

biological therapies and gene-editing approaches, such as agriculture.

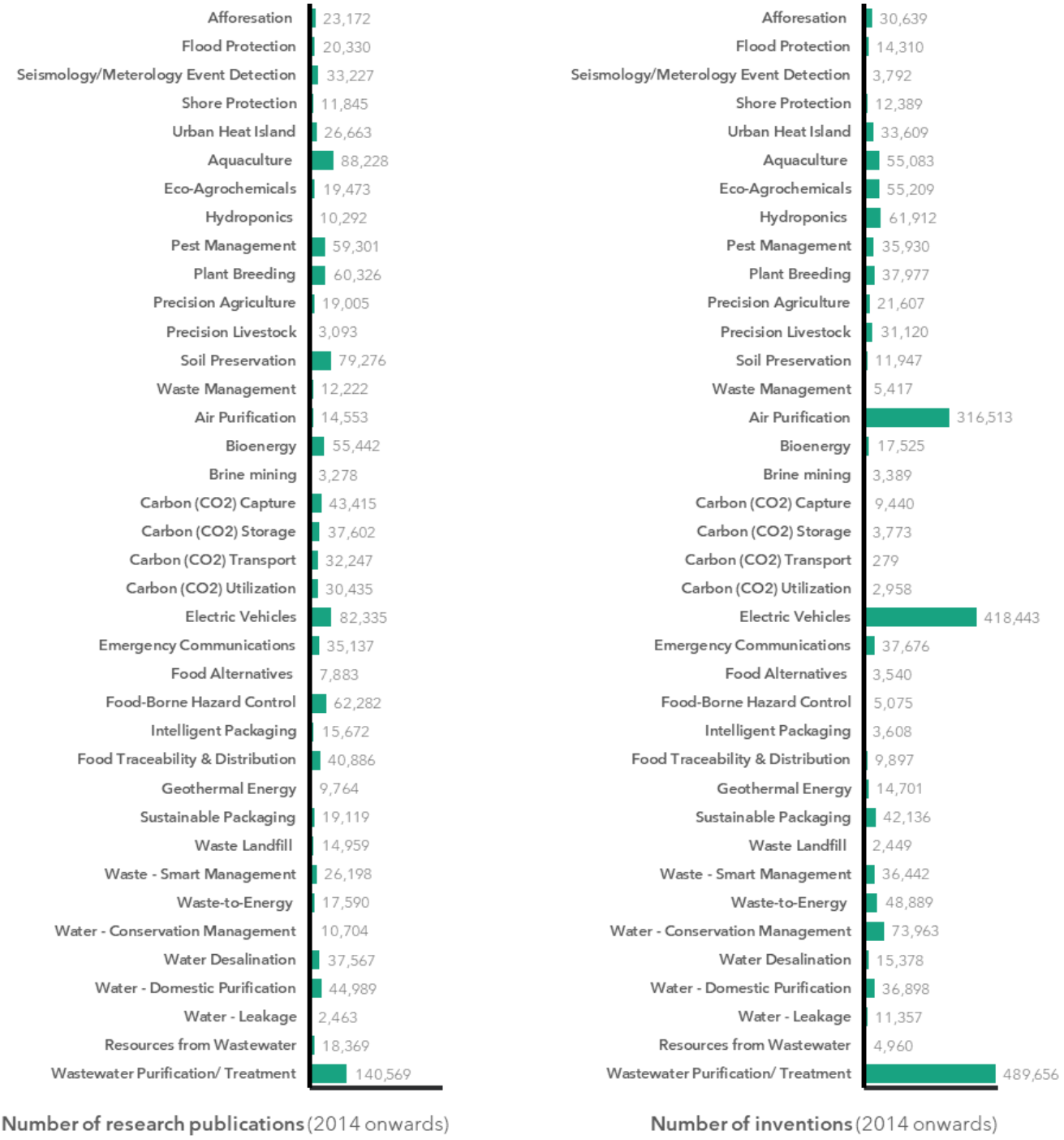
- Initiatives like the Green Patent Highway (GPH) expedite the examination process and can significantly reduce the time to market for innovations in renewable energy technologies, such as solar panels and wind turbines.

- WIPO Green facilitates international cooperation by connecting innovators with those needing sustainable technologies (e.g., in desalination, carbon storage), promoting broader access to patented green innovations.

- Corporations and academic institutions increasingly align their efforts with the United Nations Sustainable Development Goals (SDGs). For instance, patents in sustainable agriculture technologies, such as drought-resistant crops, directly support SDG 2 (Zero Hunger) and SDG 13 (Climate Action).

The complete list of research topics that define the national priority area of Sustainability and Essential Needs within this study, with global volumes across research publications and inventions, is shown in Figure 1.

*Figure 1: Overview of the number of research publications and inventions within Sustainability and Essential Needs between 2014 and 2023*



## OVERVIEW

The Sustainability and Essential Needs priority area of RDI represents an opportunity to transform the lives of the local population within Saudi Arabia regarding food and water supply, along with the natural environment, including agriculture, atmosphere and sustainable transport through electric vehicles.

RDIA is dedicated to steering and executing the Kingdom's RDI strategies across the four national priorities. It has led the organization of capacity-building activities, equipping Saudi leaders and practitioners with the vital skills needed for sustainability innovation.

- King Saud University, King Abdulaziz University, King Fahd University of Petroleum (KFUPM) and Minerals and King Abdullah University of Science and Technology (KAUST) were regularly among the top 5 publishing entities in Saudi Arabia.

- The top four Saudi organizations in terms of the number of papers published with an industry collaboration in the area of Sustainability and Essential Needs are KAUST, King Abdulaziz University, King Saud University and KFUPM, with the last three sharing second place.

Many Sustainability and Essential Needs research topics fall into the Technology Readiness Level (TRL) level 5. Only two research topics, Electric Vehicles and Wastewater Purification, sit in the higher TRL levels of 7-9.

The overall impact of medium TRL will be a balance of research and invention volumes, while technology has not yet matured enough to satisfy market needs. Subsequently, the time to return on investment may be slower than more mature research topics. Nonetheless, Saudi Arabia's heritage conducting research at scale in drought and heat-stressed environments could be the catalyst required to produce the innovations of the future in the field of Sustainability.

Saudi Arabia is set up for success by leveraging corporations such as Saudi Aramco with research synergies, particularly across Water and Carbon-related research topics.

**Key Opportunities within Sustainability and Essential Needs:**

- **Prioritize higher performing and higher commercial potential research topics:** Key research topics within Sustainability and Essential Needs have significant commercial potential, specifically Electric Vehicles, Water Desalination and Wastewater Purification. Combined, these three research topics have the potential to generate $2.33Bn for the Saudi Arabian economy if 7,500 inventions are protected,

generating the expected yield of very high-strength inventions, and are subsequently successfully commercialized.

- **Select key academic-corporate partnerships (ACP) for specialized ecosystems:** Focusing on Electric Vehicles; Hyundai, Kia Motors, or Toyota have significant invention portfolios and experience with collaborative commercial research with academia and could, therefore, be suitable partners to expand and accelerate Saudi technology transfer in local and global markets.

- **Accelerate the creation of the Saudi Arabian Sustainability private sector:** To commercialize Sustainability and Essential Needs research topics, ambitious economies should consider both local and global markets and, therefore, require IP protection. The vehicle for IP protection could be start-ups, joint ventures or existing corporations such as Saudi Aramco, which are synergistic with existing business lines. Electric Vehicles progress includes Lucid Group building Saudi Arabia's first electric vehicle manufacturing site. To fully realize the potential of the EV space, other research topics should be considered, such as battery management. These actions align with RDIA's mission 3.6 Become the 4th largest producer of EVs and EV batteries by 2035.

- **Funding local academia in key research topics with lower TRL will provide long-term value:** Research topics such as Eco-Agrochemicals, Carbon (CO2) Transport, Food Alternatives, Food-Borne Hazard Control and Traceability and Distribution may benefit from additional foundational academic research. In contrast, Water Domestic Purification, Wastewater purification and Water Desalination require greater technology transfer and further research funding.

- **Build an ecosystem around Saudi Aramco's Sustainability and Essential Needs diversification**: Saudi Aramco has innovation in the fields of Desalination, Electric Vehicles, Carbon (CO2) Transport, Landfill Waste, Water – Conservation Management, Domestic Purification, Leakage, Wastewater purification. These areas have planned long-term investments and leverage Saudi Aramco's scale and expertise. Research topics that are not strategically important to Saudi Aramco should receive investment into alternative private organizations to work closely with local academia.

Reflecting on the natural resources and challenges underpinning the development of desalination, solar panel and carbon transport research topics, Saudi Arabia has considerable potential to drive and obtain a significant return on investment in the

Sustainability and Essential Needs research topics.

Nonetheless, the route to market, time to reap the rewards and local compared to global market strategy will differ significantly across research topics such as Water, Carbon and Electric Vehicles.

The insight within this study provides a multi-dimensional evaluation of research topics within the Sustainability and Essential Needs priority area to provide key actions and options to consider and benchmarks against global leadership. Subsequently, the tailored insight, metrics and findings can enhance both the foundational research within academia and commercially applied innovation to achieve the national missions and aspirations of Saudi Arabia.

# 120M SAR

**funding allocated for 100 research groups across Sustainability and Essential Needs**

## KEY FINDINGS

Drawing upon the insights from research and invention performance, Academic-Corporate Partnerships, and the Technology Maturity evaluation for Saudi Arabian and global organizations, this section provides key actions tailored to Saudi Arabia's relative position for each technology, using industry-leading metrics to offer the next steps.

These findings outline the potential of the research topics specifically for Saudi Arabia, where to invest, and whether more academic funding is required. The findings also outline further Academic-Corporate Partnerships, the transfer of technology from academic to private entities, and the potential for continuing existing strategies.

*Table 1: Sustainability and Essential Needs research topic scorecard.*

| | | | | High | Medium | Low |
|---|---|---|---|---|---|---|
| | Saudi Arabia's Research Strength | Saudi Arabia's Invention Strength | Saudi Arabia's Partnership Strength | Saudi Arabia's research productivity | Technology Maturity | Future Predicted Growth |
| Eco-Agrochemicals | 399 | 156 | 0.3% | 2.69 | 5 | 5.1% |
| Carbon (CO2) Transport | 893 | 74 | 2.5% | 0.98 | 4 | 11.0% |
| Electric Vehicles | 1935 | 2566 | 2.1% | 2.13 | 7 | 8.3% |
| Food - Alternatives | 142 | 0 | 0.0% | 1.11 | 4 | 6.7% |
| Food - Food-Borne Hazard Control | 1634 | 177 | 0.9% | 1.02 | 5 | 7.4% |
| Food Traceability & Distribution | 814 | 387 | 1.7% | 2.78 | 5 | 7.8% |
| Waste Landfill | 242 | 483 | 0.0% | 1.42 | 3 | 8.9% |
| Water - Conservation Management | 327 | 1281 | 1.0% | 2.16 | 5 | 6.8% |
| Water - Desalination | 3290 | 3571 | 3.6% | 0.86 | 4 | 7.1% |
| Water - Domestic Purification | 1249 | 1613 | 3.0% | 0.69 | 6 | 6.3% |
| Water Leakage | 48 | 314 | 1.6% | 1.83 | 5 | 7.8% |
| Water - Wastewater Purification/ Treatment | 6148 | 11912 | 1.2% | 0.68 | 7 | 6.3% |

The scorecard above contains factors analyzing Saudi Arabia's position per research topic. They are defined as:

- **Research Strength:** Total number of Saudi Arabian research papers multiplied by CNCI. A document's Category Normalized Citation Impact (CNCI) is calculated by dividing the actual count of citing items by the expected citation rate for documents with the same document type, year of publication and subject area.

- **Invention Strength:** Total number of Saudi Arabian inventions multiplied by the Derwent Strength Index (DSI). This is a Clarivate™ metric of the strength and quality of a patented idea. Based on the impact of the invention on others (based on the frequency of downstream citation by the patent applications of third parties), the global footprint of patents granted (based on the % of world GDP covered by the patent asset), the investment level in the invention by the applicant (based on the number of patent jurisdictions in which the applicant sought protection) and the inventions rarity (based on the number of inventions in the global database that share the same technology mix).

- **Partnership Strength:** The mean partnership % for research papers and inventions in Saudi Arabia.

- **Research Productivity:** Productivity relative to global productivity is measured by the number of Saudi Arabian papers on a specific research topic divided by the number of global documents on the same research topic and period.

- **Technology Maturity:** Each research topic within the National Priority Areas is mapped to an individual Technology Maturity Index from 1—least mature through 9—most mature.

- **Future Predicted Growth:** CAGR predicted growth extrapolated from historic inventions level.

In all the investigated research topics, except for Eco-Agrochemicals and Water Conservation Management, at least five of the top 10 collaborators with Saudi Arabia in terms of the number of documents were also among the top 10 globally in terms of the number of documents. This shows that Saudi Arabia collaborates with key global players on those research topics.

**Electric Vehicles and Water Desalination** score highly on research and invention output and quality. These research topics also score medium and high, respectively, on partnership levels, averaging 2.1% and 3.6% across research publications and inventions. Electric Vehicles also score highly against research productivity and technology maturity. At the same time, Water Desalination has a technology maturity of 4/9 and only 0.86% research productivity. The future predicted growth is 8.3% and 7.1%, respectively. The above metrics are on 1,087, and 2,244 research papers, along with 75 and 117 inventions, respectively. Notably, there are **10-20 times more research papers than inventions generated in both research topics.** The level of inventions from Saudi Arabian corporations is relatively low, with representation only from Saudi Aramco.

Subsequently, for **Electric vehicles, suitable international partners** could be organizations such as Hyundai, Kia Motors or Toyota based on overall invention levels, high invention scores and high levels of academic-corporate partnerships. Existing Electric Vehicle inventions could be licensed to international corporations or considered for spinning out start-ups. Electric Vehicle research topics could add $1.33 billion to Saudi Arabia's economy. If 2,500 inventions are protected in this field, the likely yield would be around 30 very strong inventions.

Due to lower technology maturity of 4 out of 9 in the scorecard, **Water desalination** research topics **could benefit from further academic funding within local academia, as** seen in Figure 2 for inventions and Figure 3 for research papers such as King Fahd University of Petroleum and Minerals, KAUST, along with Saudi Aramco and Saudi Water Authority due to their size and specialism in this technology area. Water desalination could add $0.23 billion to Saudi Arabia's economy. If 833 inventions are protected in this field, the likely yield would be around five very strong inventions.

**"Electric Vehicle research could add $1.3 billion to Saudi Arabia's economy. If 2,500 inventions are protected in this field, the likely yield would be around 30 very strong inventions."**

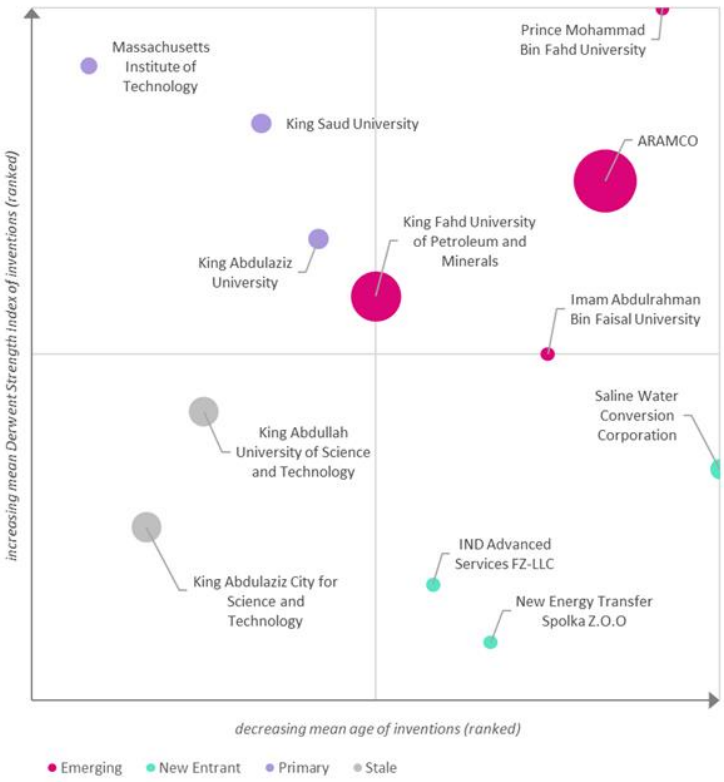



*Figure 2: Commercial dynamics model for the top patent assignees active in Saudi Arabia in the research topic Water Desalination*

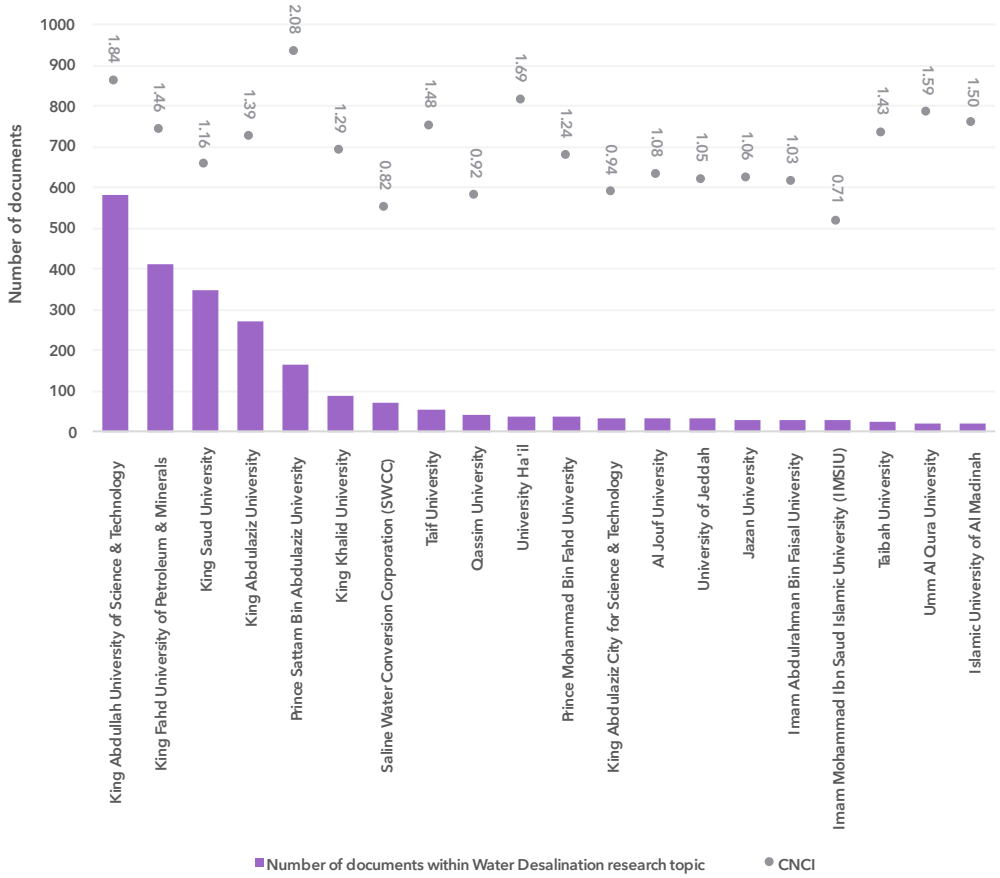



*Figure 3: Top 20 Saudi organizations in terms of publications published in the research topic Water Desalination in the period 2014-2023 and their corresponding CNCI.*

**Eco-agrochemicals, Carbon (CO2) Transport and Food – Alternatives** all have low levels of research paper volume and quality metric forming Research Strength; they also have lower Invention Strength derived by volume and strength of inventions.

The Technology Maturity level is 5, 4 and 4, respectively **suggesting these research topics are not ready for commercial production;** subsequently, these research topics **could benefit from additional academic research.** Carbon (CO2) Transport has a high predicted growth rate of 11% and ACP in research papers of 2.52%. Eco-Agrichemicals and Food – Alternatives are lower with 5.1% and 6.7%, respectively.

There is a notable difference in the research paper to invention levels across these research topics 319: 2, 436: 2, and 96:0. These ratios and **no ACP inventions** further suggest additional academic research would be beneficial.

Within **Carbon (CO2) Transport**, Saudi Aramco could collaborate with international research organizations seen in Figure 4, such as China University of Mining & Technology, Sinopec or Marathon Petroleum along with King Saud University, KAUST KFUPM and King Abdulaziz University and/or other carbon tech leaders.

**Agriculture – Agrochemicals** could further enhance academic research levels by forming partnerships between Saudi Aramco and international research leaders such as the Institute of Animal Sciences of CAAS, the Chinese Academy of Science or Guangxi Zhuang Autonomous Region Institute of Shandong Sunway Gardening Technology, all of whom have over 150 inventions of the highest global average invention strength.

**Food – Alternatives** may benefit from further academic research from King Saud University, King Abdulaziz University, Umm Al Qura University and Taif University.

**Food-Borne Hazard Control** and **Traceability & Distribution** both have low invention strength scores and volumes. However, Food-Borne Hazard Control has a medium-level research score, focusing on micro-topics, as seen in Figure 5.

**Traceability & Distribution** have medium levels of ACP and high research productivity, whereas these factors are low for Food-Borne Hazard Control.

Considering the medium technology maturity and predicted invention level growth, it is **suitable to provide academic research funding;** however, it prioritizes other research topics within Sustainability and Essential Needs, such as Electric Vehicles, Water Desalination and Conservation Management. In the area of Food-Borne Hazard Control, KFUPM holds three inventions, and KACST holds one invention.

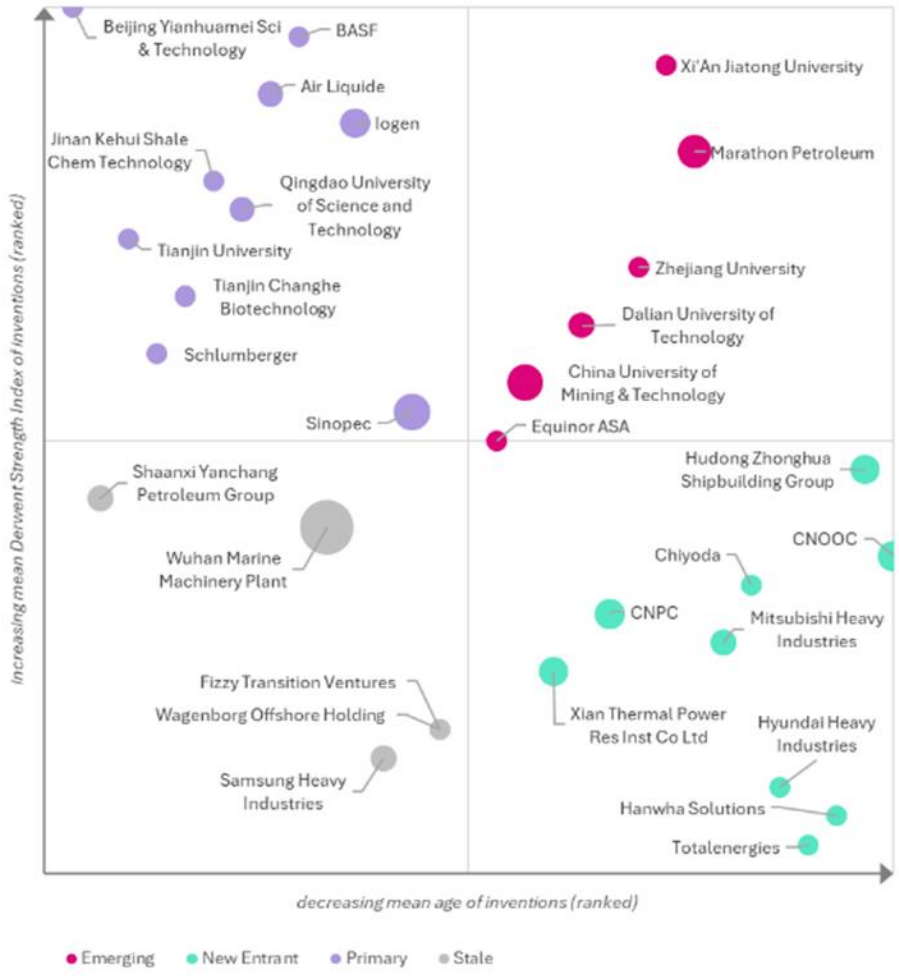



*Figure 4: Commercial dynamics model for the top global patent assignees in the research topic Carbon (CO2) Transport*

**Waste Landfill** research topics have a low level of research and invention strength and volume in Saudi Arabia. There are no ACPs and low technology maturity, but there are high predicted levels of growth. Considering the low level of research papers 159 and inventions 14, **it is considered only for ad-hoc academic research funding to existing local research institutes** such as KFUPM and Saudi Aramco.

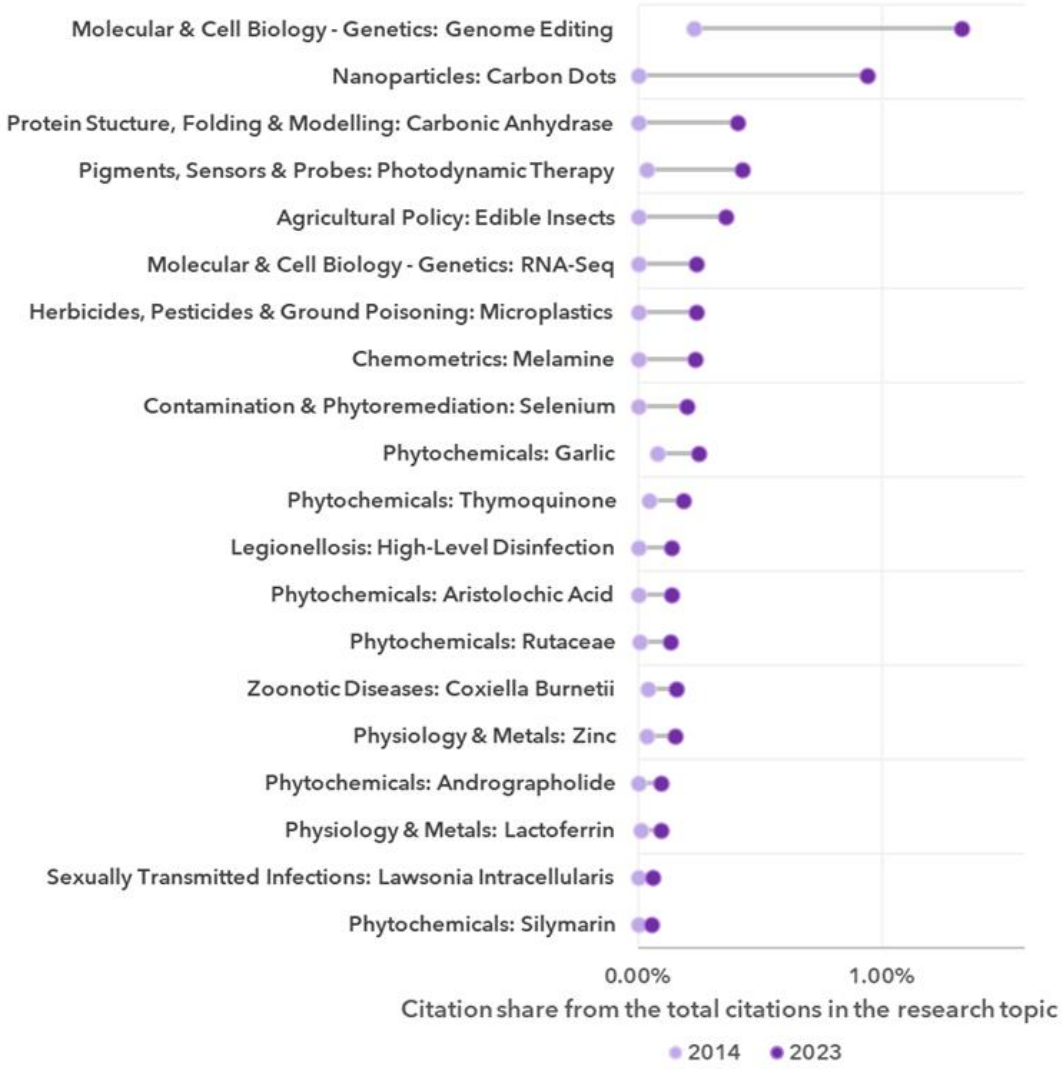



*Figure 5: Top 20 emerging micro-topics globally in the research topic Food-Borne Hazard Control in the period 2014-2023*

**Water Conservation Management** is a field with low research strength and high invention strength. It also has low ACP levels. It has high research productivity and medium technology maturity. 155 research papers and 46 inventions were produced in Saudi Arabia during the last 10 years. This ratio suggests that investing further in academic research could yield more Saudi Arabian inventions. KAUST, KFUPM and Saudi Aramco hold all of the inventions emanating from Saudi Arabia. Therefore, ACP between these three organizations and **further funding may increase the invention yield**.

**Water – Domestic purification** has low research paper strength and volume compared to medium invention volume and strength. There has been an average of 3% ACP production of research and inventions. There has been low research productivity, medium technology maturity and low predicted invention growth. Due to the technology maturity of 6, **consider utilizing the existing 49 inventions**, especially from Saudi Aramco, King Fahd University of Petroleum & Minerals and King Abdullah University of Science & Technology.

**Water Leakage** is a field with low research volume and strength and low invention volume and strength in Saudi Arabia. This technology has medium ACP levels, research productivity, technology maturity and predicted future growth. Saudi Aramco holds three inventions, and KFUPM holds five inventions. This area may require focused **academic funding or in-sourcing technology** to assist with Saudi Arabia's natural arid climate. Mainland China has significant invention leadership in this field, as seen in Figure 6.


*Figure 6: Global distribution of inventions related to Water leakage. The size of each bubble corresponds to the number of unique inventions published in that country or jurisdiction.*

**Wastewater Purification/Treatment** is an area of low research volume and strength; however, it is very high in invention volume and strength, as seen in Figure 7. There has been a medium level of ACPs and low research productivity, and it is a mature technology with low predicted invention-level growth.

Therefore, there is an opportunity to focus on applying these existing inventions in the market from local innovators: Saudi Aramco - 107, King Abdulaziz University - 25, Imam Abdulrahman Bin Faisal University – 17 and King Saud University – 14 inventions, respectively. **Spinning out a start-up from these research organizations could be a successful way to commercialize the research topics.** It is predicted that Water – Wastewater Purification/Treatment could add **$0.77 billion to Saudi Arabia's economy**; if **4,167 inventions** are protected in this field, the likely yield would be around 18 very strong inventions.

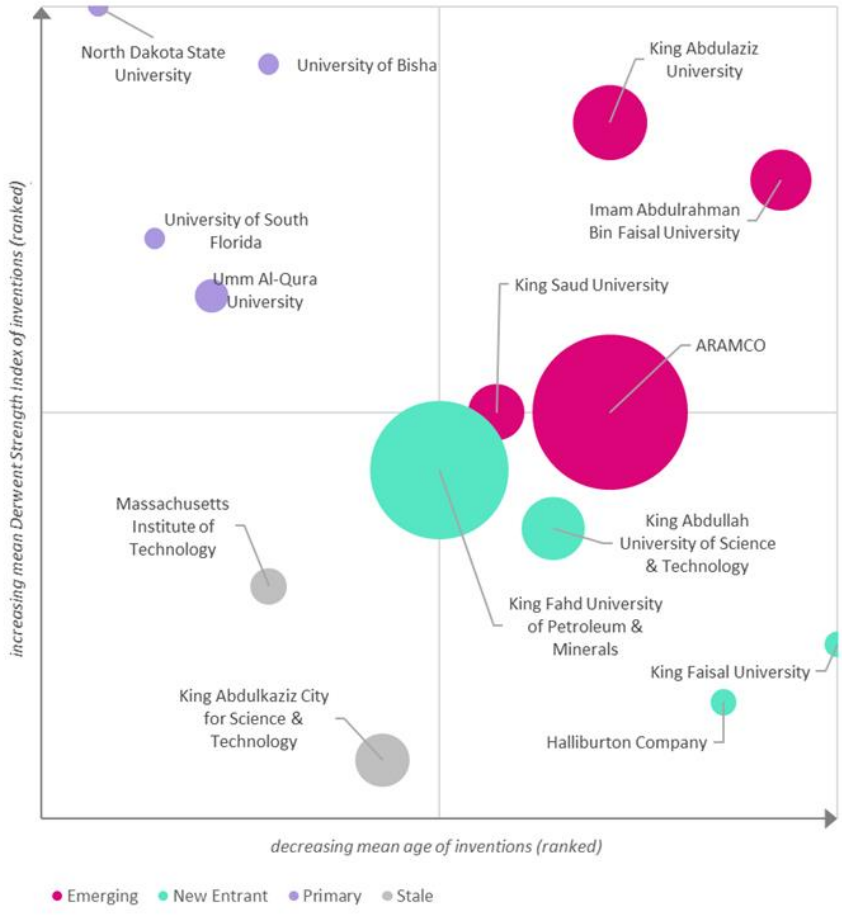



*Figure 7: Commercial dynamics model for the top patent assignees active in Saudi Arabia in the research topic of Wastewater Purification*

In conclusion Sustainability and Essential Needs research topics within Saudi Arabia have a strong base of academic research linked to medium technology maturity, with only Electric Vehicles and Wastewater Purification categorized as a high technology maturity field.

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