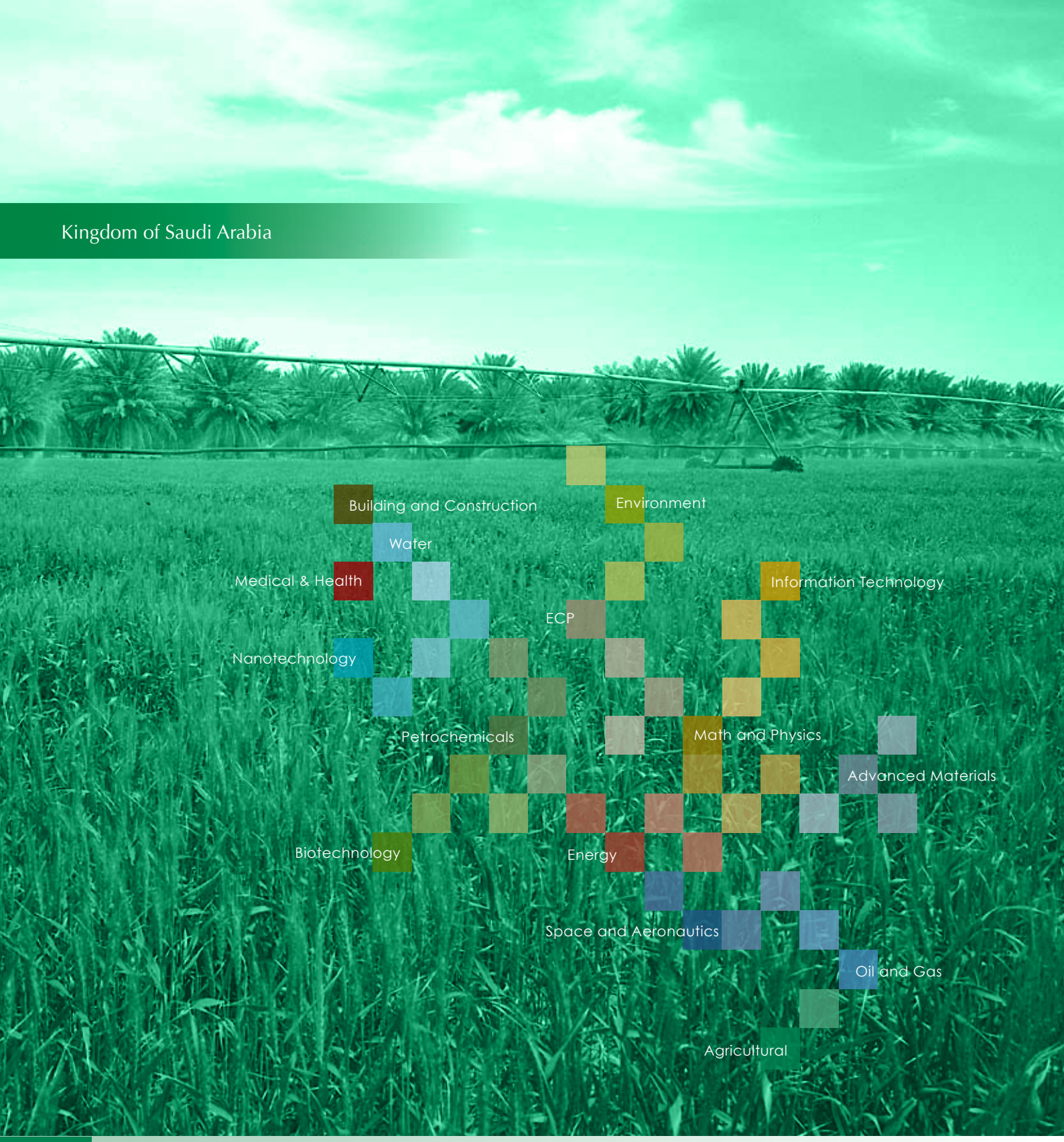
Kingdom of Saudi Arabia



Strategic Priorities for Agricultural Technology

مدينة الملك عبدالعزيز
للعلوم والتقنية KACST
King Abdulaziz City for Science and Technology

Kingdom of Saudi Arabia
Ministry of Economy and Planning
http://www.mep.gov.sa

Kingdom of Saudi Arabia

King Abdulaziz City for Science and Technology

Ministry of Economy and Planning

Strategic Priorities for Agricultural Research

Contents

Contents

Executive Summary

The National Policy for Science and Technology, approved by the Council of Ministers in 1423 H (2002 G), defined programs for localization and development of strategic technologies that are essential for the Kingdom's future development. The King Abdulaziz City for Science and Technology (KACST) was given responsibility for developing 5-year strategic and implementation plans for each of these 14 technology programs.

In addition, KACST facilitated strategic planning in key applied technology areas that draw upon fundamental technologies and impact human lives.

However, many critical issues remain to be addressed. For example, the country has limited water resources and expansion of water-intensive farming has put additional stress on the national water resources. Expansion of agriculture in certain areas and certain crops has threatened the rural-urban development balance as well as the balance across the sector's value chain. Lack of policy attention and programmatic interventions have resulted in limited growth in value-added manufactured food products.

Given these and other challenges and the accelerating pace of progress in science and technology around the world, it is a national imperative for the Kingdom to draw appropriate technology road maps and strategies for the agricultural sector.

Realizing the impending need to address important challenges facing the sector, agricultural technology research and innovation have received utmost priority in the country's science policy agenda. In keeping with its national policy making and technology planning responsibility, KACST collaborated with major stakeholders to develop a National Agricultural Technology for the Kingdom. This document embodies the product of that stakeholder-driven strategic planning endeavor.

This plan is based on input from the users and stakeholders of agricultural technology in the Kingdom, including research organizations, government agencies, universities and industry. The plan received extensive input, review, and comment from stakeholders as well as experts from reputed global institutions.

Executive Summary

The planning processes

- Identified the key needs of the Kingdom for agricultural research and innovation
- Assessed the strengths, weaknesses, opportunities, and threats for the program, including an analysis of KSA research performance
- Defined a mission and vision for the program
- Defined the key technologies and other program areas needed to address the Kingdom's needs in agricultural research and innovation

In addition to the technical needs, strategy participants identified a number of areas where policies need to be changed or barriers removed to facilitate agricultural technology innovation. These needs include:

- Policies to facilitate research and development (R&D) collaboration between KACST, universities, and industry.
- Policy and organizational changes in research performing institutions
- Expanded human resources for R&D.
- Provision of incentives, learning opportunities and career development paths for research professionals.

A number of priority technology areas emerged from this process. These are categorized under the following higher-level categories:

- **Production**
  - Plant Production
  - Animal Production
  - Aquaculture
- **Manufacturing**
  - Food
  - Non-food
  - Aquaculture
- **Natural Resources**
  - Pastures and Forests
  - Genetic Origins

Introduction

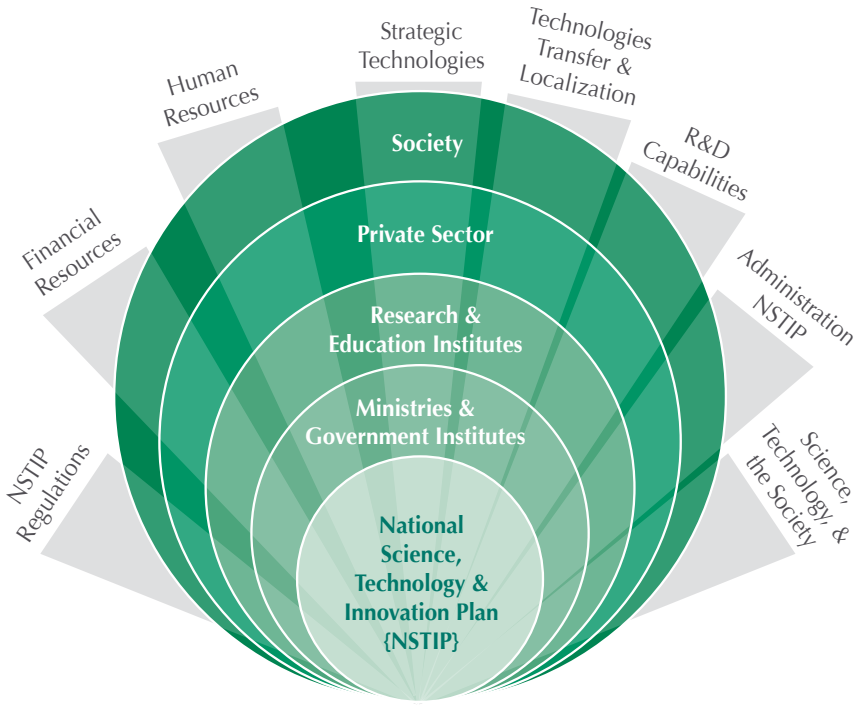
Background

The King Abdulaziz City for Science andTechnology(KACST)wasdirected by its charter of 1986 to "propose a national policy for the development of science and technology and to devise the strategy and plans necessary to implement them." In accordance with this charter, KACST launched a comprehensive effort in collaboration with the Ministry of Economy and Planning (MoEP), to develop a long-term national policy on science and technology. In July 2002, the Council of Ministers approved the national policy for science and technology, entitled "The Comprehensive, Long-Term, National Science and Technology Policy."

KACST and MoEP embarked on a national effort in collaboration with stakeholders to develop the national plan for science, technology and innovation (STI), which drew up the future direction of science, technology and innovation in the Kingdom, considering the role of KACST as well as that of that of universities, government, industry, and society at large. The plan encompasses eight major programs, depicted in figure 1, as follows:

- Strategic and advanced technologies.
- Scientific research and technical development capabilities.
- Transfer, development, and localization of technology.
- Science, technology, and society.
- Scientific and technical human resources.
- Diversifying financial support resources.
- Science, technology, and innovation system.
- Institutional structures for science, technology, and innovation.

Figure 1: Science and Technology Plan



In the "Strategic Technologies" area, KACST is responsible for 5-year strategic and implementation plans for 14 technologies. In addition, KACST facilitates strategic planning in key applied technology areas that draw upon fundamental technologies and impact human lives.

In keeping with this responsibility, KACST collaborated with relevant stakeholders to develop an agricultural technology strategy for the Kingdom. This document embodies the product of that stakeholder-driven strategic planning endeavor.

Scope

The scope of this plan is national: it is an agriculture research and innovation plan for the Kingdom of Saudi Arabia. It details the strategic plan for acquisition, development and transfer of agricultural technologies in the Kingdom for the next five years (2010-2015). It was developed by KACST's strategic planning department, in a coordinated effort involving key public and private sector organizations from food and agriculture stakeholders.

Introduction

The plan sets a vision and mission and strategic objectives aligned with the goals of the National Science & Technology Plan, taking into consideration the current and prospective scientific and research potential and needs of the Kingdom. It identifies stakeholders and users, determines the highest priority areas, and sets ambitious, yet realizable goals for the program.

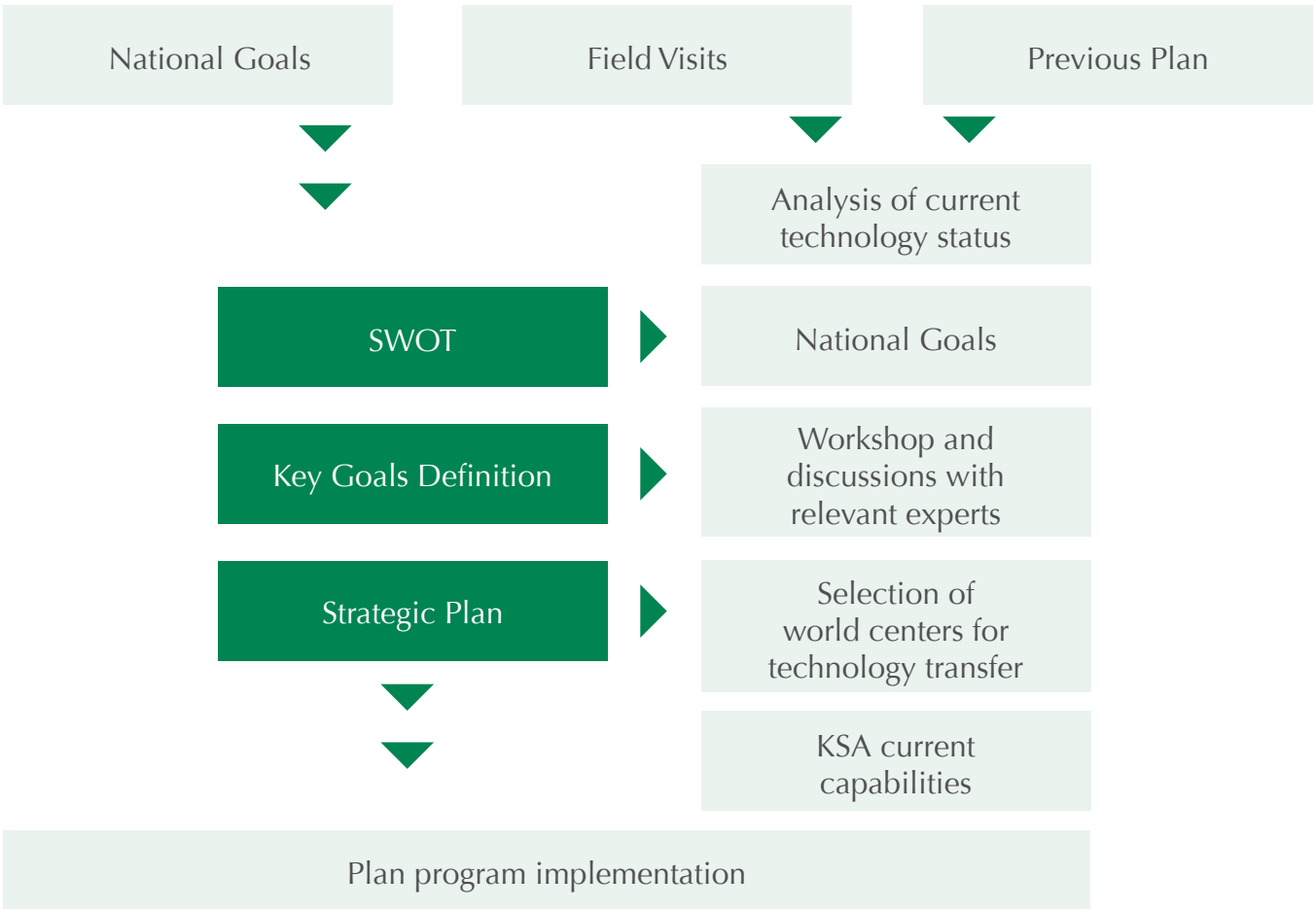
The plan focuses on three main issues: production, manufacturing and natural resources. Within each focal area, sub-areas are identified and specific paths to technologies and applications are developed to meet the goals of the national strategic plan.

Plan Development Process

The development of this plan began with identifying the stakeholders and users of agriculture research and innovation in the Kingdom. An assessment of broad national development goals, followed by a deep analysis of current activities, needs and challenges, set the foundation for the research strategy development phase.

Understanding current and emerging technology trends, combined with an understanding of the national needs, allowed the strategy development team to set national technology goals and identify paths to attain those goals. The plan development methodology is summarized in figure 2.

Figure 2: Plan Development Methodology



As presented above, a series of workshops, which included experts in fields related to agricultural technology, was held to evaluate the Kingdom's current status in terms of production, pastures and mechanization. In these workshops, the most significant regional and international agreements, as well as relevant legislations and laws were discussed. R&D related stakeholders were identified and convened to exchange views. Current global technology trends were examined and challenges and issues facing agriculture in the Kingdom assessed. A SWOT analysis was conducted before the Kingdom's key R&D needs and priorities in agriculture were identified.

Strategic Context

The Kingdom's population is estimated to be approximately 27 million, and growing at 2.9% annually. This rate of growth, the highest in the world, implies a growing demand on agricultural goods and raises significant challenges to the agricultural sector in the Kingdom. Agricultural technologies will help improve agricultural production both in quality and volume, and limit the depletion of water resources.

These technologies are also expected to develop the food manufacturing industry, while optimizing the utilization of the Kingdom's resources.

Given the accelerating pace of progress in science and technology, it has become necessary for the Kingdom to draw appropriate technology road maps and strategies. These plans would serve the agricultural sector, which is one of the pillars of the Kingdom's national economy and a central component of the country's food security.

Strategic priorities of the agricultural technologies program revolve around three focal areas of the sector's value chain: agricultural production, agricultural manufacturing, and natural resources.

Agricultural Production in the Kingdom of Saudi Arabia

Once dominated by traditional practices, Saudi Arabia's agricultural sector has evolved rapidly, adopted modern production and marketing approaches and succeeded in generating export revenues. The value-add generated by the Saudi farming sector grew from SR 0.99 billion in 1969 to SR 37.19 billion (USD 9.92 billion) in 2004. The sector is estimated to have grown at 10.9% annually over this period, compared to an annual GDP growth of 11.6%.

The agricultural sector accounts for nearly 7.2% of the Saudi production sector workforce. It employed 596.7 thousand workers in 2004, compared to 470.0 thousand workers in 1984. The agricultural sector is as important as the industrial sector in terms of job creation, with the exception of the oil and petrochemical industries, which alone account for 607 thousand jobs.

Plant Production

The overall harvest area in the Kingdom covered a surface of 1.074 million hectares in 2007, as shown in the following table, with a grains harvest area of 582,000 ha yielding nearly 2.967 tons. The Kingdom also produces many vegetable crops, with a harvest area of nearly 112,000 ha, yielding approximately 2.6 millions tons. Approximately 229,000 ha of land yielded over 1.58 million tons of fruits, including 982,000 tons of dates.

Given the ban on fodder exports, the Kingdom's feed production has been gradually decreasing, although production in 2007 witnessed a slight increase compared to the previous year. Overall, the Ministry of Agriculture is moving to limit fodder production in view of its high consumption of water. In 2007, 151,000 ha of land were used for fodder production leading to a yield of 2.69 million tons that included 1.78 million tons of clover.

Production Statistics for 2007

Crops	Surface (thousands of ha)	Thousands of tons
Grains	285	7692
Vegetables	211	2956
Fruits	922	1851
Fodder	151	8826
Total	4701	

Source: 2008 Statistical Yearbook

The Ministry of Agriculture has also dedicated efforts to pastures and forests, important renewable natural resources, with planting of seedlings, construction of dikes, embankments, and levees, and development of nurseries and national parks. The Kingdom has 30 grazing enclosures 200 km long with a surface of 172 km. In addition, Ministry 20,000 kgs of domestic and imported fodder seeds were planted. Furthermore, 4,820 ha of forests were planted. The perimeter of fenced forests was about 97 km in length. Over 791 thousand forest trees were planted in the afforestation sites in addition to plantation in roads and streets landscaping projects and the national parks projects.

Animal Production

In 2007, the Kingdom produced 279,000 camels, 401 000 cows, 8.01 million sheep, 2.2 million goats, 506 million poultry, and 3.41 billion eggs. Raw milk production reached 1,095 million liters, whereas honey production reached nearly 156 tons.

KSA Animal Production in 2007

Animals	Quantity
Camel	279,338
Sheep	8,082,852
Goats	2,212,543
Cattle	101,210
Poultry	506,268,656 poultry
Eggs	3,411,557 thousand eggs
Fisheries and Fishing	81,069 tons
Milk	1,095 million liters
Honey	155,929 kg
Horses	20,507

Source: 2008 Statistical Yearbook

Fish Production

The Kingdom enjoys significant fisheries resources along its coastal line, the longest in the region, stretching over more than 2,500 km along the Red Sea and the Arab Gulf. The Kingdom's total fisheries production in 2007 reached 81,059 metric tons (MTs), with 65,473 MTs (80.8% of total) of sea catches and 15,586 MTs from fish farms (19.2% of total). Sea catches from the Arab Gulf amounted to 42,038 MTs where as those from the Red Sea amounted to 23,435 MTs. Salt water fish farms yielded 12,094 MTs whereas fresh water fish farming yielded 3,492 MTs.

Food Manufacturing

Saudi food manufacturing factories produce dairy products, meat products, pastries, oils, confections, biscuits, pasta products, dates and date products and tomato products. The food industry ranks 4th among manufacturing industries with 16% of overall Saudi manufacturing plants, investments totaling SR 55.1 billion (USD 14.7 billion), and an annual growth rate of 6%. The Kingdom lists 588 food manufacturing plants worth nearly SR 20 billion and employing more than 46,000 workers. It's noteworthy that the food and

beverages industries have been growing at a steady pace, from a net worth of SR 611 million in 2001, to SR 1.67 billion in 2004. Saudi exports of food reached SR 1.96 billion in 2004. Food imports however grew by 7%.

Self Sufficiency

The Kingdom is currently self-sufficient in terms of wheat production. It is 75% self sufficient in high corn production, and covers 85% of domestic consumption of vegetable products and 65% of domestic consumption of fruits. Animal production exceeds domestic consumption in eggs and milk, and addresses 50% of domestic consumption of meats.

Percentage of Self-sufficiency

Animal Product	% self sufficient
Red Meats	63
Poultry	55
Fish	55
Fresh Milk	49
Eggs	117
Total Meat	105

Fruits	% self sufficient
Dates	105
Citrus	30
Grapes	84
Other	35
Total	63

Grains	% self sufficient
Wheat	100
Barley	0
High Corn	76
Millet	40
Other	5
Total	23

Vegetables	% self sufficient
Potato	121
Tomato	70
Cucumber	101
Watermelon	107
Other	79
Total	86

Key National Issues and Challenges

Water security and food security equilibrium

The Kingdom has scarce water resources, and a farming sector that consumes nearly 90% of overall annual consumption of water. A growing Saudi population also means growing demand for water and food, and a need to boost food production, thus expanding farming activities and raising water consumption. This poses a serious challenge to the vital water security and food security equilibrium the Kingdom needs to maintain, preserving water resources while maintaining its farming production to support its food security. This critical equilibrium emphasizes the Kingdom's need for strategic technologies and methods to drastically reduce the current depletion of groundwater resources and optimize its water consumption without reducing agricultural production. The Kingdom also seeks to find new sources of water.

Regional equilibrium between rural and urban areas

The large producers were the main beneficiaries of the Kingdom's policy to subsidize the agricultural sector, whereas small producers were left at a disadvantage. The end result was an uneven subsidization amongst the Kingdom's regions. To remedy this situation, investment opportunities must be created to all individuals in the agricultural sector, and income levels need to be raised in rural farming areas to provide a social framework that would help contain rural flight.

Structuring regional agricultural production and comparative advantage

The extensive production of wheat, fodder and palm trees in the Kingdom has come at the expense of the production of other crops. This trend contradicts the regional comparative advantage principle which distributes crops farming according to the advantage of each region in terms of water and soil abundance and quality.

Efficient allocation of resources

The Kingdom's efforts to achieve agricultural self-sufficiency have come at a heavy cost of water, land and capital resources. Horizontal expansion of wheat, fodder and palm trees growth has severely depleted groundwater sources, especially non-renewable reservoirs. Furthermore, the horizontal expansion in the distribution of fallow land amongst farmers and agricultural projects without proper regular follow up of land reclamation and maintenance methods has resulted in the deterioration of soil fertility. In addition, the extensive subsidization of barley production came at the expense of more efficient production sectors, not

to mention the increased support and loans of imported farming equipment and machinery, inflicting useless excess spending on the government budget.

Agricultural marketing

The Kingdom's agricultural development was directed to increase agricultural production, yet it lacked effective marketing policies to deliver farm crops to consumers. Furthermore, this development initiative was also flawed with weak cooperative marketing associations and a poor spirit of cooperative work amongst farmers whose products were not being marketed in a manner that protected their rights.

Agricultural manufacturing

The exponential increase in agricultural production intended to satisfy the growing demand on food goods and achieve self sufficiency in some kinds of crops, was disproportionate to manufacturing of food products. As a result, manufactured food imports grew, causing severe competition with domestic industries.

Fodder manufacturing

The deterioration of pastures, continuous subsidization of barley, and the shortage of fodder manufacturing have deeply damaged the concept of balanced nutrition, crippling the optimal operation of existing fodder factories and/or weakening investments in fodder manufacturing.

Domestic production of animal and fish products for domestic consumption

Overfishing recently peaked in the Red Sea and the Arab Gulf with the use of both modern and traditional techniques. Urban and industrial expansion, filling and burial of coral reefs and sea pollution have also resulted in serious reduction of fish stock below acceptable levels. To replenish this deficit, fish farming needs to be developed, especially with the growth of the annual consumption of fish products per capita to 13.8 kg/year.

Workforce in the agricultural sector

Issues related to the agricultural sector workforce include limited opportunities in the private sector for Saudi workforce, inadequate education and professional development, enduring rural exodus and continuous flow of foreign labor, all of which have resulted in lower wages in the private sector.

Agriculture-related information

The Kingdom has a lack of integrated and accurate agricultural information, which creates a serious obstacle to agricultural development. The recent developments in computer technologies and agricultural information systems have made it further important to deliver requested information in due time to farmers, engineers, supervisors and public and private officials. KACST thus recently supported the development of a computer system for the water needs of farming crops in the Kingdom. It also supported the design of an integrated computer encyclopedia of green crops farming in the Kingdom to include key green crops farming data (such as diseases, pest epidemics and others, crops storage) with an electronic map of the Kingdom's farming regions. These digital information systems are expected to help develop optimal agricultural methods and transactions for farmers and agricultural companies in the Kingdom.

Technology transfer, implementation and localization

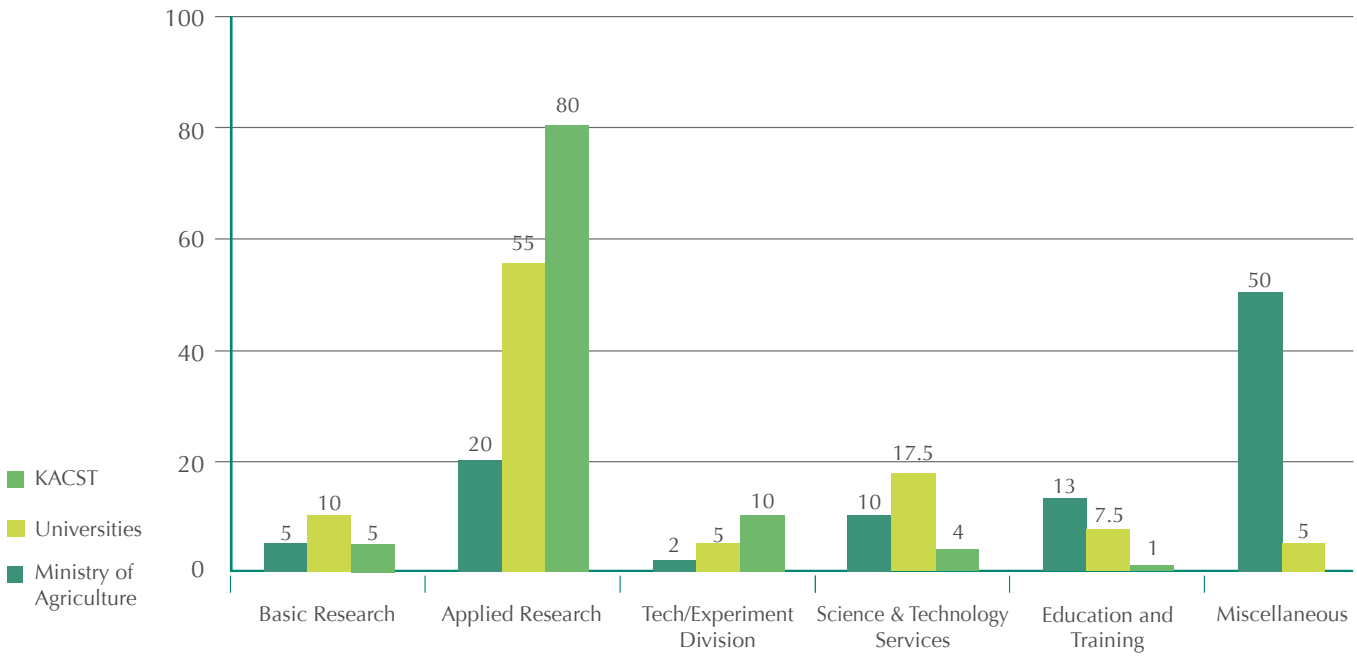
Scientific research is constantly evolving and generally focused on developing specific technologies with potential applications for beneficiary sectors. The farming sector is among the top priority sectors as it produces, manufactures and markets food products. Each new technology thus needs to have an economic

and practical value to facilitate its implementation. The Kingdom has diverse environmental conditions and an arid weather, which means that a thorough feasibility study must be conducted before any technology applied in other countries with different environments, can be transferred to the Kingdom.

Science and Technology Activity in the Kingdom

There are many stakeholders in the Kingdom involved with agricultural services and research. Data was collected during this study from 6 research centers affiliated with the Ministry of Agriculture, in addition to university research centers and stations (Special Research station at KSU, and King Faisal University Research Center of Excellence). These centers are essentially dedicated to: basic research, applied research, technology development, technical and scientific services and education and training related to agricultural sciences, as well as other miscellaneous services.

Applied research leads research activities at KACST and Saudi universities (55% to 80% of overall research activities), yet falls below 20% of all research at the Ministry of Agriculture. It is noteworthy that the Ministry's research centers provide a great part of the miscellaneous services, including analysis of soil, water, fertilizer and plant tissue samples, offering recommendations and consultation, as well as other guiding newsletters and services (50% of the activities of centers affiliated with the Ministry of Agriculture).



Strategic Context

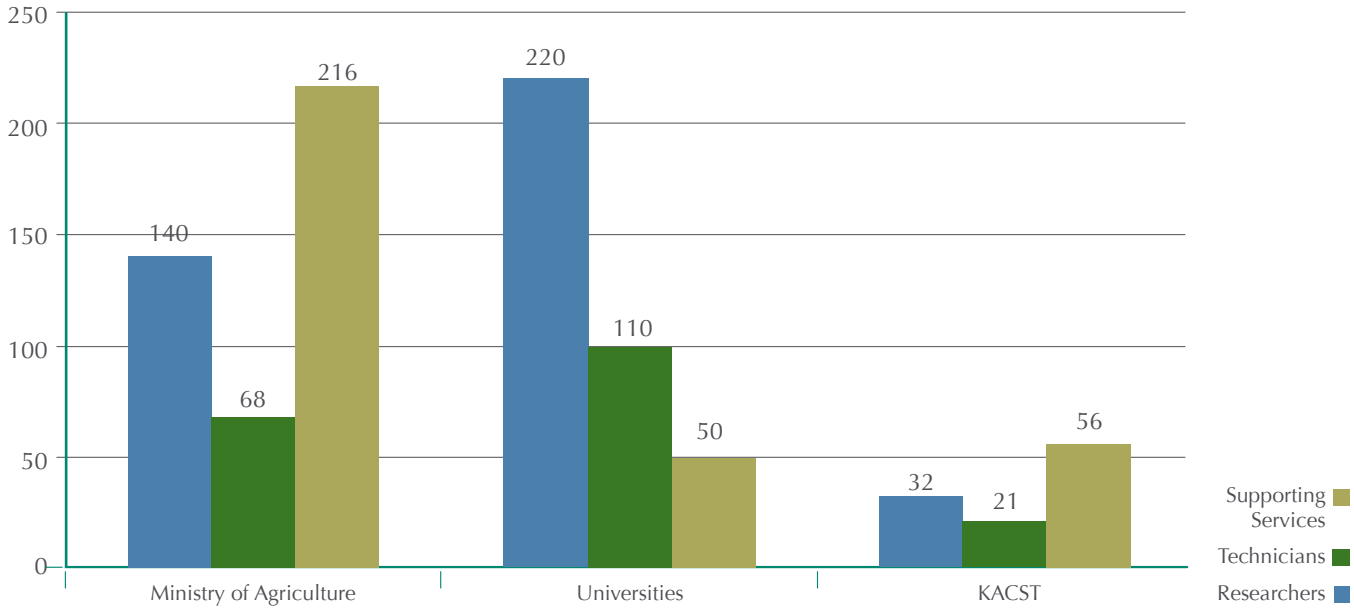
Agricultural research bodies are essentially interested in: plant production, animal production, plant protection and soil research. This study shows that both the academic sector and KACST seem to address similar topics, while the Ministry's research centers are lacking in activities related to awareness and guidance, irrigation, and food industries.

Science and technology activity areas

KACST	Universities	Ministry of Agriculture	Sc. Activity
√	√	√	Plant production
√	√	√	Animal
√	√	√	Plant Protection
√	√	√	Soil
√	√	-	Awareness & guidance
√	√	-	Irrigation
√	√	-	Food Industries
-	-	√	Others

(√) Activity exists (-) none

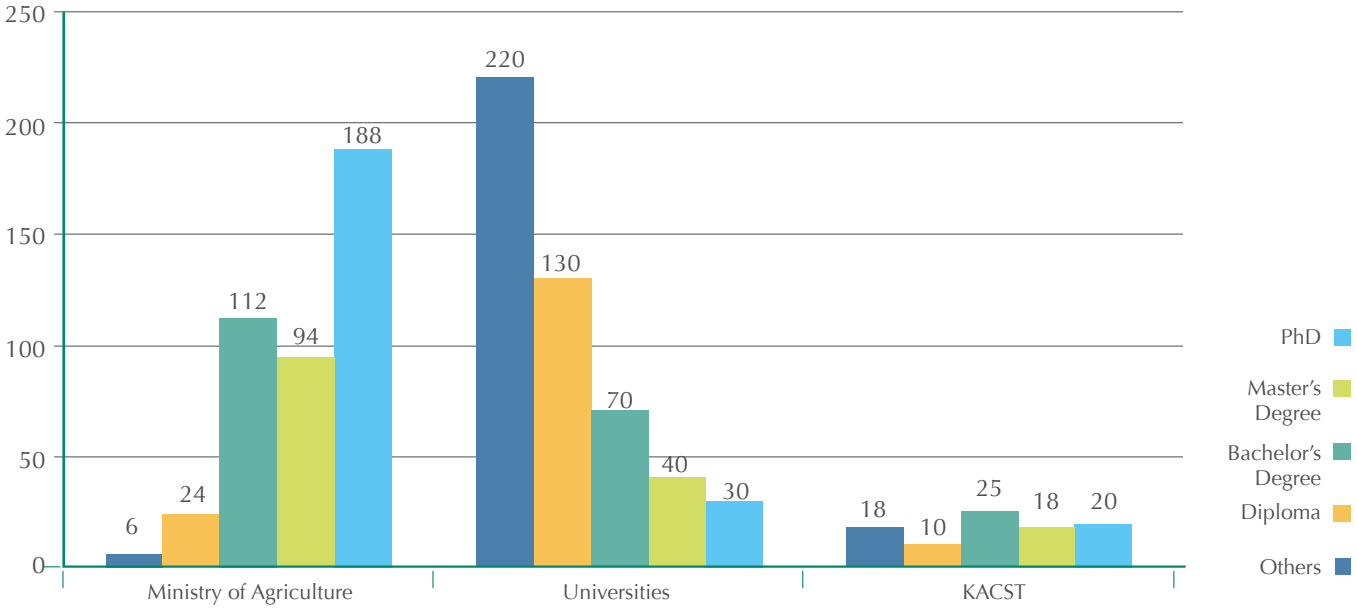
The study also showed that individuals working for relevant stakeholders were either researchers, technicians or support services specialists. Furthermore, it appears that universities accounted for the greatest number of full-time researchers, technicians and support services specialists, followed by the 6 centers of the Ministry of Agriculture across the Kingdom, and KACST.



Strategic Context

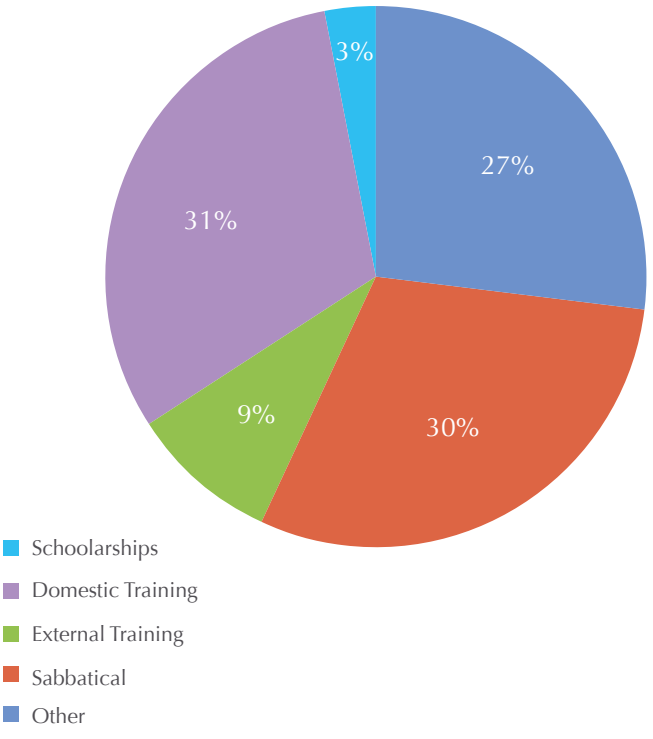
The study also showed that the academic sector employs the most number of PhD and Master's degree professionals, followed by KACST and the Ministry of Agriculture research centers.

Both KACST and the academic sector seem to focus on sabbatical scholarships, while internal and external training represents 39%.

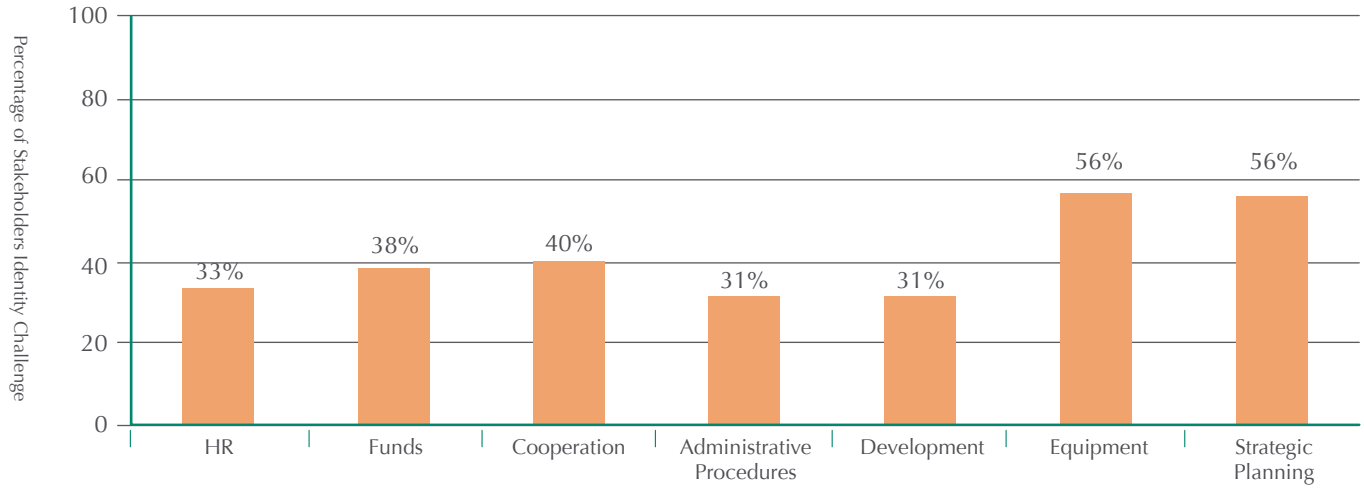


The study indentified the following main challenges facing the agricultural research sector:

1. Lack of strategic planning and shortage of equipment.
2. Lack of external and internal cooperation with centers of excellence.
3. Deficient of funds and inadequate staffing (in every aspect).



Key Challenges Identified by



Analysis of Comparable Agricultural R&D Institutes

Agricultural technology research publications are produced by more than 20,000 research institutions throughout most of the world. A study of research performance measured by number of publications in peer-reviewed journals in 2008 shows that the United Stated Department of Agriculture (USDA) (2,247 articles) is the leading agricultural research organization in the world. The USDA has a strong emphasis on plant production and protection research. National research agencies and institutes are significant producers of agricultural research articles worldwide, notably the USDA, the French National Institute for Agricultural Research (INRA), the Spanish National Research Council (CSIS), and the Canadian Department of Agriculture and Agri-Food (AAFC).

Global Agricultural Technologies R&D Organizations (2008)

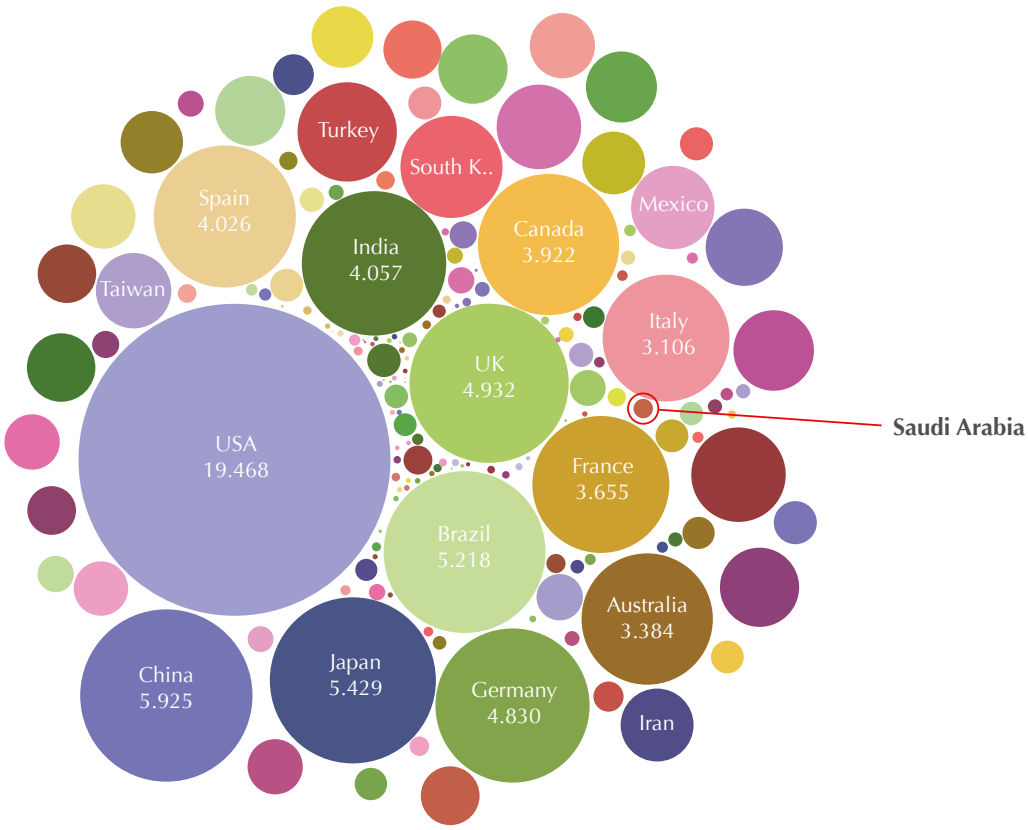
Institution	Total	Average Impact	Plant Production and Protection	Animal and Dairy	Food Sciences and Nutrition	Soil and Water Resources Management	Economics, Policy, and Interdisciplary Agricultural Studies	Fish
USDA	2247	0.43	1226	443	285	290	153	41
Chinese Acad Sci	1395	0.33	807	186	70	305	40	70
INRA	928	0.47	340	262	200	98	97	21
Univ Calif Davis	834	0.49	276	350	115	86	60	21

Institution	Total	Average Impact	Plant Production and Protection	Animal and Dairy	Food Sciences and Nutrition	Soil and Water Resources Management	Economics, Policy, and Interdisciplary Agricultural Studies	Fish
CSIC	766	0.46	273	128	233	102	98	22
Univ Fed Sao Paulo	725	0.20	196	282	154	60	51	9
China Agr Univ	622	0.33	284	161	90	94	38	3
Cornell Univ	574	0.50	220	210	114	41	27	13
Agr & Agri Food Canada	574	0.37	280	124	100	87	32	1

Analysis of Publications and Patents in Agricultural Technology

In 2008, there were 82,848 articles published worldwide in agricultural technologies research fields. The following figure 3 shows the number of publications produced by selected countries over this time period.

Figure 3: Publications by Country (2008)



Strategic Context

The United States is the largest producer of agricultural technologies articles, by a wide margin, with 19,468 articles - more than 23% of total global output. The People's Republic of China was second, producing 5,925 articles followed by Japan and Brazil with 5,429 and 5,218 articles respectively. Saudi Arabia was ranked 71st in article output, producing 77 articles.

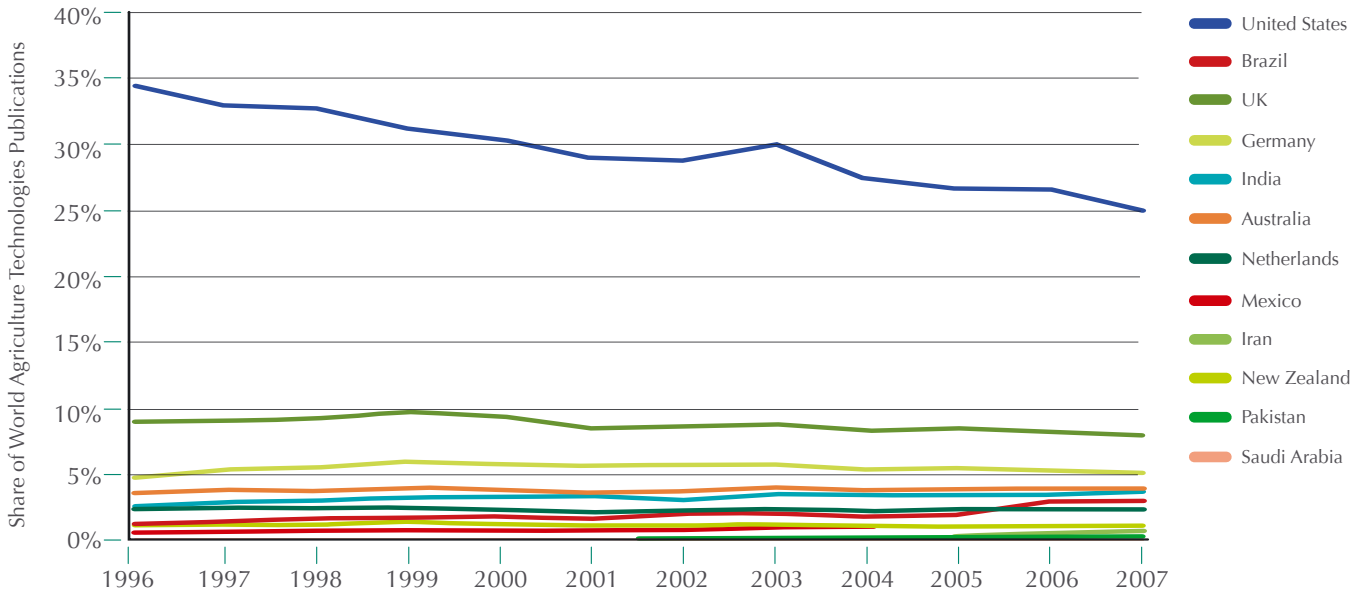
Plant production and protection research together with animal and dairy research account for the majority of agriculture-related articles(26,826 and 25,919 respectively) followed by food science and nutrition (14,886), soil and water resources management (10,132), economics, policy and interdisciplinary studies (10,132), and fish (3,736). Activity in Saudi Arabia was focused relatively heavily on animal and dairy, accounting for 38% of total KSA publications compared to 31% total for the field in the rest of the world.

Agricultural Research Sub-Topics 2007

Sub-Topic	World Publications	% of World Publications	KSA Publications	% of KSA agricultural research publications
Plant Production and Protection	26826	32%	17	22%
Animal and Dairy	25919	31%	29	38%
Food Sciences and Nutrition	14886	18%	15	19%
Soil and Water Resources Management	10132	12%	14	18%
Economics, Policy, and Interdisciplinary Agricultural Studies	5733	7%	0	0%
Fish	3736	5%	3	4%

Globally, the benchmark countries selected by KACST for inclusion in this study account for approximately 55% of agricultural research publications. The relative output levels of the benchmark countries have not changed significantly over the last 10 years, with the exception of the United States, which has dropped from 35% of global output in 1996 to 25% on 2007. Other benchmark countries with notable changes in their level of output include Brazil, which more than doubled its share of global output from 1.26% in 1996 to 3.06% in 2007, Mexico which increased from 0.67% in 1996 to 1.15% in 2007, and Iran which increased from 0.09% in 1996 to 0.84% in 2007. Saudi Arabia's share of global output decreased from 0.17% in 1996 to 0.09% in 2007.

Figure 4: Share of World Agricultural Technologies Publications (1996-2007)



The relative emphasis placed on agricultural research in a given country can be measured by the field's activity ratio. The activity ratio compares the relative level of activity in a specific country to the global level of activity in a given field. For example, in 2007, agricultural technologies publications accounted for 14.8% of all global publication activity. In New Zealand, agricultural technologies accounted for 38.1% of all publication output, yielding an activity ratio of 2.58 (38.1 divided by 14.8). By this measure, agricultural research is strongly emphasized in countries such as New Zealand, Mexico, Brazil and Australia, while countries like Germany and Saudi Arabia show less emphasis in this field.

Share of Publication Activity (2007)

Country	Activity Ratio
New Zealand	2.58
Mexico	2.10
Pakistan	1.91
Brazil	1.87
Australia	1.70
India	1.52
Netherlands	1.31
United Kingdom	1.23
United States	1.22
Iran	1.19
Germany	0.93
Saudi Arabia	0.71

Benchmark Country Publication Impact

Average publication impact is calculated as the number of citations of articles from a particular country divided by the total number of articles published by authors from that country. For instance, a country that published 50 articles that were cited 100 times would have an average publication impact of two. Because this analysis is focused on recent publications from 2008, the impact statistics are biased in favor of articles that have immediate, widespread readership in fast-moving fields with rapid rates of publication.

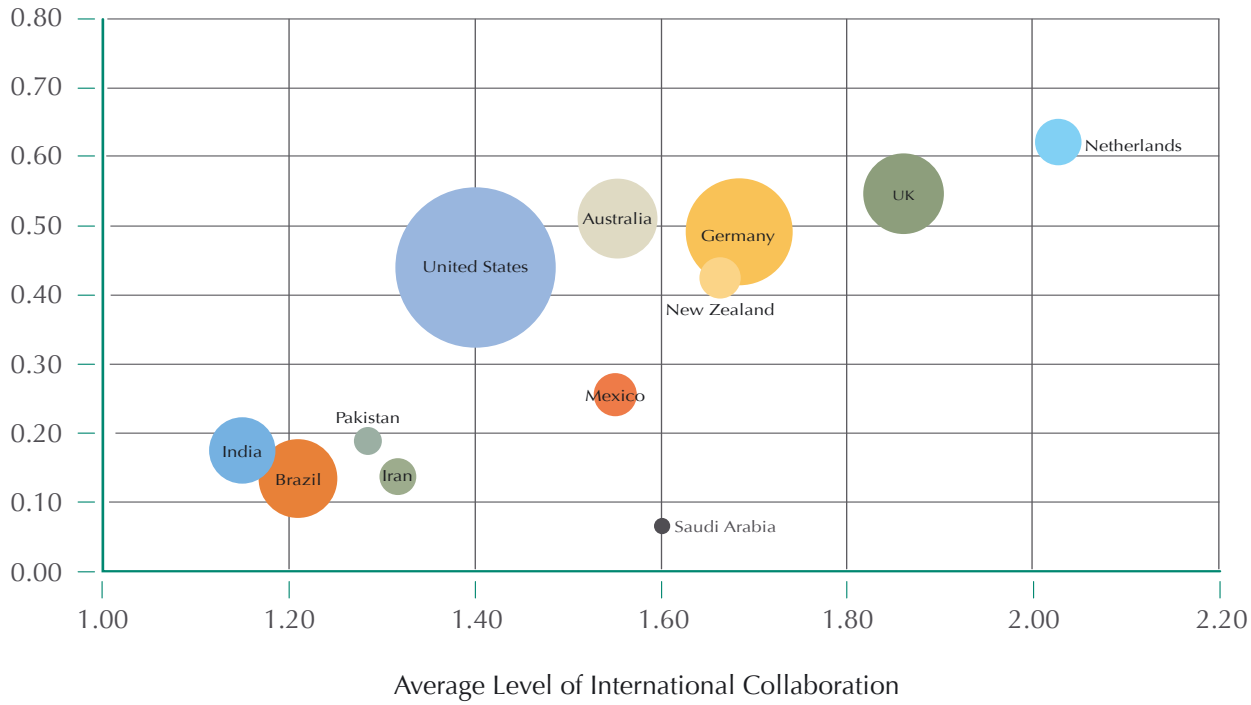
In 2008, the Netherlands had the highest average publication impact of all countries at 0.63 followed by the United Kingdom (0.54) and Australia (0.49). The average publication impact for Saudi Arabia was 0.06 with 5 citations of 77 articles. By this measure, the agricultural research articles that are published by authors affiliated with KSA institutions appear to have a lower impact when compared with those from benchmark countries.

Highly cited agricultural technologies publications included "Effect of various pretreatment methods on anaerobic mixed microflora to enhance biohydrogen production utilizing dairy wastewater as substrate" (18 citations) authored in India and "History of commercializing sexed semen for cattle" (14 citations) authored in the USA and China. KSA-affiliate authors produced 4 articles cited by others, including "Splenic rupture and splenectomy in a foal", authored by "Stables King Abdullah & Sons" in Riyadh.

International Collaboration and Publication Impact

For countries with a similar level of publication activity, those countries with a high level of international collaboration also tend to produce publications with a high level of impact. In this study, international collaboration is calculated as the average number of countries represented per publication, based on authors' addresses. The chart below plots a country's level of international collaboration (horizontal axis) against the average impact of its publications (vertical axis). The Netherlands and the United Kingdom which show significant international collaborative activity also tend to produce papers with a higher average impact. Countries such as the Brazil and India, on the other hand, are significant producers of agricultural technologies research outputs but show low levels of both international collaborative activity and impact. The Kingdom of Saudi Arabia achieves relatively low impact for its level of international collaboration.

Impact of Collaboration and Publication in Agricultural Technologies (2008)



Agricultural Research Collaboration Patterns

Scientific research is frequently an international activity. Connections between researchers across the globe can be analyzed as a network; countries with a high level of connectivity in the network serve as centers for collaborative activity and may be well positioned to tap into international knowledge flows. The following table identifies leading centers of global collaborative activity in the agricultural technologies field. The United States is a key player linking researchers together from many nations, but other significant hubs of collaborative activity include the United Kingdom, Germany, the Netherlands and Australia.

Number of Collaborating Countries (2007)

Country	Number of Collaborator Countries
USA	145
UK	121
Germany	112
Netherlands	97
Australia	96
India	73
Mexico	68
Brazil	66
New Zealand	62
Iran	52
Pakistan	37
Saudi Arabia	23

As shown in the following table, within Saudi Arabia, the institutions generating the largest number of articles related to agricultural technologies are: King Saud University (18), King Faisal University (13), and Al Qasseem University (11). These institutions rank 1426th, 1800th and 1989th in terms of total number of publications among all agricultural research institutions captured in the SCI-E database. These same three institutes are the KSA leaders in both animal & dairy and plant production & protection. King Saud University and King Faisal University are the leading organizations in Food Science and Nutrition. King Fahd University of Petroleum and Minerals, the Saudi Geologic Survey and the Saline Water Conversion Company are the leading soil & water resources management institutions, while in the fish sub-topic, no KSA institution produced more than a single publication in 2008.

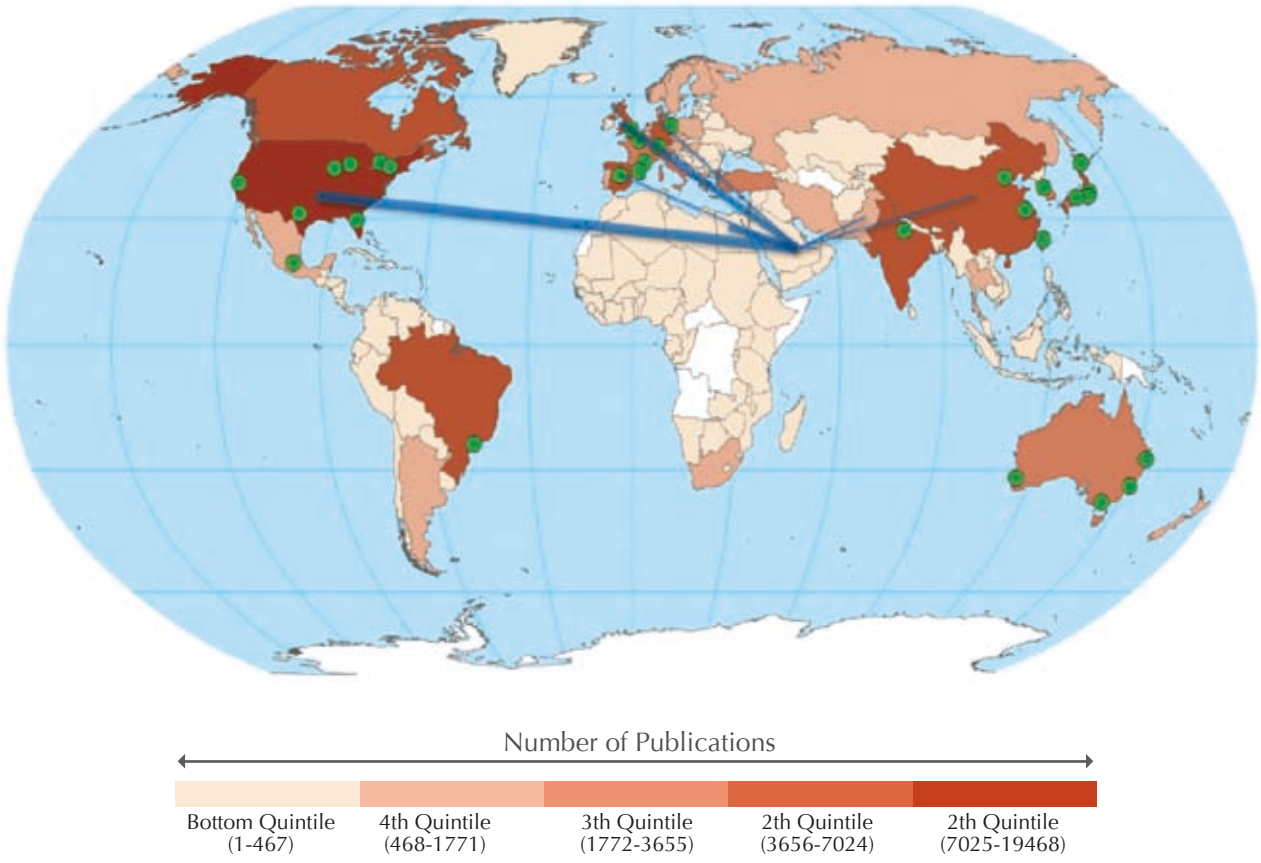
KSA R&D Agricultural Technologies Organizations

Institution	Animal and Dairy	Plant Production and Protection	Food Sciences and Nutrition	Soil and Water Resources Management	Fish
King Saud University	4	4	5	1	1
King Faisal University	7	2	4	0	0
Al Qasseem Univ	6	4	1	0	0
King Abdulaziz University	0	1	0	1	1
King Fahd University of Petroleum & Minerals	1	1	0	3	0
King Abdulaziz City for Science and Technology	0	1	1	1	1
Natl Wildlife Res Ctr	4	0	0	0	0
Saudi Geologic Survey	0	0	0	3	0
King Khalid Univ	0	1	1	0	0
King Khalid Wildlife Res Ctr	2	0	0	0	0
Saline Water Conversion Corporation	0	0	0	2	0
United Sugar Co	0	1	1	0	0
Taif Univ	1	0	0	0	0
Stables King Abdullah & Sons	1	0	0	0	0
Saudi Aramco	0	0	0	1	0
Satellite Plants Jeddah	0	0	0	1	0
King Abdulaziz Medical City	1	0	0	0	0
Natl Commiss Wildlife Conservat Natl Commiss Wildlife Conservat & Dev	1	0	0	0	0
Minist Agr	0	1	0	0	0
EXPEC Res Ctr	0	0	0	1	0
Jamjoom Pharmaceut Co Ltd	0	0	1	0	0
Teachers Coll	0	0	1	0	0
Islam Dev Bank	0	0	0	1	0
Girls Coll Sci	0	0	1	0	0
Girls College	0	0	0	1	0
Biol Pest Control Expert CO UNDP FAO	0	1	0	0	0
Al Watnia Poultry	1	0	0	0	0

Strategic Context

Authors affiliated with KSA institutions collaborated with researchers in 23 countries throughout the world. Significant partners included researchers in the United States (8 publications), the UK (6), Egypt (6). Additionally, KSA-affiliated authors collaborated on more than one publication with authors from: Pakistan, China, Spain, UAE, Germany Ireland, Italy, Turkey, the United Kingdom, Yemen, and Qatar. Figure 4 provides an overview of KSA collaboration activity (blue lines), national publication output (country color), and leading research centers (green dots). Several of these leading research centers are summarized below.

KSA Agricultural Technologies Collaboration Activity



Agricultural Technologies Journals

The table below presents the top journals, by publication count, for agricultural technologies sub-fields in 2008.

Agricultural Technologies Journals by Publication Count (2008)

	Journal	Publications
Plant Production and Protection	BIORESOURCE TECHNOLOGY	1180
	PLANT PHYSIOLOGY	490
	JOURNAL OF NATURAL PRODUCTS	421
	JOURNAL OF ETHNOPHARMACOLOGY	406
	PHYTOCHEMISTRY	355
	PLANT JOURNAL	324
	NEW PHYTOLOGIST	291
	EUPHYTICA	269
	CROP SCIENCE	265
	JOURNAL OF ECONOMIC ENTOMOLOGY	253
Animal and Dairy	ZOOTAXA	1108
	VACCINE	873
	VETERINARY RECORD5	566
	JOURNAL OF DAIRY SCIENCE	516
	INDIAN VETERINARY JOURNAL	477
	ANIMAL BEHAVIOUR	391
	JOURNAL OF ANIMAL SCIENCE	376
	VETERINARY PARASITOLOGY	351
	POULTRY SCIENCE	342
	INDIAN JOURNAL OF ANIMAL SCIENCES	330
Food Sciences and Nutrition	JOURNAL OF ANIMAL AND VETERINARY ADVANCES	330
	JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY	1646
	FOOD CHEMISTRY	958
	FOOD AND CHEMICAL TOXICOLOGY	520
	JOURNAL OF DAIRY SCIENCE	516
	BIOSCIENCE BIOTECHNOLOGY AND BIOCHEMISTRY	489
	AMERICAN JOURNAL OF CLINICAL NUTRITION	463
	OBESITY	402
	EUROPEAN FOOD RESEARCH AND TECHNOLOGY	371
	INTERNATIONAL JOURNAL OF FOOD MICROBIOLOGY	340

	Journal	Publications
Soil and Water Resources Management	JOURNAL OF NUTRITION	330
	WATER SCIENCE AND TECHNOLOGY	560
	WATER RESOURCES RESEARCH	497
	WATER RESEARCH	496
	ENVIRONMENTAL GEOLOGY	412
	JOURNAL OF HYDROLOGY	401
	HYDROLOGICAL PROCESSES	376
	SOIL BIOLOGY & BIOCHEMISTRY	314
	REVISTA BRASILEIRA DE CIENCIA DO SOLO	285
	WATER AIR AND SOIL POLLUTION	246
Economics, Policy, and Interdisciplary Agricultural Studies	GEODERMA	233
	JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY	1646
	JOURNAL OF THE SCIENCE OF FOOD AND AGRICULTURE	340
	CIENCIA E AGROTECNOLOGIA	276
	INDIAN JOURNAL OF AGRICULTURAL SCIENCES	255
	PESQUISA AGROPECUARIA BRASILEIRA	240
	AGRICULTURE ECOSYSTEMS & ENVIRONMENT	178
	COMPUTERS AND ELECTRONICS IN AGRICULTURE	143
	AUSTRALIAN JOURNAL OF AGRICULTURAL RESEARCH	110
	AMERICAN JOURNAL OF AGRICULTURAL ECONOMICS	108
Fish	SCIENTIA AGRICOLA	105
	AQUACULTURE	423
	JOURNAL OF FISH BIOLOGY	366
	CANADIAN JOURNAL OF FISHERIES AND AQUATIC SCIENCES	227
	FISHERIES RESEARCH	215
	AQUACULTURE RESEARCH	206
	FISHERIES SCIENCE	184
	FISH & SHELLFISH IMMUNOLOGY	173
	ICES JOURNAL OF MARINE SCIENCE	142
	NIPPON SUISAN GAKKAISHI	127

Agricultural Technologies Patent Activity

Between 2006 and 2008, there were 13,931 agriculture related patent applications filed with the United States Patent and Trademark Office (USPTO). The majority of these (9,515 applications) listed at least one inventor from the United States. Other countries with a significant number of inventors include: Germany (884 applications), Japan (768 applications), and Canada (653 applications). The most cited agriculture related patent applications (6 citations each): "Camera system for canines, felines, or other animals" and "Training guidance system for canines, felines, or other animals" both list the same inventor from the United States: Kates, Lawrence. There were two agriculture related patent applications that listed an inventor from Saudi Arabia over this time period. "System for delivery of insecticide" involved two inventors from Saudi Arabia, while "Carbon Neutralization System (CNS) for CO2 Sequestering" involved one inventor from Saudi Arabia.

Top Agriculture Related Patent Applications by Country (2006-2008)

Rank	Country	Animal and Dairy	Food Sciences and Nutrition	Soil and Environmental Management	Fish	Plant Production and Protection	Total
1	United States	1589	2582	131	509	4704	9515
2	Germany	60	286	1	4	533	884
3	Japan	104	335	10	49	270	768
4	Canada	96	146	13	27	371	653
5	United Kingdom	76	178	3	11	208	476
6	Netherlands	25	180	2	2	215	424
7	France	49	118	4	3	200	374
8	Australia	28	56	3	11	139	237
9	Denmark	10	106	0	1	80	197
10	Taiwan	36	61	2	13	85	197
52	Saudi Arabia	0	0	0	0	2	2

1 Kates, Lawrence. Camera system for canines, felines, or other animals. Patent US7424867. 2008.
2 Kates, Lawrence. Training guidance system for canines, felines, or other animals. Patent US7434541. 2008.
3 Sheppard, Norman J. Carbon Neutralization System (CNS) for CO2 sequestering. Saudi Arabian Oil Company, assignee. Patent US20070092962A1. 2007.
4 Al-Sulaiman, Faleh A., and Muhammad A. Huwwa. System for delivery of insecticide. Patent US20090007481A1. 2009.

Two inventors are listed on significantly more agriculture related patent applications than any other. Eby, William H. and Weder, Donald E. are listed on 89 and 70 applications, respectively. Other inventors listed on a significant number of applications include: Kovalic, David K. (38 applications), Prakash, Indra (38 applications), and Dubois, Grant E. (37 applications). The top five agriculture inventors are all from the United States.

Top Agriculture Inventors (2006-2008)

Inventor	Inventor Country	Number of Patent Applications
Eby, William H.	United States of America	89
Weder, Donald E.	United States of America	70
Kovalic, David K.	United States of America	38
Prakash, Indra	United States of America	38
Dubois, Grant E.	United States of America	37

While the majority of agriculture related patent applications are defined as individually owned patent applications (7,606 applications) by the United States Patent and Trademark Office, some institutions are designated as the patent assignee on a number of applications. Pioneer Hi-Bred International, Inc. is listed as the patent assignee on 398 agriculture patent applications followed by Monsanto Technology LLC (212 applications) and Syngenta Seeds B.V. (114 applications). One of the two patent applications with an inventor from Saudi Arabia lists Saudi Arabian Oil Company as the patent assignee. The other is an individually owned patent.

Leading Agriculture Assignees (2006-2008)

USPTO Assignee*	Number of Patent Applications
Individually owned patents (no assignee)	7606
Pioneer Hi-Bred International, Inc.	398
Monsanto Technology LLC	212
Syngenta Seeds B.V.	114

Sources: US Patent Trademark Office

Global Trends in Agricultural R&D

Trends in Sustainable Agriculture

Sustainable agriculture has been the subject of growing interest over the last two decades, especially in light of the depletion of significant resources worldwide for harvesting purposes, and extensive farming which heavily relies on water resources, fertilizers, pesticides and other elements with adverse effects on the ecosystem health. Sustainable agricultural systems thus aim to develop cost-effective production techniques to harvest healthy

foods with limited adverse impact on water resources and soil properties. Examples of this trend include:

- Good Agricultural Practices (GAP) & organic farming techniques.
- Precision agriculture techniques.
- Development of detection and treatment technologies for environmental pollutants.
- Development of renewable energy technologies (solar, wind, etc.) to limit consumption of water and energy.
- Efficient use of agricultural and industrial residues.
- Anti- desertification research.
- Role of farming in economic, social and rural development.
- Soil properties treatment technologies, as well as salt, pollutant, heavy minerals and pathogens resistant technologies to protect soil and groundwater.
- Focus on research to optimize highly efficient productivity with minimal impact on soil, environment and least consumption of fuels.
- Comparative advantages in water resources, soil properties and environmental conditions

Trends in Water Resources Conservation and Water Security

Crops and fodder harvesting require heavy consumption of water. Research has therefore been conducted to find techniques that require efficient irrigation, such as:

- Study water farming needs and crops productivity under environmentally straining conditions.
- Non-traditional food and fodder farming, such as fish harvesting from coastal fisheries, and fodder production from algae plants irrigated with sea water.
- Farming techniques designed to enhance the efficient consumption of water and energy with soilless culture and hydroponic technologies.
- Create integrated databases on soil, water, harvest and the environment to program and enhance effective irrigation techniques.
- Irrigation control of extreme thermal properties impact on farming crops.
- Development of use of non-traditional water resources, such as municipal and agricultural wastewater treatment.
- Support food security studies and its relation to water security.

Farming Automation and Mechanization Trends

The progress of science and computer systems has been paralleled with tremendous progress in farming operations (soil conditioning, crops storage, etc.). Due to the growing demand on food, research has been increasingly focused on the development of automation and mechanization systems, such as:

- Agricultural data and statistics precision and availability on the World Wide Web, and systems enhancing speed and precision of information access due to its importance to agricultural policies.
- R&D of farming equipment design and operation to fit different regions, crops kinks and animals.
- Automation technologies and mechanization systems development and their applications in agricultural operations.
- Support of greenhouse modern production technologies, including thermal, humidity and lighting automated control technologies.

Biotechnology Trends

Biotechnology and genetic engineering research studies and technologies have lately tackled various agricultural and food security issues, including:

- Environmentally resistant plant and animal breeds, with enhanced resistance to salinity, drought or thermal conditions, or highly resistant to weeds, insects and lesions.

- Allopathy.
- Knowledge-based bio-economy research.
- Genetic enhancement of domestic animal breeds to adapt them to environmental conditions.
- Identification of genes responsible for undesirable genetic traits.
- Agricultural nanotechnology.
- Animal health research.
- Biosafety and germplasm conservation studies.
- Development of food manufacturing techniques with increased efficiency and lower costs, ensuring food security for longer periods of time with conservation and packaging techniques.
- Quarantine research support to enhance early detection of any potential contamination with future influx to the Kingdom.
- Farming product quality research.

Kingdom's Agricultural R&D Needs

The strategic agricultural R&D process for the Kingdom revealed the key needs of this sector in light of the Kingdom's economic, social and environmental needs. The rationalization of water consumption is at the top of those priorities given the scarcity of the Kingdom's resources. This implies optimizing the use of water, and supporting technologies to limit water consumption as well as looking for new renewable water sources.

From the point of view of economics of agriculture, the Kingdom's farming sector has high investment costs and suboptimal demand ensuing from ineffective marketing. Consequently, a comprehensive marketing strategy needs to be developed to ensure improved related regulations including market-based pricing, regulatory and technology policy. A marketing database needs to be developed to serve stakeholders. Furthermore, agricultural manufacturing investments need to be supported to remedy situations where increases in farming are not matched with similar growth in manufactured food products.

Rural flight to urban centers with employment and investment opportunities is another aspect of the economic context of the Saudi farming sector. Agricultural investment opportunities thus need to be created in rural areas to serve small local investors, as they are essential to rural communities. From a geographic point of view the significant size of the Kingdom and the diversity of its environment emphasize the need to use regional comparative advantages, which require adjusting the allocation of crops farming to serve each region.

The rationalization of water consumption policy resulted in limiting areas of fodder farming in the Kingdom, which created a shortage in animal production fodder. Thus, there needs to be a policy to limit the shortage of fodder resources, such as increasing the fodder nutritional value and saving pastures from decline. In addition, the shortage of fish production requires supporting fish farms as well as the traditional and industrial fishing sector.

The Kingdom's key R&D needs in the agricultural sector were identified as follows:

- Contribute to food security while preserving water security.
- Transfer, localization and development of agricultural technologies to help support a knowledge-based economy.
- Employ agricultural R&D outputs to help achieve sustainable agricultural growth.
- Development of national R&D capacity to serve the Kingdom's farming sector.

- Preservation and development of agricultural water resources.
- Apply comparative advantage principle to some of the Kingdom's regions.
- Maintain balance between rural and urban development.
- Databases.

SWOT Analysis for KSA Agricultural Research and Innovation

This section presents a SWOT (strengths, weaknesses, opportunities, and threats) analysis of the Saudi Arabia Agriculture Research and Innovation Program relative to achieving its vision. In a SWOT analysis, strengths and weaknesses are internal to the organization while opportunities and threats are defined as external to the organization. For the purpose of this analysis, the "organization" is the Saudi Agricultural Technology Program, including KACST, universities, Ministry of Agriculture and companies.

Strengths

- Availability of funding for R&D activities
- Significant part of infrastructure available to support R&D activities in this sector
- Availability of trained and qualified R&D staff
- Research sectors (universities, KACST) interest in modern technologies, such as nanotechnology and biotechnology, which promise to lead to new R&D horizons in agriculture
- Access to advanced agricultural technologies in the private sector
- A long term R&D strategy for the Kingdom

Weaknesses

- Insufficient staff and inadequate training in the agricultural sector
- Weak links between R&D technology sectors and parties benefiting from research outputs
- Poor R&D technology outputs in the Kingdom
- Need for additional support for modern R&D activities infrastructure
- Poor coordination and cooperation among the Kingdom's research sectors
- Insufficient effective international cooperation on technology transfer

Opportunities

- Comparative advantage principle
- Geographic and environmental diversity in the Kingdom
- Significant investments (private and public) in agriculture
- Existing opportunities in international agreements
- Need to diversify sources of national economy
- Government interest in achieving food security

Threats / Challenges

- Scarcity of water resources and maintaining the delicate balance between agriculture and the conservation of water reserves
- Insufficient awareness of R&D beneficiary sectors of the importance of research support, funding and adoption
- Low economic returns of agriculture (compared to industry and commerce for example)
- Competition with imported products
- Rural exodus
- Harsh environmental conditions (drought and extreme temperatures)

Higher Strategy

This section provides the vision, mission, and strategic priorities for the Kingdom's Agricultural Technologies Program.

Vision

The vision for the Agricultural Technology Program is leadership in sustainable agricultural development.

Mission

The mission of the KSA Agricultural Technology Program is to transfer, localize and develop agricultural technologies, and to conserve and grow natural resources for the benefit of Saudi Arabia.

Program Values and Culture

To achieve excellence and carry out its mission, the program will develop an internal culture through both the sponsorship of its leadership and commitment of its operational teams, based on the following values:

- Spirit of team work
- Creativity and innovation
- Excellence
- Competency
- Loyalty and transparency
- Moderation
- Dialogue
- Partnership

Program Strategic Goals

The following direct, program-level strategic goals of the Agricultural Technology Program are aligned with broader goals of economic development, self-reliance, security and sustainable growth set forth by the National Policy for Science and Technology. Furthermore, these strategic goals provide a basis for defining technology area selection criteria and program implementation objectives.

- Transfer, localization and development of competitive and environmentally safe agricultural technologies intended to promote the Kingdom's sustainable growth and biosafety.
- Development of human knowledge of urgent agricultural issues and related technology.
- Development of a competitive R&D infrastructure for KSA agricultural technologies.
- Creation of a competitive environment for an agricultural technologies industry to compete in global markets.
- Steering modern technology applications and research to support vertical farming.

Technology Areas

Selection Process

An initial list of important technology areas in the field of agriculture was developed by the strategy development team taking into account the program's strategic goals and the higher strategy. The initial list was narrowed down using a set of selection criteria developed through stakeholders' workshops. Extensive inputs from stakeholders shaped the final list of priority areas, subareas and technologies.

Selected Technology Areas

The following three areas and the subareas underneath those represent the core components of the agriculture sector value chain. An expanded list of related sub-paths and priority technologies needed are presented in the following table.

- **Production**
  - Plant Production
  - Animal Production
  - Aquaculture
- **Manufacturing**
  - Food
  - Non-food
  - Aquaculture
- **Natural Resources**
  - Pastures and Forests
  - Genetic Origins

Technology Areas

Technologies	Sub-paths	Paths	Sub-areas	Core area
■ Irrigation scheduling technologies ■ Water harvesting techniques ■ Irrigation systems enhancement technologies ■ Irrigation water salinity treatment ■ Water-use efficiency techniques in crop production ■ Hydroponic techniques ■ Sewage water treatment and use techniques ■ Agricultural drainage water utilization techniques ■ Development of water resources	■ Irrigation water sources ■ Drainage and irrigation systems ■ Water quality ■ Water relations ■ Irrigation management	Irrigation water	Plant production	
■ Production increase and enhancement ■ Dates production increase and enhancement technologies ■ Post-harvesting technologies ■ Genetic enhancement ■ Greenhouse technologies ■ Agricultural mechanization technologies ■ Best agricultural management practices technologies ■ Agricultural clean technologies ■ Fodder production enhancement technologies ■ Organic agriculture technologies ■ Plant environmental control technologies ■ Soil free agricultural technologies ■ Precision agriculture technology	■ Field crops ■ Fruit crops ■ Green crops ■ Fodder crops ■ Nontraditional crops	Crops		
■ Land reclamation ■ Soil salinity treatment technologies ■ Soil survey and classification ■ Fertilizers and enhancers development technologies	■ Soil properties ■ Soil fertility ■ Soil degradation	Soil		

Technology Areas

Technologies	Sub-paths	Paths	Sub-areas	Core area
■ Chemical control techniques ■ Bio-control techniques ■ Plant epidemics control techniques ■ Detection and diagnosis techniques ■ Integrated control techniques ■ Plant quarantine ■ Control mechanisms technology ■ Red Palm Weevil control techniques	■ Microbial diseases ■ Pets ■ Control techniques	Plant health		
■ Nutrition requirements technique ■ Genetic enhancement techniques ■ Milking equipment technology development ■ Abattoir machines technology development ■ Stockyards technology ■ Production increase and enhancement technologies ■ Pollutants emission control technologies ■ Stockyard environmental control technologies	■ Camel ■ Goat ■ Lamb ■ Cattle ■ Other	Animals/ Farm Animals		
■ Air quality control in poultry stockyard ■ Pollutants emission control technologies ■ Nutritional needs ■ Genetic enhancement technologies ■ Environmental control technologies ■ Stockyard design and development techniques ■ Breeding techniques ■ Production increase and enhancement technologies	■ Female poultry ■ Poultry meat ■ Poultry egg ■ Ostrich ■ Other	Poultry	Animal Production	
■ Disease detection and diagnosis technologies ■ Quarries development techniques ■ Biosafety technologies ■ Zoonosis control technologies ■ Trans-boundary disease control	■ Disease prevention and control ■ Immune system response enhancement ■ Zoonosis ■ Effect of hormone and doses use	Animal and poultry health	Animal Production	

Technology Areas

Technologies	Sub-paths	Paths	Sub-areas	Core area
■ Fishing systems development ■ Closed water system ■ Integrated fish farming technologies ■ Floating cages and enclosure agriculture ■ Production increase and enhancement ■ Genetic enhancement techniques ■ Aquaculture proliferation techniques ■ Live food production techniques	■ Freshwater fish farming ■ Sea fish farming ■ Crustaceans farming ■ Mollusks farming ■ Algae, and herbs farming	Farming	Aqua culture	
■ Detection, diagnosis and treatment techniques ■ Aquaculture Immune system enhancement techniques ■ Aquaculture environmental enhancement techniques	■ Microbiological ■ Environmental ■ Nutritional ■ Genetic	Aquaculture health	Aqua culture	
■ Manufacturing technologies ■ Conservation technologies ■ Nanotechnologies ■ Irradiation technologies ■ Dates and palm trees	■ Manufacturing ■ Conservation ■ Transportation, storage and handling	■ Plant sources ■ Animal sources ■ Bio-sources ■ Water	Food	
■ Food safety testing and detection techniques (chemical, microbial, biological, irradiation) ■ Hormones and antibiotics detection techniques ■ Pesticides residues detection techniques	■ Raw food products ■ Manufactured food products ■ Food additives safety	Food safety	Food	

Technology Areas

Technologies	Sub-paths	Paths	Sub-areas	Core area
■ Nutritional value enhancement techniques ■ Fodder manufacturing techniques ■ Traditional fodder alternative technologies	■ Non traditional fodder ■ Fodder additives	Fodder	Food	Manufacturing
■ Non traditional product technologies ■ Recycling technologies ■ Biological reactions (fermentation) ■ Manufacturing technologies ■ Product conservation technologies ■ Dates and palm residues recycling technologies	■ Manufacturing ■ Recycling	■ Plant sources ■ Animal sources ■ Bio-sources ■ Water ■ Residues	Non Food	Manufacturing
■ Information systems ■ Farming technologies ■ Bio-analysis environmental technologies ■ Environmental pollution assessment techniques ■ Pastures survey and environmental evaluation techniques ■ Rehabilitation techniques ■ Use of forests and pastures by-products ■ Plants disposal technologies ■ Spatial information technologies ■ Timber residues manufacturing technologies ■ Forest trees enhancement technologies ■ Rain harvesting technologies (forest areas) ■ Forest fires control technologies	■ Pastures and forests survey ■ Protection and sustainable development ■ Long term productivity ■ Pastures and forests development ■ Pastures and forests assessment ■ Natural resources economics ■ Environmental interpretations ■ Windbreaks, shelterbelts and sand dune fixation ■ Environmental changes ■ Invasive plants ■ Grazing animal feeding (wild and domesticated)	■ Environment ■ Management ■ Treatment and enhancement	Pastures and forests	Natural Resources
■ Collection and identification technologies ■ Propagation technologies ■ Conservation Genetics ■ Conservation informatics ■ Exchange technologies	■ Collection and identification ■ Propagation ■ Conservation ■ Exchange	■ Plant ■ Animal ■ Aquaculture ■ Microbiology	Genetic origins	Natural Resources

Appendix A: Stakeholders & Strategy Participants

Strategy Participants

The plan received extensive input, review, and comment from the stakeholder participants through numerous strategy workshops. The following tables list the participants and contributors to this national effort.

Study Team Members

Name		Name
KACST	Team president	Dr. Hassan bin Yayah Al-A'ad
KACST	Member	Dr. Ahmad bin Hamdi Alharbi
KACST	Member	Dr. Ali bin Abdullah Al Jalaud
KACST	Member	Dr. Ibrahim bin Mohammad Al Rekei
KSU	Member	Dr. Abdullah bin Abdulrahman Al Sadun
Ministry of Agriculture	Member	Dr. Abdulrahman bin Sulaiman Al Habib
KACST	Team director	Dr. Abdullah bin Adulmuhksin Al Rajhi
KACST	Team secretary	Mr. Mohammad bin Sayed Al Gamdi

Appendix A: Stakeholders & Strategy Participants

Participating Experts

Organization	Name
KACST	Mr. Abdullah bin Sultan Al Khalid
KSU	Dr. Ibrahim bin Mohammad Areef
King Faisal University	Dr. Ahmad bin Mohammad Al Jaber
KSU	Dr. Abdullaziz bin Mohammad Al Sayed
KSU	Dr. Mansour bin Saad Al Khuraidiz

Stakeholders Representatives

Organization	Name
National Commission for wildlife Conservation and Development (NCWCD)	Mr. Tarek bin Mohammad Amin Al Abbas
Ministry of Agriculture	Dr. Abdullah bin Ali Al Hindi
Saudi Food and Drug Authority	Dr. Ibrahim bin Abdulrahman Al Shadi
KSU	Dr. Abdullaziz bin Rabih Al Harbi
Ministry of Water and Electricity	Dr. Mohammad bin Ibrahim AlSaud
KSU	Dr. Yusuf bin Mohammad Al Yusuf
Ministry of Water and Electricity	Engr. Sayed bin Ali Al Diyer

Tel 488 3555 - 488 3444
Fax 488 3756
P.O. Box 6086 Riyadh 11442
Kingdom of Saudi Arabia
www.kacst.edu.sa

King Abdulaziz City for Science and Technology

Doc. No. 40P0001-PLN-0001-ER01