جـامعة قـرطاج
Université de Carthage

Visions and Research Strategy

"We will either find a way or make one"

2023-2030

This document has been drawn up by the members of Carthage University's Research Commission on the basis of discussions and consultations held within the Commission to define the research priorities and strategies to be adopted over the next ten years to meet the challenges facing the country and the world.

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Preamble,

Background and reasons for drafting the document

The emergence of modern science marks a turning point, both for knowledge and for awareness of the power of science, as defined by *Francis Bacon*[1] in his famous phrase "knowledge is power". The search for new knowledge must be seen in the context of the societies of the time, in whichit acquired a form of autonomy. Exchanged and disseminated throughout the world, it is buildinga de facto common heritage for humanity. In fact, knowledge generates applications, and vice versa. It wasn't until the industrial era that the acquisition of radically new knowledge became the main driving force behind technical progress.

The twentieth century saw the transformation of the scientist into a researcher, and an increase in the number of scientists. Science increasingly became a collective endeavor. The importance of exceptional breakthroughs, exemplified by Einstein's relativity, does not contradict this evolution. A multitude of teams contribute to results at all levels and to their validation. The working practices of researchers and engineers vary greatly according to the discipline, the nature of the research (more theoretical or experimental), the techniques used and the type of objective. We must be wary of generalizations. The major disciplines have subdivided. Scientists are increasingly specialized. They have less and less time to broaden their horizons, if only within their own disciplines.

What place does science have at the beginning of the twenty-first century? Does it really permeate the whole of society? Scientists are to be found in the major public organizations and semi-public or private research centers, in universities, of course, and in companies. What role do they play in other activities? Scientists, and even those with only a scientific background, seem to have all but disappeared from the ranks of our political leaders, and perhaps even from those of our top corporate managers.

Research and innovation have underpinned human and societal development since the dawn of civilization. This has brought enormous benefits for human well-being, while at the same time bringing the world to a critical crossroads where development without additional constraints risks harming society and the environment. The current pace and direction of innovation is insufficient to achieve the *United Nations*' (UN) ambitious goals for a sustainable and inclusive future for all, partly because of a relatively narrow focus on technological innovation without also addressing societal, institutional and cultural innovation. We need to rebalance so that all dimensions of innovation and invention are promoted simultaneously, including the fight against inequality.

[1] Baron de Verulam, Viscount St Albans, Chancellor of England, was an English scientist, philosopher and statesman. He was born in London on January 22, 1561, and died in *Highgate,* near the same city, in 1626.

Similarly, more proactive efforts are needed to promote dissemination and learning, and to overcome the obstacles, constraints and unforeseen consequences of innovations.

Our new era is marked by a certain effervescence, knows all the great dangers and uncertainties that threaten humanity and the planet, but paradoxically offers opportunities to steer development towards a just, resilient and sustainable future. The current coronavirus 2019 (COVID-19) pandemic is disrupting the status quo, promoting the creation of sustainable societieswith higher levels of well-being for all and the mitigation of environmental impacts at all scales. Correctly directed, the stimulus packages underway to restart economies can take advantage of the effects towards sustainability. The risk is that they will contribute to the resurrection of the"old normal", returning to the status quo, rather than to a transformation towards sustainability.

This document seeks to define new directions for research and innovation at Carthage University and is deeply inspired by the *United Nations* initiative, **The World in 2050[2].** This initiative is based on the voluntary and collaborative effort of more than 60 authors and contributors from some 20 institutions around the world, who have come together virtually to develop science-based strategies and pathways for achieving the Sustainable Development Goals (SDGs). Presentationsof the TWI2050 approach and work have been made at numerous international conferences such as the *United Nations* Science, Technology and Innovation Forums and high-level political forums.

In 2018, TWI2050's first report on transformations to achieve the Sustainable Development Goals identified six exemplary transformations needed to achieve the SDGs and long-term sustainability to 2050 and beyond:

i) Human capacity, demographics and health;

ii) Consumption and production;

iii) Decarbonization and energy;

iv) Food, biosphere and water;

v) smart cities;

vi) Digital revolution.

[2] **TWI2050 was** created by the *International Institute for Applied Systems Analysis* (IIASA) and other partners to provide the scientific basis for the UN's 2030 Agenda for Sustainable Development.

The focus of the second report, *The digital revolution and sustainable development*: *opportunities and challenges*, launched in 2019, was the sixth transformation. While it can arguably become the greatest catalyst for sustainable development, it has, in the past, helped to create many negative externalities such as the transgression of planetary boundaries. The digital revolution provides entirely new and enhanced capabilities and thus serves as a major force in shaping both the systemic context of transformative change and future solutions; at the same time, it can potentiallyhave a strong societal disruptive power if not handled with caution, care and innovation.

The third report, *Innovations for Sustainability*: *Pathways to an efficient and sufficient post- pandemic future,* assesses all the potential positive benefits that innovation brings to sustainable development for all, while highlighting the potential negative impacts and challenges ahead. The report outlines strategies for harnessing innovation for sustainability, focusing on efficiency and sufficiency in the provision of services to people, with a particular emphasis on consumption and production. It concludes with governance challenges and related policy implications.

The publication of this report in July 2020 and its launch at the *UN* High-Level Political Forum are timely. TWI2050 presents ten key messages on the links between innovation, efficiency and sufficiency, and sustainability transformations:

1. The world is at a crossroads; achieving the Agenda 2030 is possible, but requires accelerated action and transformative paths to sustainable development.
2. A sustainable, just and resilient future for all; implies socio-economic development for greater human well-being while preserving the resilience of the earth system.
3. The COVID-19 pandemic is a major threat to humanity; but it also offers an opportunity for change and innovation towards sustainability.
4. Six TWI2050 transformations provide a framework for realizing the 2030 Agenda; together, they integrate all the SDGs and provide an entry point for achieving them.
5. Transformative governance is emerging; there is a growing understanding of the governance needs for the integrated implementation of the SDGs.
6. Science, technology and innovation are at the heart of human progress; paradoxically, they have also had negative effects, but they also provide solutions.
7. Small, granular innovations generally have faster adoption and diffusion; they can enable rapid change, but require sustained investment.
8. The science-policy-society interface is essential for evidence-based transformations; research and development are catalysts for sustainability-driven innovations.

9. Transforming service delivery systems is necessary; improving human well-being and sharing resources equitably requires people-centered efficiency and sufficiency.
10. Transnational crises require context-sensitive global responses; support from local to international players is essential to accelerate reforms to achieve sustainability transformation.

Despite the scale of the challenge and the current unsustainable direction of development, also impacted by the COVID-19 pandemic, transformation to a sustainable future is achievable - we have the knowledge, the means and the capabilities. However, at present, with only 7 years to 2030, there is a general lack of political will within many governments around the world to mobilize the necessary resources and make the political and structural changes required toachieve the 2030 goals. The TWI2050 report provides policy and decision-makers around theworld with invaluable new knowledge to inform action and commitment to achieving the SDGs in these interesting and challenging times. The level of global commitment and cooperation displayed during the elaboration of the 2030 Agenda for Sustainable Development must continue and deepen during this critical phase of implementation.

Part A:

The Tunisian economy in 2021:

Assets, challenges and issues

The findings of the past 10 years

The Tunisian economy recorded an unprecedented 8.8% decline in 2020 compared with 2019, the National Institute of Statistics (INS) said in a statement published on its website[3].

In the fourth quarter of 2020, gross domestic product (GDP) fell by 6.1% compared with the fourth quarter of 2019, at year-earlier prices, the NSI explained. Compared with the third quarter of this year, GDP fell by 0.3%.

It should be noted that the second-quarter growth rate has been revised by 0.4 points to (-21.3%) and the third-quarter growth rate has been revised by 0.3 points to (-5.7%).

These results, which are essentially explained by declines in vital sectors, are far from the government's forecasts set out in the 2020 Supplementary Finance Act (i.e. a contraction of 7.3%).

In its World Economic Outlook - October 2020 report, the International Monetary Fund (IMF) forecast a 7% contraction in Tunisia's economic growth rate throughout 2020, dropping to 4% in 2021 and 3% in 2025.

Manufacturing value added down 4.5

In the fourth quarter of 2020, value added in the manufacturing industries fell by 4.5% compared with the same period of 2019.

This decline is essentially explained by lower production in most industries, such as chemicals (-13.8%), food (-8.2%), textiles and clothing (-5.5%), and mechanical and electrical engineering (-0.9%).

[3]Source: https://www.webmanagercenter.com/2021/02/15/463550/tunisie-un-taux-de-recession-record-de-88-en-2020/

By contrast, the building materials and ceramics sector recorded growth of 1% compared with the same period last year.

3.2% decline in non-manufacturing industries

Value added in non-manufacturing industries fell by 3.2% in the fourth quarter of 2020, compared with the same period of the previous year.

This decline is due to a 34% drop in production in the mining sector, as a result of lower raw phosphate output. Production in this sector is estimated at 3.1 million tonnes in 2020, compared with 3.7 million tonnes in 2019.

The oil and gas extraction sector also recorded a 0.3% decline. The construction (-1.3%) and electricity (-1%) sectors were also down, due to lower industrial energy demand.

9.4% decline in value added in the market services sector

The market services sector contracted by 9.4% year-on-year in the fourth quarter of 2020, following a drop in production in most of its strategic sectors, such as hotel, restaurant and café services (-49.1%), and transport services (-23%).

On the other hand, value added in telecommunications services rose by 3%, as did value added in financial services, which increased by 4.2%.

Non-market services down 7.6% in value added

In non-market services (services rendered by public authorities), a 7.6% drop was recorded in the fourth quarter of 2020, following the adoption of the new working regime in public authorities with exceptional working hours.

4.4% rise in value added in the agriculture and fisheries sector

According to statistics from the Ministry of Agriculture, Hydraulic Resources and Fisheries, value added in the sector rose by 4.4% in 2020.

The situation before 2011

Tunisia is an upper-middle-income country. It is characterized by a gross domestic product (GDP) that grew by 3.5% per year over the period preceding the 2008-2010 revolution[4], a GDP of 3,310 euros per capita[5], in 2011, a relatively healthy macro-economic environment and a fairly diversified, export-oriented economy supported by foreign direct investment (FDI).

In 2011, exports accounted for 51%[6] of the country's GDP. The following seven sectors accounted for 80% of trade in goods and services: textiles, electronics, electrical and mechanical engineering, chemicals, agriculture, tourism and information and communication technologies (ICT)[7]. In 2011, the services sector accounted for more than 45% of GDP[8] thanks mainly to ICT[9]. ICT alone accounts for 10% of GDP[10] and offers significant potential, with an estimated market value of 4.8 billion euros and a compound annual growth rate of 6% between 2007 and 2012[11]. Industry isalso well represented in the economy, with the electrical and electronics industries growing in importance, with an estimated business volume of over 2.2 billion euros in 2012, and a 16% increase on the 2005-2010 period[12].

[4] Source: World Bank data,

http://donnees.banquemondiale.org/indicateurr/NY.GDP.MKTP.KD.ZG

Note: GDP in purchasing power parity (PPP), year-on-year growth over 2007-2012.

[5] Source: World Bank data, http://databank.worldbank.org/ddp/home.do.

[6] Source: Agence de Promotion de l'Industrie et de l'Innovation (APII),

http://www.tunisianindustry.nat.tn/fr/home.asp.

[7] Source: Institut National de la Statistique. Note: GDP in PPP, 2012.

[8] Source: OECD Information Technology Outlook, 2010.

[9] Source: Foreign Investment Promotion Agency (FIPA),Note: GDP in PPP.
http://www.investintunisia.tn/site/en/article.php?id_article=779

[10] Source: IDC CEMA Black Book 2011.

[11] Source: Foreign Investment Promotion Agency, http://www.investintunisia.tn/site/en/article.php?id_article=774.

[12] Note: The countries in the Middle East and North Africa region are as follows: Algeria, Bahrain, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Palestine, Oman, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, United Arab Emirates, Yemen.

Traditionally strong human capital

The country's strengths in terms of education (both in terms of factors and learning outcomes) are one of the main explanations for its economic dynamism. In 2011, the United Nations Human Development Index was higher than the regional average (0.70 for Tunisia, compared with 0.64 for other countries in the Middle East and North Africa region[13]), while remaining below 0.87 according to the *Organisation for Economic Co-operation and* Development (OECD)[14]. In the same year, 78% of the population was literate, compared with 98% for the OECD average[15]. Beyond these fundamentals, the secondary school enrolment rate is high, standing at 90%[16] in 2009. In terms of educational results measured by the OECD's *PISA* program (*Programme for International Student Assessment*)[17], Tunisia is improving its performance (401 points for science comprehension in 2009 vs. 386 points in 2006), but still lags behind the OECD average (501 in 2009)[18].

Policies to support innovation are in place, but not yet coordinated or fully implemented Policymakers have drawn up a number of programs to promote innovation and the development of the knowledge economy.

The country's innovation system is based on the "triple helix" model, i.e. collaboration between universities, research institutes and start-ups. Innovation is concentrated in certain cities such as Tunis, Sousse and Sfax. Research and development (R&D) is relatively high compared to

[13] Source: United Nations Development Programme, http://hdrstats.undp.org/fr/pays/profils/TUN.html.

[14] Source: UNICEF,
http://www.unicef.org/french/infobycountry/Tunisia_statistics.html.

[15] Source: World Bank data,
http://donnees.banquemondiale.org/indicateur/SE.SEC.ENRR.

[16] Note: PISA (Programme for International Student Assessment) is an international study launched by the OECD in 1997. Its aim is to evaluate education systems around the world every three years, by assessing the skills of 15-year-olds in reading, mathematics and science.

[17] OECD, PISA 2006, 2009,
http://www.oecd.org/pisa/46643496.pdf and http://www.oecd.org/pisa/46660259.pdf.

[18] Source: World Bank,
http://donnees.banquemondiale.org/indicateur/GB.XPD.RSDV.GD.ZS.

comparable countries in the region, with R&D spending amounting to 1.1% of GDP in 2010 (versus 0.21% in Egypt, 0.42% in Jordan and 0.08% in Saudi Arabia)[19].

Between 2006 and 2010, 17,068 scientific articles were published, with work and co-authorship in the following fields[20]:

- physics and astronomy (64%),
- neuroscience (58%),
- materials science (53%) and
- immunology (55%).

However, a number of policy hurdles continue to hold back the country's performance in the knowledge economy: a strong role for the state, lack of coordination between public bodies, pervasive bureaucracy, declining capital inflows and insufficient access to private sector finance and capital, particularly after companies have been set up. The lack of coordination betweenpublic bodies and the length of time it takes to review funding applications - up to six months for a response, according to a private sector survey - is prompting the innovative companies surveyedto gradually reduce their formal applications and turn to the private sector. The number of venture capital firms remains limited, while venture capital investment companies (SICARs) and bank loans are relatively unsuitable for start-up financing. In terms of capital inflows, foreign direct investment in the knowledge economy is lower than in Morocco or other countries in the Middle East and North Africa, with FDI inflows declining by 9% between 2007 and 2010.

[19] Source: SCImago (2007) SJR - SCImago Journal & Country Rank.

[20] Source: World Bank data, http://donnees.banquemondiale.org/indicateur/BX.KLT.DINV.CD.WD.

The challenge: unleashing Tunisia's potential through knowledge-based policies and actions. Since January 2011, the country has been experiencing the economic difficulties inherent in the transition phase it is going through. Significant obstacles have yet to be overcome, including a rigid labor market, an inequitable tax system, a lack of appropriate competition policies and askills deficit, all of which contribute to high unemployment.

More specifically, a number of challenges need to be addressed in order to develop a comprehensive knowledge-based strategy: gaps in capabilities and innovation need to be identified and targeted, and relevant targets for investment need to be highlighted. The most important issue is to define an appropriate framework for both analyzing and filling these gaps, starting with a definition of the knowledge economy, a notion that is not yet clear in the literature.

What's more, given their limitations, current conventional approaches, based on horizontal or vertical analysis and focusing solely on governance, institutional variables, the regulatory or policy framework, do not seem to take full account of the main driver of economic growth, i.e. knowledge.

The questions

The general question to ask is:

In which sectors and in which areas of research should the University of Carthage invest in order to produce beneficial effects on innovation, employment and the development of the knowledge economy in Tunisia, while at the same time making its investment profitable?

To answer this question, we need to break it down into several elements:

- How to achieve "opportunity value" in Tunisia?
- What are the factors that accelerate or, on the contrary, slow down the development of knowledge-based capabilities?
- In what area(s) are there gaps in capabilities and innovation?
- Where are these gaps located, geographically, at national and sub-national levels?
- What are the gaps by type of network and value chain?
- How can they be filled in practice, i.e. which laboratories, units or projects should be targeted?

Investment opportunities in information and communication technologies, the electronics and electrical sectors, and healthcare

These three sectors account for 4.8 billion euros, 2.2 billion euros and 398 million euros of GDP respectively.

Tunisia is a regional leader in the ICT sector. According to the Davos World Economic Forum's ranking index (2008), the country ranks first in Africa and third in the Arab world. Over the 2007-2012 period, the sector's compound annual growth rate was 6%.

Industry is also well represented in the economy, with the electrical and electronics industries (EEI) sector growing, with a volume of activity of 2.2 billion euros and annual growth of 16% from 2005 to 2010[21].

The pharmaceutical sector also offers interesting potential for growth and innovation.

This market was worth an estimated 398 million euros in 2010, with growth of 15% over the 2004-2009 period[22].

[21] Source: Foreign Investment Promotion Agency (FIPA Tunisia),

[22] Source: Agence de promotion de l'industrie et de l'innovation, Monographie, "Les industries chimiques en Tunisie" (2010), downloadable at: http://www.tunisianindustry.nat.tn/FR/download/CEPI/mono_ich.pdf.

Part B:

The challenges of today and tomorrow

Priority research themes:

Water, The scarcity of water resources

When we talk about extreme poverty or hunger in the world, we're also talking about a global shortage of drinking water. Less than 1% of the world's water supply is usable for us as humans (the rest is salt water, in the form of ice or underground). And that 1% we have to share between 7.7 billion people worldwide. That leaves 844 million people without access to drinking water and 2.3 billion without access to basic sanitation. This sets people up for a cycle of global thirst that fuels both hunger and poverty around the world.

So how do we break the cycle? There are a number of root causes of thirst and water scarcity that can impact everything from crops to public health. Tackling these root causes will help us find more effective ways to make the most of this 1%. To get us started, here are 5 causes of global thirst.

1. **Contaminated drinking water**

   Sometimes, water can be abundant - but drinking water is another story. Many parts of the world have poor systems for treating wastewater - water that is affected by human use such as domestic, hospital or industrial processes. As the UN notes, this is particularly widespread in low-income areas of towns and villages. On a global scale, 80% of wastewater flows back into the ecosystem without being treated or reused, which, according to UN figures, leaves 1.8 billion people using water that may be contaminated by faecal matter, and therefore at risk of contracting cholera, dysentery, typhoid and polio.

2. **Climate change and drought**

   Experts suggest that over the next decade, environmental changes brought about by global warming are likely to increase the vulnerability of the poor. In a number of African countries, regular drought increases the risk of acute and chronic hunger. Soil fertility is a major problem: 80% of agricultural land is affected by severe degradation, leading to significant nutrient loss and soil erosion.

   Floods can also lead to water shortages, playing on the effects of El Niño and La Niña. These natural disasters are at the root of other problems linked to hunger and poverty around the world. While drought and floods can lead to major crop failures. Flooding washes away seeds and saturates the soil with water, so crops can't grow. If heavy rains follow periods of drought, valuable topsoil can also be washed away. In such situations, populations can be threatened by water shortages and food insecurity.

3. **Wars and conflicts**

Wars and conflicts lead populations to sink into a water crisis caused by the destruction of the country's infrastructure - in particular municipal water networks. The absence of this vital element poses a serious risk to public health.

4. **Wasting water**

Unlike wastewater, water wastage is more common in certain regions where taps run non-stop, watering lawns and building swimming pools and spas are comparative luxuries for developing countries.

In 2018, Cape Town managed to avoid "Day Zero" - the day they would have to turn off all water taps for its 4 million inhabitants - by limiting water use and focusing on necessities first.

Leaky pipes aren't inevitable either: these little annoyances can account for between 30% and 40% of a city's lost water. The average family can waste 690 liters a week, or 35,590 liters a year, due to domestic leaks, amounting to some 3,407 billion liters of water lost every year[23].

5. **Lack of infrastructure for water treatment, storage and distribution**

Many governments lack the infrastructure to invest properly in their water resources, enabling purified drinking water to reach those who need it most.

While water infrastructure is a resource with high financial implications, the value of water is taken for granted and, as the UN notes in its High-Level Panel on Water, "is generally capital-intensive, long-lived with high sunk costs. It requires a high initial investment followed by a very long payback period."

Countless water sources have remained unusable due to violence, poor condition and overuse. Possible solutions include the use of manually-operated "village drills", which eliminate the need for electricity. They are also 33% cheaper than conventional mechanized drills, and can be transported to remote areas and assembled on site.

[23] Cape Town is not the only city facing a Day Zero: London, Sao Paulo, Jakarta, Istanbul, Tokyo and Mexico City are also threatened in the near future.

Energy, The greatest energy challenges facing humanity

With global population growth and increasing industrialization in developing countries, humanity's thirst for energy is reaching unprecedented levels. More than half of all energyconsumed comes from fossil fuels extracted from deep within the earth's crust. Since commercial oil drilling began in the 1850s, over 135 billion tonnes of crude oil have been sucked up to drive cars, supply power stations and heat homes. This figure increases every day.

Gas consumption over the past two centuries has wreaked potentially devastating havoc on the planet. The burning of coal, oil and gas has been inextricably linked to rising levels of greenhouse gases in the earth's atmosphere, and is one of the main contributors to climate change. The world's scientists agree that we are on the path to a catastrophe that can only be halted by changing our habit of consuming fossil fuels.

"The energy industry is facing decades of transformation," according to a recent report by the World Energy Council. Yet the implications of the changes underway go much further. Political, economic and social issues are at stake.

Perhaps the biggest issue raised by scientists, policy experts and businesses alike is how to cope with the immediate rise in energy demand predicted for the coming decades.

In truth, the picture may not be as bleak as it could be. Around a fifth of the world's primary energy already comes from renewable sources such as wind, solar, hydro and geothermal power. This sector is set to continue growing by 2.6% every year until 2040.

Until recently, the main source of renewable energy was hydroelectric power, and wind power was the fastest-growing. But new advances in solar panel technology, enabling them to generate electricity even in cloudy conditions, have seen an increase in the amount of energy produced using the sun.

In the UK, for example, over 12 GW of solar power has been added to the grid in the last 12 months - the equivalent of an entire coal-fired power station. Worldwide, the amount of solar power generated increased by 50% last year. Researchers in many countries are working on new photovoltaic cells that can be printed on flexible sheets, which could further reduce the cost of solar energy.

However, connecting these new energy producers to existing grids will not be straightforward. "One of the big challenges of deploying these intermittent renewables like wind and solar is the impact they could have on the system," says Watson[24]. In many Western countries, the grids that

[24] **Jim Watson**, Director of the UK Energy Research Center

carry our electricity supply to our homes and offices are decades old, designed to cope with stable and reliable power generation. Wind and solar power are highly dependent on the weather - and the time of day, in the case of solar - which means they don't necessarily produce most of their electricity at times of peak demand.

Watson argues, "Previously, summer was a very quiet time for the grid operator compared to winter". He then explains, "Now they have this spike in generation in the summer because of solar power when demand is low. They have to juggle that because we can't store electricity in large quantities yet. It's a new way for them to operate"".

Most countries are currently tackling this problem by keeping more reliable sources of energy production in reserve. This means having nuclear, gas and even coal-fired power plants idle or operating at low levels, but ready to ramp up production when the wind dies down or the sun dips below the horizon.

According to Robert Armstrong[25], director of the Massachusetts Institute of Technology Energy Initiative, this limits the amount of renewable energy you can practically use. Armstrong's models suggest that, without energy storage, only around 10% of our energy could come from the sun. "The reason for this is that solar energy is concentrated around midday, so you need production to meet demand in the evenings and mornings. There are issues around who builds that and who pays for it. "

One solution to this is to expand the grids that distribute electricity - creating "supergrids". The basic idea is that if energy is shared over a wider area, there's a greater chance of the sun shining or the wind blowing in part of a supply network.

These programs envisage connecting the energy grids of several countries together so that electricity can be shared between nations. Proposals for a European supergrid and another in the USA have been discussed for decades. More recently, there have even been calls for a global energy grid - an idea supported by Chinese State Grid, which has set up the World Development and Cooperation Organization for Energy Interconnection.

There are already moves in this direction. The UK is building new subsea connections to power grids in France, Belgium, Denmark, Ireland and Norway, with the capacity to import or export up to 11 GW of electricity. There are also efforts to build an Asian supergrid linking Japan, Russia, China, Mongolia and South Korea.

[25] **Robert Armstrong**, Director, Massachusetts Institute of Technology Energy Initiative

"Transporting electricity from regions that need it least to those that need it most would help generate substantial economic benefits," asserts Ksenia Letova[26], Asian Supergrid project manager at the Skoltech Institute for Science and Technology in Russia. "In countries like Japan and South Korea, the maximum seasonal load falls in summer due to intensive use of air conditioning. In the Russian Far East and Siberia, this is the period of lowest electricity demand."

Utilizing excess capacity in neighboring countries can help reduce the construction costs of new energy projects. For example, there are plans to develop large-scale wind and solar power plants in the Mongolian Gobi Desert and in the northern regions of China. These regions are sparsely populated, but exporting the surplus energy produced could generate significant revenues.

"The problem is the cost of building such a network." says Janusz Bialek[27]. Power transmission over long distances can be inefficient, and many countries will need to upgrade their power lines to cope.

"There are also political considerations," states Bialek. He insists on the fact that "Any failure or attack against a global network could have very serious consequences threatening security of supply in many countries."

This is an important point. Energy security is already the main driver of the geopolitical landscape. Countries with large oil reserves can largely dictate global policy, and countries like Saudi Arabia have won powerful allies like the USA thanks to the black gold buried beneath their soil.

Yet, as nations rely more and more on alternative energy sources, they could also see these traditional power struggles change. The world's biggest oil producers are Saudi Arabia, the USA and Russia. By contrast, the biggest producers of solar power today are China, Germany and Japan,while the USA, China and Germany are the world leaders in wind power.

"As new technology is developed it will shift the geopolitics of energy," says Watson. "It will change relationships."

With countries like Morocco building giant solar farm projects in their vast desert areas in the hope of exporting this vast resource to other countries, this could lead to states playing a more prominent role on the world stage. If Mongolia builds its huge wind and solar energy reserves in the Gobi, it could transform geopolitical relations in East Central Asia.

Yet the need for supergrids and energy-sharing agreements between countries would be reduced if a good way of storing electricity could be found. As well as being widely available and affordable,

[26] **Ksenia Letova**, Skoltech Institute for Science and Technology in Russia

[27] **Janusz Bialek**, Skoltech Institute of Science and Technology

fossil fuels have a major advantage over renewable energy sources: they are very easy to store and transport.

There is currently no easy way of storing the electricity generated by wind or solar power for appreciable periods of time. Technologies such as capacitors and flywheels can provide stored energy for a few minutes or hours. But power grids have to be finely tuned. They only work when the amount of energy supplied is the same as that used. Supply must match demand.

Many still wonder what to do when the sun is shining and the wind is blowing, and electricity demand is low. Hydroelectric dams can provide part of the solution. In the UK, surplus electricity is used to pump water to the top of these dams in Scotland and Wales, where it is stored as potential energy. When required, the water is released to drive the turbines.

The cables currently being laid under the North Sea will also soon give the UK access to large quantities of hydroelectric storage in Norway. Excess wind and solar power will be exported to Norway for storage, before being bought back when needed.

But building new hydroelectric dams is controversial and extremely damaging to local habitats. This has left researchers looking for another solution. Some are considering building battery banksto store this energy, but battery technology is not yet sufficient to store large quantities of energy efficiently.

Armstrong claims "I suppose the solution will come in the form of fuel". He adds, "We can make fuel from excess solar or wind energy, perhaps splitting water to produce hydrogen and eventually taking some of that excess energy and reducing the carbon dioxide to combine with the hydrogen to make synthetic hydrocarbons."

Currently, there are a number of small-scale projects around the world attempting to do just that. Aberdeen, Scotland, for example, is running the world's largest demonstration project for hydrogen fuel cells in buses. Renewable energy is used to produce hydrogen, which is used to power 10 public buses in the city.

It could also solve one of the pressing problems facing many countries with colder climates: how to stay warm. "One of the big challenges facing countries like the UK is how to make heating more sustainable," Watson adds. "These countries still use fossil fuels for heating. You might need months of storage. This is an area that's really ripe for innovation, and we're really only at the beginning of deploying and testing potential solutions.

Most Northern European countries, including the UK, use natural gas to heat their homes. If Britain were to abandon gas and use electricity for heating, it would require a four- or five-fold increase in grid capacity overnight, according to Julian Leslie[28], head of grid development at the UK's National Grid.

"It's going to be enormously expensive," he says. "You'd struggle to get planning consent for the cables and production needed. The future of gas is very strong and we can decarbonize gas a lot by producing hydrogen or biogas to inject into the gas grid. We need to explore more alternatives to further decarbonize gas."

Biogas and biofuels are often seen as one of the most viable alternatives to fossil fuels, with companies like BP investing huge sums in the development of production lines. Yet burning these fuels will not prevent the release of greenhouse gases into the atmosphere. And with shale oil and gas extraction booming in many parts of the world, it seems likely that we'll be dependent on fossil fuels for some time to come.

"By 2050, 75% of our energy will still be derived from fossil fuels," said Armstrong. "A crucial issue for us will be how to reduce carbon dioxide emissions from these energy sources. This will require the storage and use of carbon capture. Reducing the cost of carbon capture is probably the most difficult element, but we also need to figure out how to store it for geological time periods."

Carbon capture involves cleaning gaseous carbon dioxide from flue gases. Typically, this involves expensive chemicals to bind the carbon dioxide and requires the replacement of power plants so that the mixture can be heated as part of the scrubbing process. But there are new approaches under development which use metal ions, avoiding the need to heat the chemical mixture.

Some believe that the problems we face with renewable energies can be overcome in more direct ways, such as closer monitoring of household energy consumption. By 2020, the European Union aims to install 500 million smart meters in homes to monitor energy consumption.

Detailed minute-by-minute information on demand should help utilities to better manage networks. "Artificial intelligence will be essential for analyzing the vast amounts of data generated around the power grid and making real-time control decisions," explains Valentin Robu[29], Professor of Smart Grids at Heriot-Watt University in Edinburgh, Scotland.

It could also lead to fundamental changes in the way we consume technology. "We're not that far away from me asking my energy company for the cheapest rate possible and them sending me

[28] **Julian Leslie**, Head of Grid Development, UK National Grid

[29] **Valentin Robu**, Professor of Smart Grids at Heriot-Watt University in Edinburgh, Scotland.

plugs that connect to my WiFi network," Leslie explains. "That will mean you no longer have control over your dishwasher or washing machine."

Energy companies will control when appliances run. They will be able to switch them on when the weather is sunny and solar power is abundant, or when demand is otherwise low.

Such approaches would mean a fundamental abandonment of the on-demand energy consumption pattern to which we have become accustomed over the last century. For example, when our refrigerators go through cooling cycles or appliances are switched on can be determinedby weather fluctuations or the time of day. Our dishwashers, for example, can run during the day while people are at work, rather than at night.

"For years, we've used energy when we wanted to and paid a flat rate for it," says Martin Freer[30]. "We'll have to start redirecting our energy use to when it's there and available, rather than redirecting energy production based on our usage."

Information, hopes and challenges

The future of information technology

Although the information revolution is in full swing, the development of information technology may rest on one question: can silicium -based computer technology sustain Moore's Law beyond 2020? In 1965 - three years before co-founding Intel with Bob Noyce - Gordon Moore published an article that proved strangely prophetic.

Moore wrote that the number of circuits on a silicium chip would continue to double every year. He then revised this figure every 18 to 24 months, a prediction that has held up remarkably wellfor several decades.

To date, Moore's Law is the driving force behind a billion-dollar industry. But how will this continue in the future? A typical wire in a Pentium chip is now 1/500 the width of a human hair, the insulating layer just 25 atoms thick. The laws of physics suggest that this doubling cannot last forever. Physicists predict that by 2025, transistors will become so small that their silicon components will approach the size of molecules. At these incredibly tiny distances, the bizarre rules of quantum mechanics take over, allowing electrons to jump from one place to another without passing through the space in between (Heisenberg's uncertainty principle). Like water from a leaking fire hose, electrons will gush onto atom-sized wires and insulators, causing deadly short circuits.

[30] **Martin Freer**, Director of the Birmingham Energy Institute, University of Birmingham

There is currently no known, proven solution to the problem of miniaturization limits. The search for a successor to silicium has become something of a crusade. Some of the theoretical options being explored include:

- the optical computer,
- the DNA computer,
- molecular and dot computers,
- the quantum computer (Kaku, 2000).

The optical computer replaces electricity with laser light beams. Unlike wires, light beams can pass through each other, making three-dimensional microprocessors possible. An optical transistor has already been invented; unfortunately, the components are still very bulky and clumsy. The optics of a desktop computer would be the size of a car.

The DNA computer seems to be one of the most ingenious ideas pursued in the field of information technology. It treats the double-stranded molecule as a kind of biological computer tape. Instead of encoding O and 1 in binary, it uses the four nucleic acids, represented by A, T, C, G. This approach holds great promise for computing large numbers. Consequently, large banks and institutions could one day use it. However, a DNA computer is an unwieldy contraption, consisting of a jungle of organic fluid tubes, and is unlikely to replace a laptop computer in the near future.

Molecular and dot computers. Other exotic designs replace the silicium transistor with a single molecule in the molecular computer and a single electron in the dot quantum computer. These molecules and electrons then act as tiny logic gates and switches. These approaches face significant technical problems, such as the mass production of atomic wires and insulators. No viable prototype yet exists.

The quantum computer is sometimes referred to as the ultimate computer. The idea is to direct a laser or radio beam onto a carefully arranged collection of atomic nuclei, each of which spins like a top. As the beam bounces off the atoms, it flips the spins of some of them. Complex calculations can be made by analyzing how the spins have been reversed.

U.S. intelligence agencies are nervously watching these new designs for quantum computers, in particular, which are said to be so powerful that they could one day break the most complex secret codes the CIA can concoct.

However, these computers appear to be extremely sensitive. The slightest disturbance (even a passing cosmic ray) can change the orientation of their computing atoms, messing up the calculation. At present, quantum computers can only perform trivial calculations on perhaps five atoms. To do any useful work, they would need to calculate on millions of atoms.

Most are still on the drawing board, and even those with working prototypes are too rudimentary to compete with the convenience and efficiency of silicium.

The future of information access policies

As early as 1980, Alvin Toffler[31] identified three waves of civilization. The first wave was launched by the agricultural revolution, and the second wave was driven by the industrial revolution. The third wave is at the origin of a new civilization characterized by its own jobs, lifestyles, work ethics, sexual attitudes, life concepts, economic structures and political mentalities. Thanks to advanced telecommunications, the third wave is creating a global society heavily dependent on the creation and transfer of information. This information revolution is having an even greater impact on the world than the first and second waves.

Several conceptual/operational efforts (e.g., the Global Villages, the Information Superhighway,the National Information Infrastructure in the U.S.) are examples of evidence that leaders in government, the information industries and libraries are genuinely interested in improving the transfer of information from one human being to another. Technology is certainly a means to an end. Nevertheless, it is a proven "catalyst" with the potential to improve the human condition worldwide.

So far, there have been gigantic advances in networks connecting to other networks. Some of these steps have taken place with virtually no long-term planning or overall control. The G7 countries began to talk about the expected benefits of the Global Information Infrastructure (GII). Library chiefs from various countries are organizing conferences to exchange ideas on how to improve cooperation; a good example of such a conference is the Sino-American Library Conference held in Beijing (August 1996). All this exploration is certainly necessary. However, it is now time to create a global information policy.

On the basis of rapid technological change and the volatile information environment alone, a global information policy is justifiable. And this becomes even more obvious when we considerthe dynamics of different cultures, economic conditions and political factors. There is no doubt that much preparation needs to be done before a single global information policy can be

[31] **Alvin Toffler:** American writer, sociologist and futurologist. He is one of the most famous futurists of his time.

established. An inventory of existing national information policies should be drawn up. Creating a global information policy may initially seem a little like "mission impossible":

Who should be responsible for drafting the overall policy?

Should the framework policy evolve from existing national policies?

Would it be better to focus on drafting information policies for the respective countries before embarking on developing a global information policy, or vice versa?

All these questions, and many more, need to be answered.

Despite the plethora of issues, concerns and problems associated with developing policies for the global information community, "targets of opportunity" to improve the sharing and dissemination of information around the world are becoming increasingly important. Advanced technology (e.g. wireless) offers unprecedented opportunities to create interconnections with parts of the world that previously could not (or could not) afford the necessary telecommunications. Digitized library materials are now shared worldwide; in the past, these "treasures" were only accessible by visiting preservation libraries. These are just some of the many opportunities for improving access to vital information.

Big Data and AI are ideally suited to pattern recognition, and thus to the generation of similar models. This way of working can generate new benefits.

Over the next few years, virtual reality applications are likely to become increasingly sophisticated with the emergence of more powerful devices capable of developing higher quality visuals. Understanding of how we can usefully interact and navigate in virtual environments will also evolve, leading to the development of more natural ways of exploring and interacting with virtual space. Here are some imminent effects of immersive virtual reality experiences enhanced by the power of AI.

Danger warnings

In addition to their own ability to judge a situation in a split second, humans have developed a diverse range of mechanisms that can help them stay out of harm's way. However, these judgments, generally referred to as intuitions, are not infallible.

What if a machine with the combined experience of thousands could surpass such a task? Such a development could save millions of soldiers on the battlefield by helping them to anticipate opponents' movements and alert them in advance.

The digital revolution is underway. According to a study published by Dell and the Institute for the Future, 85% of the jobs of 2030 do not yet exist. Artificial intelligence and robotics will not only radically transform existing professions, but also create new ones, such as ethicists and psy-designers.

However, some of tomorrow's professions are already a reality. Robotician, data scientist, civil drone pilot, 3D printer, BIM manager.... Companies are snapping up these rare profiles, which concern many professional sectors.

Many of these professions are open to holders of 2-year higher education diplomas (BTS, DUT) or 4/5-year higher education diplomas (master's degree, engineering degree).

Part C:

Strategy

To realize this vision, the University will adopt a strategy involving three major functions that will underpin the program's activities for the next ten years:

1. Establish more effective frameworks for collaboration between university laboratories, units and Tunisian companies and industries;
2. Motivate researchers to take part in research and development work carried out by Tunisian companies;
3. Support research in priority areas.

Nevertheless, the landscape needs to be optimized to meet the overall objectives of the new global research context. To this end, the University of Carthage aims to improve the organization of its laboratories and research structures:

1. Facilitating interdisciplinary research and exploiting data interoperability to produce new science to address new societal challenges and contribute to the Sustainable Development Goals (SDGs),
2. Create more effective synergies and direction between different European and national funding sources,
3. Better integration of research infrastructures into their host institutions,
4. Continuously modernize their administrative services and working methods,
5. Support national priorities and strengthen the University's role in building national and global efforts.

New missions for research structures

Research structures play a key role in the advancement of knowledge and technology. They improve the efficiency and effectiveness of research and contribute to the overall advancementof the innovation ecosystem.

However, breakthroughs in basic research are almost always unexpected, and often involve combining previously known knowledge in new and innovative ways, often across disciplines. The relationship between research and innovation - and therefore with research infrastructures - is diverse and often complex; there is simply no single model. The time between a breakthrough in basic research and application varies and is very difficult to predict. Nevertheless, efforts must be made to reduce the gap between scientific advances and their application in practice.

Research structures should not be seen as stand-alone facilities, but as part of a wider system contributing to the longer-term development of research and innovation. This system is not only capable of integrating research structures within and between scientific fields, but must increasingly create knowledge and innovation clusters around state-of-the-art structures, attracting high-level expertise and creativity and providing a space for the sharing of knowledge and ideas.

Ongoing support for the development of a research infrastructure system is a strategic asset, fostering both breakthrough discoveries and incremental innovation. Research infrastructure is also a powerful resource for industry - often a prerequisite for industry-academia collaboration. Participation in infrastructure projects also offers Tunisian researchers and industry opportunities to stimulate cutting-edge technological development.

The potential for developing spin-offs from technological advances is also significant, and can be supported in the future by better links with UTICA[32]. In addition, research facilities must offer unique training opportunities and play an important role in training and developing new generations of scientists, engineers and data professionals. Scientists visiting these facilities receive technical support and training, acquiring new skills in the use of cutting-edge technologies, data analysis and quality control.

Concerted strategic management of research (stewardship) based on defined priorities:

A major new role as knowledge organizer and manager to support needs assessment, priority setting, progress analysis, awareness raising, and to give partners a neutral platform for discussion and harmonization of their activities.

Empowering researchers

By going beyond traditional research training to establish decision-making capabilities at individual, institutional and national levels, so that research structures can better undertake and conduct research, assert themselves in international research circles and effectively use research results for policy decisions and industrial practice.

Impacts

- National authority to set priorities for scientific research
- Quality research led by researchers and institutions
- Effective negotiation of research partnerships
- Effective application of results at policy and implementation level

[32] **UTICA**, Tunisian Union of Industry, Commerce and Handicrafts

- Sustainable regional research and knowledge networks

Individual training is an important step, but it is only the first step towards sustainable capacity building. To achieve full sustainability, such training must be undertaken strategically, taking into account both institutional needs and broader research objectives (defined by the Ministry). The full and appropriate use of research capabilities is the next step towards sustainability, both in terms of gaining the appropriate experience and authority, and in terms of being able to makethe transition from trainee to trainer. Here again, a strategic approach to research and institutional development is the best way to steer the process. Ultimately, it is through this kind of collective development, and the ability to initiate, manage and direct research in institutions and countries, with local resources, that true empowerment and country ownership of the effort is achieved.

The concept of empowerment described above should be an integral part of all actions undertaken by the university, whether in strategic management or research. The University of Carthage will build on its successes in capacity building and make further progress in this area by placing greater emphasis on research training and advanced courses, e.g. on best practice, research planning and management, technology transfer. It will make further efforts to build capacity to lead health research to meet country needs, focusing on developing the means to set priorities and translate research findings into policy and practice.

Where appropriate, the University will support the formation of networks that can sustainably strengthen the country's core research and knowledge management skills, for example in disciplines such as bioinformatics and the social sciences, to establish best practice in biological publishing and ethical review,

By their very nature, many of these networks are based in the region, and the University recommends that laboratories and research units include them in their applications to global initiatives such as the Horizon Europe Funds.

The University will continue to support the development of knowledge and capacity in basic, applied and operational research, but will extend its action to training in certain fields where thereis a great need and which integrate management, negotiation and networking skills. Research training will be refocused on priority projects funded by the Ministry's research function, which will make a special effort to find and support talented women in the research field. There will be training focused on best practice and institutional development aimed at sustainability, capacity building for regional training and empowerment of research departments within the ministry.

The university coordinates its empowerment and capacity-building activities with other key players, such as universities and national and international organizations.

Research in priority areas

The University will undertake research work in the priority areas through time-limited activities focused on the functions described below, in which it has a comparative advantage. Action will focus on strengthening three research functions:

Fostering innovation for product discovery and development

While product development partners seek to develop new and less energy-intensive water treatment technologies, there remains a need for more effective "translational research" to integrate "promising compounds" into development pipelines, as well as greater involvement of researchers from countries experiencing the same water-energy shortage in research and product development. The University will collaborate with and complement the activities of other research organizations and partners to further develop networks between laboratories, academia and institutions to discover promising new concepts, methods and materials.

The development of innovation, research and product development in the countries will be the focus of new attention. The University will seek to set up and support innovative projects and initiatives within research and development institutions, and help them develop proposals for funding.

Building on successful examples, the university will develop its relationships and networks, and mobilize further efforts in tool discovery and development by soliciting, negotiating and funding targeted research and support activities.

Promote research into the development and evaluation of interventions in the real-life setting where they will be applied

One of the most neglected areas of research is the development, evaluation and improvement of new interventions and strategies under real-life conditions. This work is, however, essential and provides useful feedback for making well-informed decisions on adjusting research orientations.

This area, involving large-scale Phase IV evaluations of safety and efficacy, will become particularly vital in the near future as more and more channels lead to intervention tools based on product development partnerships.

- Data on the safety and effectiveness of tools in real-life conditions of use to overcome performance difficulties;
- Effective tools and strategies for intervention in neglected areas of research;
- Cost-effective disposal and monitoring strategies;

- Leading role in concrete action research. We need to negotiate and bridge the gapbetween product-oriented research, carried out by product development partnerships, and the public-sector policy-oriented research that the country demands.

A master plan will develop research activities and partnerships in each field, with greater emphasis on the evaluation of results achieved periodically, particularly for diagnostics, drug combinations and new therapeutic strategies. Support for applied research based on basic hypotheses will be ensured when it can lead to concrete industrial improvements.

Research into the effectiveness and appropriate use of new and existing products under real-life conditions will play a central role. This will include selective studies on the relationship between the costs and benefits of interventions, and work to improve intervention strategies in order to increase their effectiveness.

Fundamental research will focus on developing viable, cost-effective strategies to meet tomorrow's challenges. It will determine whether and under what conditions it is possible to achieve objectives with the tools available, and will develop innovative strategies for monitoring technological metamorphoses worldwide.

Promoting research on access to interventions

Operational research leads to innovative strategies whose formidable task is to bring effective interventions within the reach of those who need them. Many products that have successfully gone through the classic R&D process have failed to reach their full potential because of implementation problems that have hindered access.

It is increasingly recognized that research has a crucial role to play in solving major operational problems. Experience has shown that it can make all the difference, helping to ensure that new products resulting from proven research partnerships have the desired impact on the local economy. A good example of this is the development of a new generation of janitor robots (e.g. for agriculture). The university will support operational research on existing products with proven effectiveness, and on new and promising products likely to have a significant impact on the competitiveness of Tunisian companies.

Through these laboratories and units, the university will give priority to joint research projects with industrial companies and the socio-economic environment.

Other strategic considerations

Portfolio of future issues and challenges

The University of Carthage aims to focus on 03 issues of the future.

- The water
- Energy
- Information

The operational separation between these and other research issues (electrical engineering, mechanical engineering, civil engineering, telecommunications, biology, chemistry, physics, mathematics, statistics, constitutional law, etc.) is becoming increasingly artificial.

The program will therefore cover water and energy technologies and rights more broadly, focusing on a limited number of well-defined activities within this range of research issues.

Regional needs

The University will develop its responsiveness to regional needs by strengthening regional influences (municipalities, governorates, national companies and civil society associations...) on its policy and strategy, strategic management and empowerment, as well as support for regional research activities.

Strategic links with the Direction Générale de la Recherche Scientifique and other co-sponsoring organizations.

Stronger links will be developed with all co-sponsoring organizations. These links with the DGVR, which is giving greater priority to research and developing a research strategy, are crucial. The program's functions of strategic management and empowerment are perfectly in line with the objectives set out by the Ministry of Higher Education and Scientific Research. If well positioned, the program could become the research arm of the ***Water Energy Nexus*** for the DGVR and other co-sponsoring organizations.

Strategy implementation

Sectors of activity

In the interests of strategic efficiency, the University of Carthage will be restructuring its activities, concentrating them on a limited number of well-defined business areas. Each of these will focus on an end product, with a business plan setting out the deliverables, milestones, deadlines, managers and partnerships.

These areas of activity will be established, evaluated and abolished on the basis of criteria defined according to need, impact and progress achieved. This approach will ensure more efficient and responsive management and administration, and facilitate interactions with partners.

Monitoring and assessment

Indicators will be developed to cover the progress, results and impact of strategic functions and business areas, as well as managerial and administrative efficiency:

Financial resources

The strategy described requires a significant increase in resources, with the current lack of means, participation in calls for tenders for international projects such as ***Horizon Europe*** and competitive funds allocated to Start-Ups to effectively support strategic management and empowerment functions, as well as sectors of activity in the research field.

In implementing its strategy, the University will examine the possibility of further developing its international role, as proposed by some interested parties.

Part D:

Dashboard for monitoring research activities and key performance indicators (KPIs)

Before describing specifically, the different types of key performance indicators (KPIs) to beadopted in our case, we will first review the general concepts of process and strategic indicators and the importance of their use.

Types of performance indicators:

- **Key process performance indicators (KPIs),** are used to analyze the achievement of tasks in relation to objectives. These indicators must be measured by an index (usually represented by a number). Measurements can be made on the progress of the whole process, or just part of it.
- **Strategic performance indicators,** verify that the organization is achieving the objectives set by management, i.e. the strategic objectives. A widely-used tool to help determine these objectives is the balanced scorecard.

Key process performance indicators for monitoring research activities

- They provide decision-makers with the information they need at every stage of the process.
- They enable decision-makers to make better decisions.
- They are designed to increase process efficiency and effectiveness.
- They also make processes faster, easier to understand and more transparent.
- In our case, key performance indicators can be used to measure the university's level of excellence.
- They enable the creation of a dashboard bringing together all available information, giving a panoramic view of processes and the company.

General concepts of key process performance indicators

- An index is derived from key performance indicators and represents the degree of performance of a process;
- The objectives must be represented by the key performance indicators of the process in a given period of time;
- Tolerance: if the target index (that which represents the process performance) is not reached, the setting of a tolerance range will show the degree of severity of the result.

Values outside this tolerance range indicate that process performance is critical, and that action needs to be taken.

The importance of using process performance indicators

Key process performance indicators are used to monitor the company's production. In other words, by collecting relevant information, they enable process progress to be tracked and monitored. In effect, they transform this information to make it available and accessible for study. Processing this information enables the manager to make decisions that will improve the effectiveness and efficiency of the process. Key process performance indicators are therefore extremely important for BPM process management. They highlight the information you need to analyze processes, continuously improve them and achieve your strategic business objectives. We also invite you to read the following article: Productivity indicators: effectiveness and efficiency of business processes.

Process performance dashboard and KPIs

Strategic objectives	Specific objectives	Expected results	Key performance indicators
Promote and maintain quality research support programs, particularly in UCAR's development priorities and research niches.	Implement and disseminate UCAR's research strategy to affiliated research structures, while reinforcing its ownership	- Research structures supporting UCAR's research strategies - External recognition of the university as a leading research institution	- National and international university rankings - Reputation survey
	Draw up an action plan for the development of each priority research area	Action plan for the development of each priority research area	- Action plan for each priority research area
	Stimulate scientific activities and innovation and increase the volume of research and faculty productivity around UCAR's priority issues (responses and adaptation to climate	Innovative scientific publications on UCAR priority research areas	- Number of scientific publications produced by research units around UCAR's priority research areas each year

	change/ technologies and rights related to water and energy exploitation)		- Proportion of projects carried out in UCAR priority research areas
	Develop relationships and networks, and further mobilize efforts to solicit, negotiate and fund targeted research and support activities in UCAR's priority research areas	Research projects on UCAR priority issues funded	- Total amount of research grants obtained by research units from government agencies, institutions or other funding sources - Rate of funding for research and creation in UCAR's priority research areas - Success rate of research project proposals submitted by the University to external funding agencies (Erasmus, Horizon Europe, etc.). - Allocated budget, laboratory/research unit equipment, facilities, etc.
Empowering researchers	Build sustainable capacities among researchers through ongoing training in best practices, research planning and management,	Researchers well trained in best practices, research planning and management, negotiation, technology transfer and networking.	- Number of training courses - Number of researchers, graduate students or post-docs trained within each research structure

	negotiation, technology transfer and networking		- Number of grants awarded to University researchers
	Support excellence in academic trainings and development of scientific personnel	Academic progress of researchers and their achievements	- Doctoral student success rates, including average time to completion - Number of university accreditation - Number of articles impacted and/or indexed - Number of citations received
	Support the creation and integration of networks that can sustainably strengthen the country's essential research and knowledge management skills, following the example of the Horizon Europe Funds	Research projects financed by Horizon Europe Funds	- Participation rates and success in national and international research networks - Number of research projects supported by international funds such as Horizon Europe funds
	Actively support researchers in their efforts to obtain grants by advising them on the various programs, conveying relevant information and offering assistance	Grants to finance research projects obtained	- Access to financing - Average time required to obtain a response to a research grant application
Fostering innovation for product discovery and development	Set up and support innovative projects and initiatives within research and development	Innovative, high-quality projects and initiatives	- Number of startups based on university research

	structures, as well as proposals for funding		- Number of patents filed by the university - Carthage University's participation in regional and national innovation clusters, technological research centers and innovation ecosystems
	Support researchers in setting up national and international collaborations to increase funding opportunities, the visibility and excellence of the research and innovation carried out by the University of Carthage	National and international cooperation	- Number of new multidisciplinary or interdisciplinary research and creative initiatives at UCAR or in partnership with other universities, nationally and internationally. - Participation in international research networks
	Develop mechanisms to promote, encourage and support interdisciplinary, inter-research structure and inter-institutional initiatives, and strengthen and consolidate research collaborations with existing partners	Research projects involving researchers from different disciplines, structures and institutions	- Number of research projects involving researchers from different disciplines - Number of inter-structure initiatives - Number of inter-site initiatives
	Collaborate with other research organizations and partners to further	Networks between laboratories, universities and developed institutions	- Number of projects and new products

	develop networks between laboratories, academia and institutions in order to develop projects involving several research fields and discover promising new products (concepts, methods or equipment)		(concepts/methods or equipment) discovered and/or developed by a group of research structures
Promote research into the development and evaluation of interventions in the real-life setting where they will be applied	Establish mechanisms to periodically evaluate the results achieved and define precise indicators to measure the impact, productivity and dissemination of research	Mechanisms in place to assess results achieved	- Total number of impacted publications and indexed articles published per year, by research area and/or researcher - Number of conferences, seminars and workshops organized to present research results - Participation in national and international conferences - Citation rate of university publications in other research works - Ranking of Carthage University publications in impacted and/or indexed scientific journals - Number of media mentions of

			university research results - Rate of consultation of online publications and research resources
	Carry out selective cost-benefit studies of interventions, and work to improve intervention strategies in order to increase their effectiveness	Studies on the effectiveness of interventions and work carried out	- Efficient use of resources (time, budget, personnel) to achieve expected research results - Feedback from users or potential beneficiaries of research results to assess the effectiveness and usefulness of proposed solutions
	Produce an annual report on research activities and compile data on the number of projects requested and the number and value of projects funded	Annual report on research activities	- Number of projects requested - Number of publication citations, researchers' h-index or other indicators of recognition and influence
Promoting research on access to interventions	Bring university research closer to the needs of industry, encourage intervention- research and motivate researchers to participate in and conduct joint research projects with Tunisian industrial companies and	Involving business and industry in university research	- Number of intervention-research theses produced - Number of research projects funded by companies - Amount of industrial

	the socio-economic environment as a priority		investment in university research projects - Amount of research contracts with external companies and organizations - Number of joint research projects and internship programs with the socio-economic community - Impact of these collaborations on industry and the economy
	Support operational research on available products with proven efficacy, and on new and promising products likely to have a significant impact on the competitiveness of Tunisian companies	Research-based products and services developed and marketed	- Number of research products and/or services commercially available - Number of awards, distinctions and recognitions received by the university for its innovations and contributions to innovation
	Ensuring effective transfer to the socio-economic environment	Knowledge and technology transfer from research to the socio-economic environment	- Number of patents filed, licenses granted or other forms of knowledge and technology transfer resulting from

			research carried out
	Set up meetings with government representatives and other relevant organizations to explore opportunities for collaboration and partnership	Collaborations and partnerships with government structures	- Number of collaborations and partnerships with government structures and other relevant organizations
	Transmit research results to governments and other appropriate organizations, and foster closer ties with public players and stakeholders to ensure that decisions and policies are evidence-based	Adoption of research results in public policy, regulations and/or practical applications in industry	- Impact of the University of Carthage research on society, health, environment or other relevant fields - Number of policy interventions based on university research findings