R&D capacity of Algeria: actors and indicators

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Abstract:

This study gives an overview of R&D capacity of Algeria, it examines indicators devoted to evaluating national R&D capacity performance, followed by a series of more detailed reviews of Algerian innovation system through analysis of the key R&D capacity actors. It also includes the strengths, weaknesses, opportunities, and challenges that Algeria is facing.

The research undertaken clearly shows that Algeria poorly performs the R&D capacity indicators and the national innovation system on needs to be improved.

The country has been invested in research and related infrastructure. Yet, the returns on these investments have not always yielded the necessary returns on issues including job creation, brain gain, scientific production, sustainable development. Algeria is still experiencing aftereffects from the bloody civil violence of 1992-2002, which caused considerable economic turmoil.

Keywords: *R&D capacity; National innovation system; R&D; Scientific production; SWOT analysis.*

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1. Introduction

Innovations typically are the result of a complex set of relationships among actors in the Innovation System, which includes governmental and public authorities, firms, educational entities, research institutions ... etc. The innovative performance of a country depends to a large extent on how these actors relate to each other as elements of a collective system of knowledge creation and to what extent they utilize technologies.

Future innovation platforms in Algeria cannot be isolated from the changes that are now reshaping the Algerian economy, which has long been known for its chronic heavy dependence on the country's natural resources. The continued deep reliance on natural resources for the past several decades has taken its toll on today's Algerian industry. Diversification is an imperative, not only because natural resources are exhaustible but also because export success in world markets increasingly demands knowledge-intensive production and innovation-based competition. Stimulating research and innovation can be considered as one of the major tasks of a national approach to increase the wealth of a domestic economy.

Algeria's efforts to transform from natural resource-based economy towards a knowledge-based economy are reflected in its science, technology and innovation policies. The country's strength lies in its human and natural resources, these resources if used effectively, can transform the economy in a reasonably short period of time.

2. Characteristics of Algeria's system of R&D

Today the Algerian economy is heavily dependent on oil: Hydrocarbons provide the majority of budget revenue and nearly all of export revenues. On the other hand, the agricultural sector employs a quarter of the workforce and produces only 10 percent of GDP; nearly half of all food is imported. From 2010 to 2020, GDP per capita decreased from $4,480 to $3,310 (ONS,2020).

2.1 Innovation background

Global innovation index 2021 ranks Algeria 120th out of 132 economies. This places it far behind more dynamic Arab countries, such as Qatar, UAE and Jordan. In the meantime, other countries have rapidly improved their standing (Global innovation index report ,2021,p 43).

Table 1. Innovation rankings of Algeria

Pillars	Rankings in 2020 (out of 131)	Rankings in 2021 (out of 132)
Global innovation index	**121**	**120**
Creative outputs	118	118
Knowledge & technology outputs	125	125
Business sophistication	126	124
Market sophistication	130	132
Infrastructure	100	96
Human capital & research	74	74
Institutions	104	104

**Source:** Global innovation index report ,2021,p 43

The index indicates that Algeria does relatively well in Human capital & research, but does much worse on Creative outputs and Business sophistication. Out of 132 countries surveyed, Algeria ranks 125th for Knowledge & technology outputs, 132nd for Market sophistication, and 104th Institutions. It also ranks 96th for Infrastructure. This is a clear indication of the need to improve research and innovation system in Algeria.

These relative positions are not particularly out of line for a country at Algeria's stage of development. Algeria is currently in the bottom tier of countries, along with other "factor-driven" economies. These "factor-driven" economies have minimal capacity to innovate, do not add much value to the goods and services they produce, have unsophisticated local enterprises with limited managerial and organizational capacity and minimal commercial and technological links to the global economy, and use low-wage and export unprocessed raw materials. If Algeria wishes to transform itself from what the World Economic Forum calls a "factor-driven" economy into an "efficiency-driven" or "innovation-driven" economy, then it must begin to improve in these critical areas related to productivity and competitiveness.

2.2 National research program:

National research program (PNR) aims to promote research & innovation by promulgating the legislations, laws and regulations conductive to the enhancement of scientific research; recruiting personal with high abilities and competencies in the fields of scientific research; adopt innovative means to encourage the private sector to participate in scientific research, funding it and benefiting from it; utilizing the results of scientific research and modern technology in decision–making and sustainable development planning; developing and disseminating science and knowledge among the people; benefiting from the experience of others in scientific research and also contributing to the advancement of basic sciences (Ministry of High education and scientific research ,2020, p.28-33) .

Fig .1. Algeria's research program
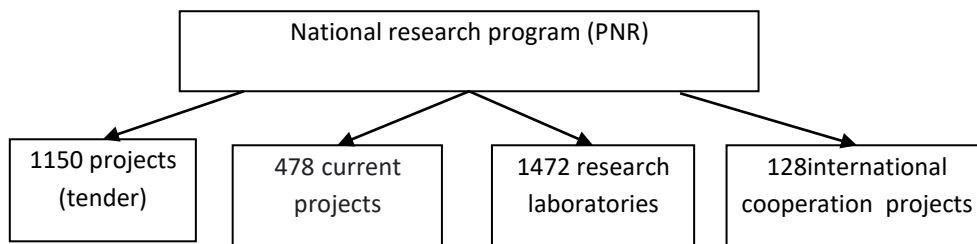
Source: Ministry High education and scientific research, 2020,p.28-33

The Government's mid-term research & innovation policy defines four priorities (The Technical Centre for Agribusiness report ,2018, p.25):

- Enhancing of research & development & innovation capacity.
- Producing world class scientists, engineers and technologists who are well grounded in theory, practice of basic sciences and the needs of entrepreneurship.
- Building local capacities in intellectual property management for effective transfer of technology.
- Encouraging private sector participation in the establishment and management of Technology Incubation Centers and Science Parks.

3. Research and innovation institutions in Algeria

Most of Algerian research and innovation institutes function through ministry of higher education and scientific research (MESRS). These institutes at first focused on the basic sciences, but subsequently diversified their programs to include medical and agricultural sciences, among other applied specializations. During the last two decades, human, social, and environmental sciences have also been added.

3.1 Research institutions evolution

The history of research & innovation institutions dates back to the 1973s, when the National organization of scientific research (ONRS) was established as a governmental body responsible for formulating policies and plans and coordinating national efforts in this respect (Ministry of High education and scientific research ,2020, p.24).

Table.2 . Evolution of research institutions in Algeria 1962 to date

	Creation date	Supervision	dissolution date
Scientific research council *(CRS)*	1963	France	1968
Scientific cooperation organization *(OCS)*	1968	France	1971
Provisional Council of Scientific Research *(CPRS)*	1971	France	1973
National organization of scientific research *(ONRS)*	1973	Ministry of higher education	1983
Commission for new energy *(CEN)*	1981	Presidency	1986
Commission for Scientific and Technical Research *(CRST)*	1984	Prime minister	1986
High Commission for research *(HCR)*	1986	Presidency	1990
Ministry of research and technology *(MDRT)*	1990	Prime minister	1991
Ministry of Research, Technology and Environment *(MDRTE)*	1991	Prime minister	1991
State Secretariat for Search *(SER)*	1991	Universities ministry	1992
State Secretariat	1992	Ministry of national education	1993
Ministry delegated to universities and research *(MDUR)*	1993	Ministry of national education	1994
Ministry delegated to the Ministry of Higher Education and Scientific Research, in charge of scientific research	2000	Ministry of higher education and scientific research *(MESRS)*	To date
General Directorate for Scientific Research and Technological Development *(DGRSDT)*	2008	Ministry of higher education and scientific research*(MESRS)*	To date

Source: Ministry High education and scientific research , 2020, p.24.

In 1973 the Algerian government was well aware of the lack of institutional support of R&D at various universities and institutions in the country. Thus, awareness on the importance of R&D has been well established for the last three decades by transferring The mandate of ONRS   to the General Directorate for Scientific Research and Technological Development (DGRSDT) 1981-2008. This institution faced the challenges to work as government high coordinating body to coordinating the various diverse fields of research and meeting the needs of the various Ministries and industries.

3.2 Institutions affiliated to MESRS

Algerian research institutions are non-for-profit organizations doing applied technological R&D, funded from public sources and have the mission to support Algerian firms, facilitating technology transfer and the adoption of innovative practices and new technologies in traditional sectors, which tend to be populated with SMEs.

MESRS is the largest public performing research institution in Algeria; it exists since 1970 and is similar to the CNRS in France. It covers all scientific domains and performs basic and applied research. It has (Ministry of High education and scientific research ,2020, p.63):

- 03 research agencies:
  ***ANDRU**: The National Agency for the Development of university Research;
  ***ANDRS** :The National Agency for the Development of medical Research; ***ANVREDET** :The National Agency for the Valorization of Research and Technological Development Results.

Their mission is to Plan, coordinate and manage the research program;

- 10 research centers:
  * **CDER**: Renewable Energy Development Center;
  * **CERIST**: scientific & technical information research Center;
  ***CDTA**: The Algerian Centre for Development of Advanced Technologies;
  ***CRAPC**: Center for Scientific and Technical Research in Physical & Chemical Analysis ….etc.

Their mission is to Conduct applied research, technology transfer and prototype applications development;

- 04 research units:
  * **UDTS**: Silicon Technology Development Unit;
  * **UDES**: Solar Equipment Development Unit;
  * **URERMS**: Renewable Energy Research Unit in Mid Saharan;
  * **URAER**: unit of applied research in renewable energy.
- More than 1000 research laboratories covering several research areas. The MESRS as a whole hold the biggest pool of scientists in Algeria.

3.3 Algerian universities

Public research institutes should view themselves as "technological service providers" whose mission it is to support local firms and other economic actors for the development of their local economies.

Universities are responsible for educating undergraduate and graduate students with the skills needed to be innovators and researchers.

Universities are also responsible for fundamental research, and may also conduct applied research in areas expected to lead to new products and services. Algerian universities must be more fully utilized for development, not only by producing an educated workforce, but by working more closely with the private sector.

Table .3. Algerian universities & colleges (2019)

	East	center	west	Total
universities	22	16	11	**49**
university centers	01	04	05	**10**
National colleges	05	04	01	**10**
Superior colleges	03	15	02	**20**
Preparatory colleges	03	03	06	**12**
Total	**34**	**42**	**25**	**101**

Source: ESAGOV ,2019, p.75.

The number of universities is very high in Algeria and most relevant technological domains are covered. These universities are mainly focused on theoretical teaching. Research activities play a minor role, especially not in applied research. Teaching quality is judged to be good, compared to other surrounding Arabic countries. As a result, many graduates are leaving Algeria for work in neighboring countries. The performance of the academic staff is measured on a regular base (focused mainly at (theoretical) publications). Therefore, incentive to do applied research, especially in collaboration with enterprises, remains low (Innovation Scorecard, 2020, p06).

Role of Algerian universities in national research program:
- Creating new basic and applied scientific knowledge.
- Training students in science and engineering.
- Participating in collaborative projects.
- Hosting and participating in Technology Innovation Centers.

3.4 Other research and innovation actors

Table 04 provides information about some of the research institutions available in Algeria and not affiliated to the MESRS. These research centers are considered among the most distinguished ones in Algeria (Hocine Khelfaoui, 2001, P05).

Table 4. Some research institutions independent from MESRS

Research institution	Designation
CRD/SONATRACH	Research & development center : SONATRACH the largest Algerian and African company and the 11th largest oil consortium in the world
CRD/SAIDAL	Research & development center : SAIDAL the Algerian leader of pharmaceutical industry
CRD/ANNABIB	Research & development center: ANNABIB Algerian company for producing pipes
CTIAA	The Technical Centre for Agribusiness
CNERIB	National Centre for Building Studies and Research Integrated
CERP	Study center of applied research and documentation for aquaculture

Source: Hocine Khelfaoui ,2001, P05.

The objectives of these institutions include the following:
- Conduct applied research and studies.
- Collaborate with other academic, institutional and industrial partners to maximize research benefits by taking advantage of the combined knowledge, skills and infrastructure these partnerships bring.

- Exploring new opportunities in scientific research and development.

4. Human resources devoted to research and innovation

To date, innovation indicators have tended to focus on two main aspects of innovation activities: creating new knowledge (absorptive capacity), and exploiting new knowledge and innovations (development capacity), hence the human resources are especially important because people are the innovators and skilled people are needed in every element of innovation system.

4.1 Number of researchers

The availability of abundant and highly qualified researchers is an essential condition to foster innovation and promote the scientific and technological development of a country.

However, figures indicate that Algeria fall well behind the world average in term of number of researchers. The gap is much larger when compared to EU (Innovation Scorecard , 2020 , p06).

First, there is the mentioned distinction between full time researcher and part-time researcher. The Frascati Manual recommends that surveys should try to estimate full-time researchers. In other words, it is useful to have an estimate of how much time the researchers actually spend doing research or involved in research projects. This is important to know since, for obvious reasons, many are not working on research projects all the time (Research and scientific development in OIC countries, 2018,p.07).

Table.5. Evolution of number of researchers

	Part-time researchers	Full-time researchers	Total
1999	6840	2714	**9554**
2000	8540	3114	**11654**
2001	10283	3516	**13799**
2002	11994	3921	**15915**
2005	13720	1500	**15220**
2008	14720	2100	**16820**
2009	18863	2700	**21563**
2010	25079	3300	**28379**
2011	26579	3900	**30479**
2012	28079	4500	**32579**
2015	30475	4620	**35095**
2017	31520	5016	**36536**

Source: Research and scientific development in OIC countries, 2018, p7.

Table 5 shows Algeria's total number of researchers for the period 1999–2017. table shows a steady increase in researchers' number since 1999, and total number of researchers almost tripled. The table also shows how the number Part-time researchers increased over the same period, from 6840 in 1999 to 31520 in 2017.

4.2 Scientific production

Usually scientific production is measured by indicators based on two types of data: the number of the publications in refereed international scientific journals and books, and the citations received by the published articles.

The higher education sector produces the bulk of scientific output in the country. The most productive universities are the Houari Boumediene University of Sciences and Technology, Mentouri-Constantine University, Badji Mokhtar University, University of Sidi-bel-Abbes, University of Oran, Mohamed Boudiaf University of Sciences and Technology of Oran, Abou Bakr Belkaid University of Tlemcen and Ferhat Abbas University (UNCTAD, 2019, p52).

Table.6. Algerian Scientific Publication Fields

	2000-2003	2004-2007	2008-2011	2012-2019
Number of Publications	2032	3975	6868	12941
Publication per 1000 capita	0.013	0.026	0.046	0.081
Publication per 1000 researcher	200	400	686	1290
Algeria's Share of world scientific publications	**0.04%**	**0.08%**	**0.12%**	**0.23%**
Physics	0.12%	0.19%	0.30%	0.52%
Chemistry	0.08%	0.13%	0.20%	0.37%
Mathematics	0.12%	0.15%	0.32%	0.41%
Engineering Sciences	0.07%	0.11%	0.21%	0.29%
Computer Science	0.07%	0.13%	0.21%	0.43%
Materials science	0.14%	0.23%	0.33%	0.39%
Environment Sciences	0.06%	0.12%	0.20%	0.38%
Biology and agriculture sciences	0.03%	0.08%	0.11%	0.16%
Medicine	0.01%	0.01%	0.02%	0.02%
Humanities and social sciences	0.01%	0.02%	0.02%	0.04
Algeria's Share of regional scientific publications	**21%**	**27%**	**30%**	**33%**

Source: UNCTAD, 2019, p.52.

The significant strides made in industrialization, the dominance of the petroleum industry and investments in chemical engineering in Algeria are reflected in the shape of its research output, which is dominated by physics, engineering, materials sciences, mathematics and chemistry. Unlike many other African countries, agricultural research and medicine make far more modest contributions to overall research production. It is also interesting that computer science in Algeria features in the top 10 fields (Amine Bensaid , 2008, p106).

In term of annual growth rate, of the five biggest science producers in Africa, Algeria recorded the highest annual growth rate of 14.0% between 2000 and 2011, as shown in table 06, the results show that the country recorded significant increases of scientific publications in all fields. The Algerian share of world scientific publications increased from 0.04% in 2000 to 0.18% in 2019, also number of publications increased from 2032 in 2000 to 12941 in 2019.

The research also took a bibliometric focus, concentrating on articles from high visibility journals taken from Scopus, the main Elsevier database for bibliometric research purposes. Articles were assessed using qualitative indicators to gauge the impact of research (including average number of citations by document and H-index) as shown in table 7.

Table. 7. Citations of published articles in 2019

Field	H index	Citation per document
Physics	33	3.91
Chemistry	37	5.98
Mathematics	24	2.74
Engineering Sciences	34	3.24
Computer Science	22	2.41
Material science	33	4.67
Environment science	32	6.43
Biology and agriculture Sciences	27	4.47
Medicine	31	7.95
Humanities and social sciences	10	1.63
Total	**68**	**4.09**

Source: Ministry High education and scientific research, 2020, p.38

The significant increase in the number of scientific articles published in international journals indicates considerable strengths in scientific research in Algeria. However, with over 90 universities and several research institutes in public and private sectors, the citation per document is still far below the potential.

5. Financial resources devoted to R&D

One of the most common, and most often quoted, R&D indicators is how much a country dedicates to research and experimental development as a percentage of its GDP. This indicator is gross domestic expenditure on research and experimental development (GERD).

Table. 8. Gross R&D expenditures (GERD) in Algeria, 2001–2017, current prices

	2010	2011	2012	2013	2014	2015	2016	2017
In million €	48	114	N/A	N/A	N/A	38	45	47
% of GDP	0.4	0.8	N/A	N/A	N/A	0.39	0.5	0.54

* Data not available.
Source: UNCTAD ,2019, p 63

As can be seen from table 8, Algeria's expenditure on R&D activities as a proportion of GDP is less than 1 percent and it has been a steady decline during the 2011 to 2015 period. Most of the funding that does exist goes on salaries and some operational costs (over 90 per cent at both the universities and the research institutes), with little left for actual research. The level of overall expenditure is not enough to support high-quality research & innovation activities across the existing system. It should, however, be borne in mind that the Algerian R&D expenditures did not cover the business enterprise sector (African Innovation Outlook, 2020, p 89).

In order to transform its economy into a knowledge-based one, Algeria needs to increase its R&D expenditure substantially, and the Government must determine which areas and activities of the research & innovation system are necessary and important, and must properly fund them to allow them to fulfill their mandates. Any proposed new resources should be accompanied by substantial improvements in efficiency and incentives to turn new expenditures into development gains (Simon Ellis, 2018, p 183).

6. SWOT analysis on Algerian system of R&D

This section reviews the main strengths, weaknesses, opportunities and threats facing the Algerian R&D system, in order to consider the extent to which the current Algerian strategy builds on competitive advantages.

Table. 9.SWOT analysis of Algeria's national system of R&D

Strengths	• Capability to produce world-class talents. • Good geographical position of Algeria. • The Government has realized the need for faster ICT development in all sectors of the country
Weaknesses	• Insufficient investment in R&D. • Lack of continuous interaction between business, government and academic institutions. • In Algeria, only a limited number of large enterprises have their own in-house R&D capabilities. • Lack of entrepreneurship and of competition in a number of sectors. • Underdeveloped fundamental research capabilities and weak research capacities in universities.
Opportunities	• Promising reforms in educational structures to enable industry-academia responses. • The proximity of the key markets and the export opportunities are offered.
Threats	• Exposure of SMEs to international competition. • Global economic outlook and its consequences for export-oriented economies. • Governmental direct control and maintenance of large stakes in the economy. • Continued brain drain.

Overall, Algeria does not have a strong national system of R&D. However, it has the potential to improve its innovative capacities and technological performance.

Algeria's national system of research & innovation has the potential to grow and become dynamic. It has many institutional infrastructures for R&D, universities dedicated to producing scientists and engineers, and institutions to support and regulate technology development. However, the national system of innovation is underdeveloped, and not performing to the level at which it will enable the country to achieve its aspiration of becoming a knowledge-based economy by 2025.

7. Conclusion

The R&D capacity approach has been successfully established as a conceptual basis for an encompassing analysis of actors, networks and institutions that influence innovation processes.

Algeria performs poorly on the R&D and innovation indicators . The country is still experiencing aftereffects from the bloody civil violence of 1992-2002, which caused considerable economic turmoil. During that period, Islamist guerrillas targeted prominent intellectuals and researchers.

The research & innovation system is far too supply-driven, owing to its overreliance on the public budget. Funding allocations are determined by the Government and often do not relate to the priorities of the providers of science and technology services (i.e. the research institutes and

universities) and much less still to the end-users of technology and research, such as the private sector, farmers, and informal enterprises. The result is a system not subject to competitive pressures to ensure quality, and not adequately focused on Algeria's own economic and social objectives.

Algeria's innovation capacity is not as well-developed as those of other Arab countries. The country needs to strengthen the collaboration between its universities and the private sector. Higher education institutions have few formal linkages to industry, and as a result tend to continue teaching outdated materials and producing graduates who are ill-equipped for the working environment

In order to develop innovation capacity of Algeria and create favorable conditions for R&D creation, first of all it is important to construct transparent infrastructure of institutions which would be responsible for the implementation of innovation policy. That would be the most efficient steps towards R&D infrastructure development in Algeria.

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