Journal of Scientometric Res. 2021; 10(3):401-411
http://www.jscires.org

Research Article

Science, Technology and Innovation Measurements in the Maghreb Union (AMU) and the Impact of Indicators: The Institutional Dimension

Abdelkader Djeflat

Faculty of Economics, University of Lille Chairman, The Maghtech Network, FRANCE.

ABSTRACT
The role of science, technology and Innovation (STI) as an engine of development has been globally recognized. This needs the formulation and regular reviews of policies using good and viable indicators. However, in most African countries, policies suffer from the negligible importance of indicators in the eyes of policymakers. The five Maghreb countries (Algeria, Libya, Tunisia, Morocco and Mauritania) have been putting significant efforts to improve publications and patents on the ground that they best translate the effectiveness of STI policies. The findings show that real progress has been made in recent years on these indicators in the region following the policies adopted. Looking more in depth at the Algerian situation, the results indicate that STI indicators have been able to transform policy-making through learning, and international cooperation this progress has been slowed down by institutional constraints and limited inclusiveness. Our contribution is to highlight the importance of having a proper institution in STI indicators construction and usage in African countries. The methodology used secondary data and an in-depth case analysis through the observant participant approach.

Keywords: STI indicators, Maghreb countries, Patents and publication, Institutional constraints, Transformation and learning capacity.

Correspondence
Abdelkader Djeflat
Faculty of Economics, University of Lille Chairman, The Maghtech Network, FRANCE.
Email id: abdelkader.djeflat@univ-lille.fr

Received: 01-08-2020
Revised: 24-02-2021
Accepted: 08-11-2021
DOI: 10.5530/jscires.10.3.58

INTRODUCTION

Science and technology and Innovation (STI) as an engine of development need the formulation and regular reviews of policies using good and viable indicators. However, in most African countries, policies are not based on scientific facts partly due to the negligible importance of indicators in the eyes of policymakers. The five North African countries (Algeria, Libya, Mauritania Morocco and Tunisia, in alphabetical order) which constitute the Arab Maghreb Union (AMU) have made substantial progress on two indicators: Publications and patents through proactive STI policies. We examine the link between these policies and the two indicators in all five countries in a first part. In the second part we will examine in depth the use of indicators in the auditing of the National Innovation System of Algeria and examine more specifically the institutional issues raised.

BACKGROUND

One common observation is that Science, Technology, and Innovation (STI) policies often do not stimulate innovation which could lead to growth, better living, and employment. While there is a significant increase in several STI indicators, only few African countries seem to be keeping pace. To address some of these weaknesses, Africa has been moving fast since the birth of the NEPAD (New Program for African Development) in 2001 through several initiatives taken at continental level. Thus, the ASTII (African Science and Technology and Innovation Indicators) initiated by AU-NEPAD[1] programme in 2005 is part of Africa's Science and Technology Consolidated Plan of Action (CPA). It aimed at building capacity 'to produce common internationally comparable indicators'[2] and to overcome this weak dimension of STI policies Siyanbola.[3] There are other weaknesses: firstly, indicators play, often, a negligible role in the eyes of policymakers lumbered with more basic development problems. Secondly, in many African countries, there is a gap between STI policy and development priorities often the result of the lack of coordination. Thirdly, the statistical instruments used are far below the current standards that accompany a proper STI indicators policy. The main official statistical bodies are usually not accustomed to produce STI oriented statistics due to lack of demand from policymakers Jerve.[4] To address these problems, the AU (African Union) Agenda 2063 launched in 2013 emphasized the role of STI to realize African unity and attain overall integrated and sustainable development. It was followed a year later by the 10-year Science, Technology and Innovation Strategy for Africa

(STISA-2024) aligned to it. This translated, evidently into even more pressing needs for higher standards indicators, internationally comparable, and easily accessible by policy-makers.

Haut du formulaire

The five Maghreb countries have spent more than thirty years trying to have proper STI policies. They have been building and implementing various programmes, often with the support of international organisations to build their national research and innovation systems. Everyone admits that the region has made notable progress towards STI strategy formulation and implementation Bizri,[5] Radwan.[6] New laws and institutions, new S&T agencies, new governing bodies have been created together with substantial research funding. These policies seem to have given substantial results on certain indicators, without, however translating into satisfactory levels of innovation as shown by Radwan. The Global Innovation Index (GII/2020)[7] shows unfavorable rankings (121st for Algeria, 78th for Tunisia and 85th. for Morocco) when benchmarked with comparators from advanced and emerging countries. They are still lumbered with problems of STI indicators which remain unsustainable and suffer inadequate information originating sometimes from official government bodies. Consequently, we are confronted with several key issues and research questions: What role do STI indicators play in policymaking in Maghreb countries what institutional support do they have and how inclusive are they? What is the role of international networks in building capacity among decision- making bodies? Our main hypothesis is that capacity building in using indicators goes beyond the simple technical problem but extend to the institutional and political spheres.

OBJECTIVES AND SCOPE OF THE STUDY

To address these questions, this paper seeks to bringing to light the critical role of STI indicators for enhanced evidence-based STI policy-making and sustainable development in the Maghreb.

We pursue two objectives: first to look at the data of the five countries on the two major output indicators: publications and patents on the ground that they best translate the effectiveness of STI policy. The second objective, which is the main one, is to examine in depth the role of STI indicator capacity in transforming STI policies in the Algerian experience and the weight of institutions.

LITERATURE REVIEW

The role of science and technology (S&T) as an engine of development has been globally recognized in several contribution Juma[8] Muchie[9] Djeflat.[10] What gives a nation competitive edge is the speed it can identify, utilize, and diffuse new knowledge as shown by Prusak,[11] and feed it into explicit strategies and policies to effectively drive innovation and development. This needs the formulation and regular reviews of STI policies in driving sustainable development OECD,[12] Siyanbola *et al*.[13] and a good mastery of indicators. STI indicators setting constitutes, however, a major weakness of African countries though the situation differs from one region to the other and from one country to the other as shown by Gaillard,[14] Gault,[15] and Siyanbola *et al*. Some important imbalances exist on the continent according to M'Henni.[16] Only few countries, namely South Africa from sub Saharan Africa and Egypt from North Africa are keeping the pace on certain indicators such as publications and patents as shown by Gaillard *et al*. Djeflat,[17] and Radwan. The marked lack of demand for STI indicators to formulate regular review of STI policies from policymakers and practitioners has been highlighted in the literature Olaopa *et al*.[18] and Siyanbola *et al*. Maghreb countries and in particular the three most important ones (Algeria, Tunisia and Morocco) are locked in the middle income trap unable to move to high STI driven growth and to join the club of the emerging economies Arezki *et al*.[19] This is the result of not properly harnessing STI strategies, and adequate implementation and monitoring using indicators. However, their width and depth depend also on the stage of development of STI. Manyuchi and Mugabe[20] found, that South Africa, for example has been making efforts to use innovation surveys while Malawi, has no institutional mechanism dedicated to produce STI indicators and there is no evidence that policy makers are being informed. Dialogue remains another important dimension in setting indicators Dutrenit *et al*.[21]

Maghreb countries are still in the process of setting proper STI strategies. Using Arber *et al*. typology for Latin America,[22] they fall within the C Group *(countries with incipient R&D systems).* In this respect, none of them produces regular R&D surveys but only occasional compendia of STI statistics.

Setting indicators in African countries is not an easy task in view of the size of the informal sector whose dynamism is legendary in the sphere of "below the radar" innovation, often difficult to harness as mentioned by Kaplynski.[23] Yet, the informal sector represents quite a substantial share of income and employment: 49.46% of the total non-agricultural employment in Algeria for example as shown by Bensaoula.[24] Milbergs and Vonortas[25] have put indicators into a historical perspective by producing four generations of indicators: the first one relates mostly to input indicators in the sixties, the second one to output indicators in the seventies and eighties, the third one to innovation indicators in the nineties and the fourth generation to process indicators in the years 2000.

The three main Maghreb countries can be classed in stage two i.e.: Second generation output indicators moving fast towards the third-generation innovation indicators. This does not apply to Mauritania and Libya (Table 1).

Based on these elements and the specific situation of Maghreb countries, we will try to put forward our conceptual framework.

CONCEPTUAL FRAMEWORK

Maghreb countries have been making a substantial effort to improve their STI policy both through a constant effort of reforms and through building several research institutions, long before any kind of interest in innovation. It is only in the nineties that this effort on research appeared to be too narrow in the eyes of policy makers and needed to be extended to other dimension of STI, namely Research and Development (R&D) and innovation. Consequently, they started developing strategies and policies to harness these two components simultaneously and putting the necessary effort in terms of resources and institutional reforms. In Algeria, for example, the 1998 law on STI is considered a major turning point[26] in this respect. In Morocco, the 2000 law triggered several reforms in the national system of educational research[2] aiming at promoting innovation. In Tunisia, an orientation law relating to scientific research and technological development was promulgated in 1996[3] and amended in 2000. Analyzing the situation of STI in the region. Bizri highlighted this turning where the reforms following the laws in Algeria, Morocco and Tunisia were all geared towards more STI and innovation driven development. The two other countries of the Maghreb have been lagging because of conflict (Libya) or lack of resources (Mauritania). To assess to what extent this effort has been yielding tangible results, we looked its impact of on both publications and patents in all five countries. To examine in more depth the impact of indicators, we looked at two studies (STI1[4] and STI2) which are part of the need to start evaluating this effort at policy-making level. But the ultimate objective of both studies was to examine the Algerian innovation system and its impact on the industrial sector.

In more details, the idea of STI 1 started at the ministry of industry level in Algeria through informal discussion in the first stage. The key issue was the lack of a clear idea of the existing innovation system. In other words the concern was the configuration of the existing National System of Innovation (NSI) as defined by Lundvall.[27] and the role of the various players and how could it help promoting innovation in industry. The aim was to Propose an institutional framework and a policy to impulse innovation[5]. The approach used 1/a diagnosis the existing research and innovation system and its performances, 2/a benchmarking with comparators both in the advanced and in the developing world 3/ a list of recommendations to build a national system susceptible to impulse innovation in the industrial sector.

The issue of indicators was not at the heart of the preoccupation of the study partly due to the fact there was a lack of demand for STI indicators from policy-makers in Algeria at that time. The National Office of Statistics[28] (ONS), did not produce any STI oriented data. This is often the case in many countries of the South as noted in the Oslo Manual[6]. However, a specific demand made by the ministry of industry related to the need to insert "Industrial technical centres" (ITCs) as an input element in the innovation system, Djeflat[29] was taken into consideration. The importance of ITCs can be linked to their role as providers of missing services that could help, usually small firms, that lack R&D capacity to conduct in house R&D projects. It is thus a missing link in the innovation system[30] as highlighted by several authors Gaillard, Mota De Castro[31]

2 Law n°01.00, 2000
3 Law n°96-6 of 31st January 1996,
4 EU/Ministry of industry Evaluation of innovation policies and programs in the industrial sector PROJET N° DZA/B8-4100/1B/98/0708/25
5 TDR: terms of reference of the consultancy contract
6 OECD/Eurostat, The Oslo Manual 2005

Table 1: Evolution of Innovation Metrics.

First-generation input indicators (1950s–60s)	Second-generation output indicators (1970s–80s)	Third-generation innovation indicators (1990s)	Fourth-generation process indicators (2000s plus emerging focus)
• R&D expenditure • S&T personnel • Capital • Tech intensity	• Patents • Publications • Products • Quality change	• Innovation surveys • Indexing • Benchmarking innovation capacity	• Knowledge • Intangibles • Networks • Demand • Clusters • Management techniques • Risk/return • System dynamics

Source: Milbergs and Vonortas (2004)

Nerdrum and Gulbrandsen[32] and Djeflat.[33] The study was funded by the European Commission[2].

The second study (STI 2)[3], originated from a demand expressed by the Department of Innovation (Ministry of Industry) newly created following the recommendations of STI 1. The objective of STI2 was the "*Evaluation and update of the Innovation System in the Industry Sector and proposal a strategy for its implementation*". Once more the funding was provided by external source namely UNDP (United Nations Development Program) Support Program for the Implementation of the Industrial Strategy and the Promotion of Investments.

STIA 2 benefited from the progress made at central level (Ministry of higher education and research namely) and the effects of the participation of Algeria in the ASTII process. We will examine, what was the learning done in STIA 2, how it built over a period of seven years (2006-2013) and how the experience was fed into policymaking. An analytical framework is used to assess the learning made at policy-level as shown in Table 2.

We will then examine this trajectory and some key problems and issues beyond the sphere of simple indicators choice and calculation. They are related to context, institutions and mode of governance, some dimensions which are often neglected in the literature and which require more attention in the future.

METHODOLOGY

To address the first question of the impact of polices on indicators, we examined the evolution of the data over a period and tried to connect these with STI policy stages. We used three main data bases: the scopus data base, the Web of Knowledge (WOS) and the Unesco Institute of Statistics (UIS). In addition, national bibliographical data bases were used wherever available. To address the second question, we drew from the specific literature and our personal experience as "observant participant" being involved in both studies, in STI1 as a head of the team and an in STI2 as sole consultant. We used field work on a broad sample of institutions, administrative and professional bodies, and central administration. The Oslo manual of input/output/impact was used as a guiding tool uncritically:[34] on the input side, we used number of researchers and funding (both public and private) while on the output, we used patents, publications and export of high technology products. International sources were mobilized

Table 2: Matrix of the STI1 and STI2 and the learning process.

Indicators	STI 1	STI 2	The learning
Input			
Output			

on top of the official documents from the various institutions. Thirty people were interviewed using a semi-directive questionnaire et included various players from the Ministry of industry and other agencies. The period extended over five months: October 2007 - February 2008.

For STIA 2, more data collected internally and data from international organisations using the input/output/impact indicators method developed in both the Oslo and the Frascati manuals. The role of benchmarking particularly with neighbouring countries was decisive to get adhesion to the STI project. Specific demand to introduce other indicators proper to the Algerian context were formulated by policy-making bodies because of the learning that did take place. In addition, a field survey of key players from a small sample of the most representative institutions was conducted. The study lasted two months from 25 May to June 2013. The results are examined in the section below.

RESULTS

Examining Science and Technology indicators in Maghreb countries: publications and patents. Publications

Publications in Maghreb countries started increasing substantially following the implementation of the STI policies of the nineties. Figure 1 shows that the takeoff point was between 2000 and 2005 for four main Maghreb countries except for Mauritania. This has been highlighted by several other studies. Thus, an evaluation of the impact of the new policy following law 1998 in Algeria for example made by the Council of Europe, indicated that contributing factors included the development and implementation of twenty seven (27) national research programs, the creation of 639 research laboratories spread over eight major fields, and the mobilization of around 15,500 researchers, (including 2,000 permanent ones) during the period 1998-2002.

As shown by the Scopus data in the period 2010-2020, the number of publications doubled for Algeria and Morocco grew 4 times for Tunisia, and was multiplied by 1.35, and 1.15 for respectively Mauritania and Libya (Table 3). Similarly, the UIS data show that the number of scientific publications (excluding social sciences and humanities) has more than doubled in the same period after STI policies were adopted (Table 4). This applies to all five countries, but disparities exist when looking at countries individually (Figure 1).

2 EU/Ministry of Industry. Evaluation of Innovation Programs and Policies in the industrial sector [des politiques et programmes d'innovation dans le secteur industriel]French- Algiers -Octobre/November 2007

3 UNDP/ Ministry of industry Implementation Strategy of Innovation System in the Industrial Sector [Stratégie de mise en œuvre d'un système d'innovation industrielle (SNII)] French Algiers - April 2014

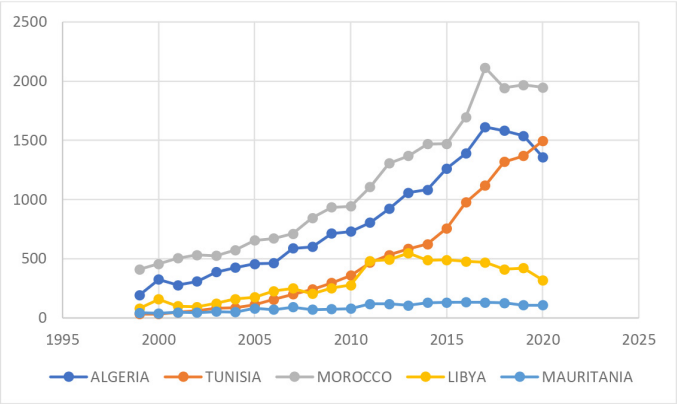

Figure 1: Publications in Maghreb countries 1999-2020.
Source: Elaborated by the author from Scopus Data base

Table 3: Number of publications in Maghreb countries scopus data base.

Years	Algeria	Tunisia	Morocco	Libya	Mauritania
2020	1359	1496	1947	319	108
2019	1538	1369	1968	421	109
2018	1581	1318	1943	411	127
2017	1613	1119	2114	470	131
2016	1389	976	1696	478	133
2015	1262	757	1472	491	132
2014	1084	624	1470	488	130
2013	1058	585	1370	548	106
2012	922	533	1307	492	119
2011	806	468	1105	482	118
2010	731	358	943	277	80

Source: Scopus data base 2020

In Algeria, scientific publications grew from 731 in 2010 to 1359 in 2020 (Table 3) as shown by scopus. This is reflected by an increase of publication intensity from [2] 685 in 2016 to 846 in 2019. This rate of growth in scientific publications is deemed one of the highest globally Q&A Sci-Dev.[35] The country took the first place in some disciplines such as physics, chemistry, engineering and mathematics[3]. Similarly, WOS (Table 4) shows[4] a significant increase from 450 publications in 2010 to 1220 in 2019 (nearly 3 times higher) with the bulk (73.8%) made of journal articles. Nearly 59% are made by Algerian residents and nearly 25¨% from France. With an

Table 4: Number of Scientific publications of Maghreb Countries by WOS.

Year	Algeria	Tunisia	Morocco	Libya	Mauritania
2020	1359	1496	1947	319	108
2019	1538	1369	1968	421	109
2018	1581	1318	1943	411	127
2017	1613	1119	2114	470	131
2016	1389	976	1696	478	133
2015	1084	624	1470	488	132
2014	1058	585	1370	548	130
2013	1058	585	1370	548	106
2012	922	533	1307	492	119
2011	806	468	1105	482	118
2010	731	358	943	277	80

Source Web of Science 2020

average citations per item of 12.67 and an *h*-index of 100. However, articles produced in international co-authorship amounted to 50.0% on average in the 2002-2018 period[5] mostly with French scholars for historical reasons.

In Libya : Despite the turmoil, making it difficult for the Libyan researchers to operate normally Tashani,[36] Libya managed to increase its output. Published articles in the Scopus database grew from 488 in 2010 to 319 in 2019 (Table 3). This trend is also shown by WOS (Table 4): publications increased from 158 in 2010 to 379 in 2019, with the bulk (73.2%) made of journal articles with an average citation per item of 11.21 and an *h*-index of 81. More than 22% are by residents Libyans, 16.4% by residents in USA and 15.8% by residents GB. This is linked to the important diaspora both students and scholars living abroad following the conflict.[6]

In Mauritania, publications increased from 89 in 2010 to 109 in 2019 (Scopus database) [7] (Table 3) WOS shows a modest increase of publications from 53 in 2010 to 99 in 2019 (Table 4) making a total of 1751 the lowest in the region. The bulk (81%) is made of journal articles. The highest proportion (27.8%) are made by non-residents who live in France followed by the residents (18.9%) and then by non-residents in the USA (15.24%). This shows the importance of the scientific and intellectual Diaspora. The average citation index of 10.57 is higher than Libya's and *h*-index of 45. The

2 https://www-scopus-com.ressources-electroniques.univ-lille.fr/term/analyzer.uri?sid=2e7af371eae8dea158022cc3f0ad99b6&origin=resultslist&src=s&s=ALL%28Number+of+publications+Tunisia%29&sort=plf-f&sdt=b&sot=b&sl=35&count=8985&analyzeResults=Analyze+results&txGid=61010c724dd75d5924a8ecfb1f34fd36

3 https://www.scidev.net/global/funding/feature/algeria-scientific-capacity-hafidh-aouragh.html

4 https://wcs.webofknowledge.com/RA/analyze.do?product=WOS&SID=F51IIuJa3bcBL9qzGSD&field=ED_Editor_Editor_en&yearSort=false

5 UIS 2019

6 Education and scientific development in OIC countries (2016)

7 https://www-scopus-com.ressources-electroniques.univ-lille.fr/term/analyzer.uri?sid=2e7af371eae8dea158022cc3f0ad99b6&origin=resultslist&src=s&s=ALL%28Number+of+publications+Mauritania%29&sort=plf-f&sdt=b&sot=b&sl=35&count=8985&analyzeResults=Analyze+results&txGid=61010c724dd75d5924a8ecfb1f34fd36

majority (90%)[2] is done in co-authorship (Scopus)[3], mostly with French researchers.

In Morocco, the Scopus data base[4] shows an increase an average of 25% of growth during the 2010-2018 from 943 publications in 2010 to 1947 (2.5 times higher) in 2020 (Table 3). This is confirmed by WOS data (Table 4): The number of publications grew from 650 in 2010 to 1643 in 2019, with the bulk (79%) made of journal articles. Fifty per cent are from residents in Morocco while 22% are from France, another indication of the weight of the diaspora in scientific activities. Co-authorship[5] rate excluding social sciences, and humanities reached 38% (2016-2018) with here again, a great proportion with French co-authors[6] for evident historical reasons.

In Tunisia, scopus data base shows a growth of publications from 358 in 2010 to 1369 in 2019 (Table 3). This trend is confirmed by WOS data (Table 4): publication grew from 763 in 2010 to 1320 in 2019 with 82% made of journal articles. Nearly 64.5% are made by residents and 20% by Tunisians living in France. The country took the first position in publication intensity in 2018 (640 per million inhabitants)[7]. It has increasingly published in quality publications and ranks first in Africa on the number of publications in relation to GDP (Gross Domestic Product). Co-authorship remains, also relatively important[8] reaching 69% for scientific publication[9], the majority from France (about 65%) for the same reasons of cultural ties and colonial legacy.

While the probability that STI policies and performances in publication seems to be relatively high, one has to take these performances with some caution, bearing in mind that the "Predatory Publication" virus is also present among scholars in the region. One observation is that they is growing awareness on the part of specialized governing bodies of this phenomenon and steps have been taken to curb it. Thus, the DGRST in Algeria issues each year a list of predatory journals[10] on its website which will not be considered for doctoral submission and career promotion. The other Maghreb countries will

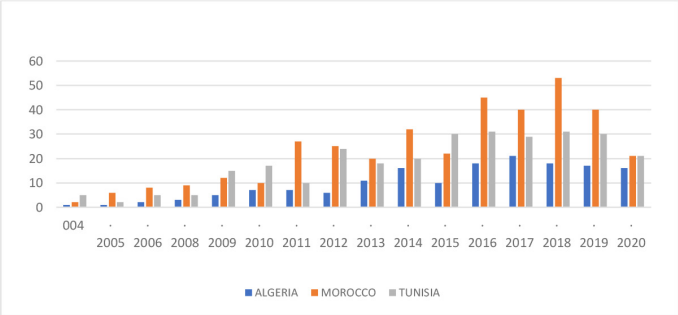

Figure 2: Evolution of number of conferences and seminars held in the three main countries of the Maghreb.
Source: Elaborated by the author from Calenda data 2020

no doubt follow shortly as it often happens. On top of that, we looked at other factors, to support the significant growth of publications. Firstly, there has been an intensification of scientific meeting and gatherings (conferences, seminar colloquia etc.) over the last decade mostly in the main Maghreb countries as shown by the Calenda data base[11]. (Figure 2).

The stagnation noticed since 2015 in Tunisia is linked no doubt to security and political instability.

The second factor is the rapid increase of journals and periodicals produced locally. The lists are regularly updated by the governing bodies: in Algeria by the DGRST, in Tunisia by the CNUDST[12], and in Morocco by the CNRST[13]. Thus, Morocco has seen its domestic scientific journals grow rapidly: 110 were listed in 2019 with 27% indexed in scopus. In a project form, there is a common plateform and an indexation system. Tunisia has a modest number of 16 domestic journals[14]. Algeria is the most advanced with 754 home grown journals[15] listed, nearly 72% in Arabic and the rest are mostly in french. However only 390 are considered as having quality standard. It has already its publication platform, the Algerian Scientific Journal Platform (ASJP)[16] and domestic indexing system: Journals are ranked in three categories A,B and C in decreasing order of quality. Bibliographical data bases have been developed by all five Maghreb countries. At a subregional level, an *Arab Citation and Impact Factor* (ARCIF)[17] data base was created in 2013 covering 22 Arab countries

2 Sorpus Data base treated by Science Metrix
3 Scopus data base
4 https://www-scopus-com.ressources-electroniques.univ-lille.fr/term/analyzer.uri?sid=2e7af371eae8dea158022cc3f0ad99b6&origin=resultslist&src=s&s=ALL%28Number+of+publications+Tunisia%29&sort=plf-f&sdt=b&sot=b&sl=35&count=8985&analyzeResults=Analyze+results&txGid=61010c724dd75d5924a8ecfb1f34fd36
5 http://www.science-metrix.com/sites/default/files/science-metrix/publications/etude_bibliometrique_tunisie_7juin2015.pdf
6 UIS 2019
7 quality also increased shown by the value of the average relative impact factor (FIRM).
8 Science Metrix 2015 http://www.science-metrix.com/sites/default/files/science-metrix/publications/etude_bibliometrique_tunisie_7juin2015.pdf
9 scopus data base
10 http://www.dgrsdt.dz/v1/?fc=News_A&id=91
11 Calenda data https://calenda.org/search?q=*:*&primary=fplace&sort=datemisenligne_date&order=desc&fplace=34946&f2date%5b%5d=2001 visited 08/11/2020
12 National University Center for Scientific and Technical Documentation [Centre National Universitaire de Documentation Scientifique et Technique]French
13 National Center for Scientific and Technical Research [Centre National de Recherche Scientifique et Technique] French
14 http://www.cnudst.rnrt.tn/produits-et-services/valorisation-revues-scientifiques-tunisiennes/
15 http://www.dgrsdt.dz/v1/index.php?fc=News_A&id=2
16 http://www.dgrsdt.dz/upload/DDTI/Classement_ARCIF_En.pdf
17 https://emarefa.net/arcif/#

including the Maghreb ones. Hosted by the Web of Science, it provides access to bibliographic information and citations to scholarly articles from over 400 Arabic journals. Algeria appears to take the first position in 2020 with 255 journals selected out of a total 681 retained according to DGRST[2].

The fourth factor is the human potential which grew substantially during the period in the three main countries. USI data show that Morocco increased its number of researchers to 50 142 HC in 2016 (1421 per million inhabitants), Algeria to 96 403 HC in 2017 (2333 per million inhabitants), and Tunisia to 37776 HC in 2016 (3260 par million inhabitants) the highest ratio in the Arab World. Q&A Sci-Dev[35] The growth is much less important for Mauritania 2223 HC in 2016 and 526 par million inhabitants. Two categories have particularly grown: the numbers of student researchers and female researchers (above world world average). Tunisia has already gone beyond gender parity: 55.4% of female researchers in 2017[3]. These impressive records cannot, however, be extended to the sphere of patenting.

Patents

Patenting has grown significantly but at lesser pace in the region indicating difficulties and acute problems in converting research results into innovative products and services.

In Algeria, the total number of patents filed in the period 1983/2006 reached 6,298, of which approximately 91% were made by foreign non-residents firms anxious to protect their industrial property in Algeria. Patents applications by residents have increased more than three times from 76 in 2010 to 252 in 2018[4] (Table 5), while decreasing for non-residents during the same period from 730 to 521. Patents granted have been decreasing for both categories. Notable is the newly acquired dynamism of Universities and "Grandes Ecoles" with nearly 50% of all patents filled domestically in 2017. Internationally, 7.27% are filed at the USPTO Office (US patents Office) while, 9% were filed at the European Patent Office (EPO) and 5.45% were filed at the PCT (Patent Cooperation Treaty) level. Patent applications/million pop scored 0.9 ranking Algeria 104/140 showing the difficulties it still meets in patenting.

In Libya, the number of patents granted international have been dismal since 2015: two in USPTO, no doubt filed by diaspora members[5] (Table 5).

In Mauritania, about 250 patent applications were registered over the period 2001-2015: 94%, were made abroad to a foreign intellectual property office, no doubt from members of the Diaspora (Table 5).

Table 5: Patents filed by Maghreb countries

	Algeria		Morocco		Tunisia		Mauritania	
Years	Residents	Non-Residents	Residents	Non-Residents	Residentss	Non-Residents	Residents	Non-residents
2009			135	856	105	452		
2010	76	730	152	882	113	508		
2011	94	803	169	880	137	543	1	
2012	119	781	197	843	150	476	1	
2013	118	722	316	828	112	437		
2014	94	719	355	742	142	400		
2015	89	716	224	797	180	409	3	
2016	106	566	237	1,066	235	348		
2017	149	594	198	2,026	172	383	3	
2018	152	521	187	2,35	180	271		

Source: WIPO 2020 – No data for Libya

In Morocco, patent applications by residents have increased from 135 in 2010 to 187 in 2018[6] reaching a peak (355) in 2017 (Table 5). (65% come from research centers and universities). The same trend is seen for patents by non-residents growing from 882 in 2009 to 2026 in 2017 as a result of the upsurge of FDI in recent years. Patents granted have been decreasing for non-residents and very erratic for residents. Internationally, the number of patents filed with EPO remains modest 9 in 2018 (World Bank 2019).

In Tunisia, Patents applications by residents have increased from 113 in 2010 to 180 in 2018[7] reaching a peak (235) in 2016 (Table 5). Patents by non-residents have been decreasing from 508 in 2010 to 2070 in 2018 due to decreasing FDI, following both the political instability and economic crisis. Internationally, patents filing remains relatively weak and erratic: they increased until 2013 (106) and then kept decreasing since then. (4 in 2015 with EPO[8] 3 in 2018 with USPTO).

While these Figures indicate improving performances, this should not hide the numerous problems met by patenting including the inconsistency of the data and the little attention given to patenting by small firms in general and to international patenting in particular which is not yet in their habits.

2 DGRST website : http://www.dgrsdt.dz/upload/DDTI/Classement_ARCIF_En.pdf
3 UIS 2018
4 https://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=DZ
5 UIS 2019
6 https://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=DZ
7 https://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=TN
8 WIPO report in 2018

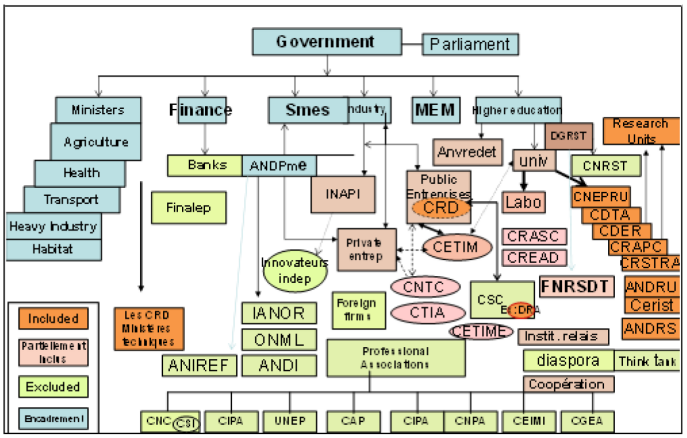

Figure 3: The structure of the National System of Innovation of Algeria (2008).
Source: Borrowed from the MIPI-EU report 2008

The Algeria Case study

The study was expected to focus on a more pronounced vision of the Sectoral System of Innovation (SSI) as a tool for the foundation of a new policy of competitiveness through "competitive clusters" using new instruments for financing research and innovation.

The STI 1: to explore the NSI and realise the mapping

The results show that STI1 contributed to introduce policy-makers at ministerial level to the STI indicators together with the concept of NSI practically unknown at that period and the issues that raises. In this respect, it contributed no doubt to accelerate a number of transformations. The first one was greater awareness raised amongst policy makers (in industry but also in higher education) of the importance of innovation and in particular of the need to have a NIS in good working order. The mapping produced by the MIPI- EU study, with its visual effect, had a particularly pronounced impact on policymakers (Figure 3). It shows all the key players of the Algerian NSI with the ties they had or did not have. As shown by the number of arrows the relations at the time of the study were relatively limited. This made it possible to identify which institution was either totally excluded (in yellow) or only partially included (in pink). We could see thus that banks, foreign firms, professional bodies, and the Diasporas were totally excluded from the interactive game. Universities, research centres, public enterprises and international cooperation were partially included only. Only a limited number of research centers (in brown) were really included.

The second one was enhancing the existing drive for an important institutional restructuring with namely the creation of a specific body dedicated to scientific and technological research at ministerial level: The General Directorate for Scientific Research and Technology (DGRST)[2] in 2010. One of the mandates of DGRST was to produce indicators for S&T country to feed policymaking. Since then, it has become a major department of the Ministry of Higher Education and Research and has acquired an important weight on the mode of governance of the research field. The third implication was the search of active international expertise to help the country implement its STI programme. This prompted Algeria to take part to the ASTII 1 programme in 2008. It took a prominent position in the ASTII 2010 report being listed among the three African countries that produced more than 10 000 papers each in the 1999 – 2009 period together with Nigeria and Kenya, one of the five biggest science producers (highest annual growth rate of 14.0% during the period with similar intensity (between 40 and 70 papers per million inhabitants). It also belonged to the group of the seven countries that consistently produced between 70 and 200 papers per year namely (Algeria, Côte d'Ivoire, Senegal, Cameroon, Tanzania, Zimbabwe, and Ethiopia).

At the Ministry of industry level, the impact was much less visible. On top of the institutional instability level, the study revealed that a dismal proportion of researchers worked in industry: More than 90% of research personnel were in universities. But perhaps more profoundly, there were no resources devoted to the implementation of STI1 policy despite large oil revenues of the country at the time.

STI 2 study to review and deepen the Innovation system in Algeria

The situation changed after STI 1 and a new era seems to have started.

Progress made and the learning in STI2

Notable progress was made in STI 2., though indicators were still drawn from the Oslo manual and the Frascati manual with more emphasis on R&D, they were more refined and more comprehensive OECD report.[37]

-*On the input side*, the study included: 1/ Estimates of full-time researchers (FTE), 2/ the number of researchers per million inhabitants and in different types of institutions. 3/the diversification of sources of funding for R&D including the business sector, and finally, 4/foreign companies involved in domestic R&D. In this respect, Algeria seems to suffer a significant delay in terms of hosting outsourced R&D from large foreign companies compared to its neighbouring countries namely Morocco, Tunisia, and Egypt. New rules giving foreign companies the right to undertake R&D activities made it possible to integrate them. Hence a certain number were able to set up R&D facilities locally: Lafarge in

2 [Direction Générale de la Recherche, de la Science et de la Technologie] in french

Table 6: Matrix of the STI 1 and STI2 studies and the learning process.

Indicators	STI 1	STI 2	The learning
Input	Oslo Manual	Oslo/Frascati	More emphasis on R&D and Innovation
Human resources	Number of researchers full count	Number of researchers head count and FTE	Estimates of full-time researchers (FTE) -researchers intensity
Funding	Public funding (essentially public funding)	Different sources of funding (Public, and private including foreign)	Foreign capital participation in domestic R&D
Others inputs	Industrial technical centers	Industrial technical centers	Industrial technical centers extended to other sectors
Output			
Patents	Number of patents filed locally	Number of patents filed locally and internationally	Intensity of filing of international patents per institution: USPTO; EPO,
Publications	Number of publications	Number of articles in scientific and technical journals Number of publications with foreign co-authors per million inhabitants	-Use of the Scopus database and its application in the analysis of the quality of publications -co-authorship
Export of high tech products	Not included	Export of high tech products (agricultural equipment)	-Diversification of export index -cluster exports
Specific indicators		Sectorial and territorial dimension of NSI	Includes sectors and territories in NSI: clusters, technopoles, etc.

Source: compiled by the author

building materials, Henkel in the chemical industry for the production of detergents and Candia and Danone in the agro-food industry for the production of milk and dairy products. Nearly all of them used both foreign expatriates and local personnel in their R&D activities.

On the output side, the changes included: more concise data (residents, non-residents, companies, individual inventors) patents filed internationally namely with USPTO, and percentages of high-tech products exports in total exports of manufactured goods. Specific and additional demand included the need to look at the *meso-economic* dimension by integrating the Sectorial and the territorial innovation dynamics largely covered in the recent literature highlighted by Malerba[38] Moulaert and Sekia,[39] Djeflat.[40] The study benefited also from stronger support from officials at both ministries higher education and research and industry as a result of the "learning by participating" to the ASTII programme which took place (Table 6).

Impact of STI 2: Several actions resulted from STI2. Firstly, it soon become evident that the 1998 law was not appropriate anymore perceived mostly a law for research and not for promoting innovation. Industry and enterprises researchers and R&D activities were hardly included in it. This resulted in a new move towards the revision the law to better integrate innovation indicators. Consequently, a new law on the Orientation of Scientific Research and Technological Development was promulgated in 2015[2]. This law sets new rules and principles governing scientific and technological research and the development of innovation. The learning occurred also at the technical level with broadening the spectrum of indicators but also a need to align their use to international standards (Table 6).

Despite all this progress, Algeria was absent from the second leg of the ASTII programme and from the African Innovation Outlook Reports[41] in 2014 and in 2019. This raises several questions related to the institutional dimension of indicators which is often occulted in the literature and which can have a significant impact on the choice and implementation of indicators as shown elsewhere. Several causes can be highlighted.

The first problem is instability of personnel in key institutions. As seen earlier, a relatively important turnover was seen at ministerial level at the industry level. Competence were not maintained permanently due to relatively high turnover. Follow-up could not be guaranteed as representatives kept changing: As an illustration, the training provided by the ASTII programme saw different participants coming in each session which prevented a serious follow-up and cumulative learning, that are needed[3] as noted in the Unesco report.[42] Secondly, often employees sent to attend training sessions were not the right people to attend (bureaucrats) and had no capacity and no background to benefit from these sessions and the basis of their delegation were not always clear. These aspects can constitute therefore important obstacles to develop a real expertise and a vision regarding the integration of indicators

2 Law No. 15-21 of December 30, 2015

3 According to an ASTII reprentative : the 16th Globelics Conference, Accra, Ghana, 22/24 October 2018

in STI policy. Thirdly, the trust in synthetic international indicators may have been eroded which explains to some extent why indicators from the South are sometime false, outdated or simply non available due to lack of cooperation of the countries. This is of course on top of the traditional problems of data collection largely covered in the literature Hoogeveen and Pape,[43] Necib.[44] The Global Innovation Index (GII) 2011 showed Algeria in the last position which was criticized by the MESRS as poorly reflecting the reality.

DISCUSSION

Looking at these results, it can be concluded that Maghreb countries are indeed performing better than other sub-regions in Africa on some output indicators and a real quantitative and qualitative jump has been witnessed in the last decade for publications. This did not however translate adequately into patenting lagging well behind. STI policies, despite several shortcoming seem to start yielding positive results. However, some observations can be made. Firstlty, regarding publications, the dominant and growing rate of co-authorship North-South, while giving valuable opportunities to learn to local researchers raise several fundamental questions of appropriation. There is a danger to see a "dependent science" rising in the region and the continent. Weak patenting has been attributed in particular to the lack of culture of industrial property among firms Hassan[45] but also to the weakness of support services and the weakness of the IP environment (specialized lawyers and patent engineers in particular).

Secondly, having good indicators is only part of the story; the main issue is how to make it sustainable through the implication of actors and institutions and how to make them adhere to the process over time.

Thirdly, indicators need wide acceptation through policy dialogue. Often the indicators were produced to comply with international standards, decided unilaterally by one prominent institution without taking into account the needs of the users. Policy dialogue is sometimes absent between major key players in the Maghreb such as the Ministry of higher education and research and the Ministry of industry. It is also absent with the other stakeholders such as research centres who feel they are not consulted and work in isolation as expressed by a social science research centre in Algeria[2]. This raises the major issue of inclusiveness in indicators settings. This goes along with the conclusions of the work done by Dutrenit *et al*.

Fourthly foreign firms participation to in R&D input/output indicators while being encouraged by the new Africa which opens to the rest of the world, is a relatively new phenomenon and it is not clear whether R&D indicators should be counted at the domestic level. Unesco[42] suggested in 2010, these R&D expenditures of foreign-controlled entities should be captured as a distinct sub-sector. Beyond a certain level, foreign involvement in R&D might reduce the control of national R&D policy and STI policy.

Finally, the power game over issues related to indicators and mandates is not to be neglected: indeed as it often occurs in countries of the South, the low level of good governance at State's level can bring institutional overlap and inter-institutional conflict and confrontation. We have seen that phenomenon in all three major Maghreb countries. The issue of who is legitimate and whose mandate it is to conduct the innovation function was often raised. This controversy stems from the fact that often R&D and innovation take place at the level of the firm (Ministry of industry) while the majority of researchers are located in universities and research centers (Ministry of higher education). In particular, who should produce the legal and regulatory instruments for innovation creating sometimes tensions between the two entities. This element may have been determinant in the lack of participation of Algeria in the ASTII 3 process and in the African Innovation Outlook Reports.

CONCLUSION

Maghreb countries have made a significant progress in STI indicators in recent years namely with regards to publications. This is the result of several factors namely a significant improvement of STI development policy, an increased awareness of governing bodies of the importance of indicators, the building of domestic capabilities to collect the necessary STI data and the rapid extension of the major international databases (Scopus, WOS, Scimago etc.). This is probably what gives them a prominent position compared to the rest of Africa where these capabilities are missing. However, this position remains fragile as shown by missing indicators in many global statistics and sometimes outdated ones. Obvious policy implications require that STI indicators become one of the priorities in future agendas.

The Algerian case study shows that, indicators can have a significant implication STI policy-making in a relatively short term as a result of the learning which takes place at the level of dedicated institutions The state of indicators in African countries does not reflect solely the state of the tools and statistics but also the state of the relations between key players and institutions in the NSI. In Maghreb countries the bureaucrat's view of indicators overwhelmingly dominates the expert's views making this process non inclusive. It is time that this balance goes in favor of knowledge and true expertise convening the large scientific and technical diaspora the Maghreb and Africa, as a whole, have.

2 Conclusions of a seminar held by the DGRST in June 2019 in cooperation with CREAD the Center for Research in Applied Economics

The role of international organization in building capacity in Africa should be stressed in view of the relatively rapid progress made by Maghreb countries in the usage of STI indicators in recent years. The ASTII program has shown its usefulness. To make it sustainable, countries need to become regular participants in this process. Maghreb countries have not always been present, showing a certain crisis of confidence. To be able to properly implement STISA 2024, there is a need to restore confidence in the African home-grown indicators that the ASTII program has been promoting.

Finally, indicators should solve the issue of governance reducing turnover within key institutions while giving higher incentive. This is particularly important at this stage of "Innovation systems in construction" where most African countries are. The challenge of comparability versus efficient implementation considering specific circumstances of the continent should be addressed.

If it is important to build capacity in indicators use, production and improvement, however the issue is to make it sustainable.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

REFERENCES

1. New Economic Programme for African Development. African science, technology and innovation indicators: Towards African indicator manuals. A discussion document; 2005.
2. AU–NEPAD (African Union–new partnership or Africa's development) 2010. African innovation Outlook 2010, AU–NEPAD, Pretoria.
3. Siyanbola WO. Beyond the Figures: Deploying STI indicators for policymaking and national planning. Proceedings of the therapeutic ASTII High-panel Meeting Kigali, Rwanda. 5-9 August; 2013.
4. Jerven M. The Problems of Economic data Africa Online Publication June 2019. doi: 10.1093/acrefore/9780190228637.013.748.
5. Bizri O. Science, technology, and innovation policies and institutional landscapes. In: Bizri O, editor. Science, Technology Innovation and Development in the Arab countries. London: Academic Press; 2018;111-361.
6. Radwan A. Science and innovation policies in North African Countries: Exploring challenges and opportunities. Entrepreneurship and Sustainability Issues. 2018;6(1):268-82. doi: 10.9770/jesi.2018.6.1(17).
7. WIPO Global Innovation Index Report 2020. Geneva: WIPO; 2020.
8. Juma C. (ed.) 2005 Going for growth: Science, Technology and Innovation in Africa, London: The Smith Institute; 2005
9. Muchie M. Re-thinking Africa's Development through the National Innovation system. In: Muchie MP, Gammeltoft P, Lundvall BA, editors. The Making of African Innovation systems. Aalborg: Aalborg University Press; 2003.
10. Djeflat A. Innovation systems capacity building in Maghreb Countries. In: Muchie MP, Gammeltoft P, Lundvall BA, editors. The Making of African Innovation systems. Aalborg: Aalborg University Press; 2003.
11. Prusak L. The knowledge advantage. Planning Review. 1996;24(2):6-8. doi: 10.1108/eb054546.
12. OECD integrating science and technology into development policies: An international Perspective. Paris: OECD; 2007.
13. Siyanbola W, Adeyeye A, Olaopa O. *et al.* Science, technology and innovation indicators in policymaking: The Nigerian experience. Palgrave Communications. 2016;2(16015). doi: 10.1057/palcomms.
14. Gaillard J, Hassan M, Waast R. Africa Science Report. Paris: Unesco; 2005;177-201.
15. Gault F. Science, technology and innovation indicators: Opportunities for Africa. African Statistical Journal. 2008;6(May):141-62.
16. M'henni H. The African STI Indicators Challenges, lecture given at the 6th Africalics Academy, Marrakech, Morocco; 2017.
17. Djeflat A. Building Science, Technology, and Innovation Systems in Africa: Experiences from the Maghreb. London: Adonis and Abbey; 2010.
18. Olaopa OR, Akindele ST, Hassan OM. Science and technology research: repositioning the thinking of policy makers in Nigeria. African Journal of Science, Technology and Innovation Development. 2011;3(1):202-25.
19. Arezki R, Yuting R, Nguyen FA. Technology adoption and the middle-income trap: Lessons from the Middle East and East Asia. Policy Research Working Paper 8870. World Bank Group; 2019.
20. Manyuchi AE, Mugabe JO. The production and use of indicators in science, technology and innovation policy-making in Africa: Lessons from Malawi and South Africa. Journal of Science and Technology Policy Management. 2018;9(1):21-41. doi: 10.1108/JSTPM-06-2017-0026.
21. Dutrenit G, Natera JM, Puchet Anyul M, Vera-Cruz O. A and Torres A. Dialogue process on STI policy-making in Latin America and the Caribbean: Dimensions and conditions, Science and Public Policy. 2018;45(3):293-308.
22. Arber G, Barrere R, Aniló G. Measuring R&D in developing countries: Measurement priorities and methodological issues in Latin America. Working paper prepared for the UNESCO Institute for Statistics. 2008.
23. Kaplinsky R. Schumacher meets Schumpeter: Appropriate technology below the radar. Research Policy. 2011;40(2):193-203. doi: 10.1016/j.respol.2010.10.003.
24. Bensaloula S. Le Secteur Informel en Algérie: ampleur et Raisons d'être [The informal sector in Algeria: Scope and purpose] Fr., Revue Algérienne Des Finances Publiques. 2016;6(1):103-15.
25. Milbergs E, Vonortas N. Innovation metrics: Measurement to insight. White Paper of National Innovation Initiative, 21st-century innovation Working Group. IBM Corporation; 2005.
26. Amdaoud M. Le Système National d'innovation en Algérie: Entre inertie institutionnelle et sous-apprentissage [The National System of Innovation of Algeria: Between institutional Inertia and sub-learning]. Fr: Innovations; 2017;53(2):69-104.
27. Lundvall BA. National systems of innovations. London: Printers Publishers; 1992.
28. National Office of Statistiques. Algérie en chiffres [Algeria in Figures]; 2017. Algiers. Available from: http://www.ons.dz/IMG/pdf/AQC_R_2016_ED_2017_-_Francais_.pdf [cited 1/12/2021].
29. Djeflat, A. Innovation take off through industrial technical centers in Maghreb Countries: a missing link in NSI or a new opportunity? Proceedings of the 6th international Globelics conference Sept. 22-24; Mexico City, Mexico
30. Ministry of Industry, European Union. (MIPI-EU) evaluating innovation programs and policies in the industrial sector in Algeria [Evaluation des Politiques et Programmes d'innovation dans le secteur industriel]. Ministry of Industry Algeria; 2008 [report]. 154 p.
31. Mota Mota De Castro LM. Connecting capabilities through technological centres. Proceedings of the 19th Industrial Marketing and Purchasing Conference: September 4-6. Switzerland: University of Lugano; 2003.
32. Nerdrum L, Gulbrandsen M. The technical-industrial research institutes in the Norwegian innovation system, TIK Working paper on Innovation Studies No. 20070614, NIFU STEP, Oslo, Sweden, 2007;p.
33. Djeflat A. Innovation takes off through Industrial Technical Centers in Maghreb Countries: A missing link in NSI or new opportunity? Proceedings of the 6th international conference global Sep 22-24 2008; Mexico City, Mexico.
34. OECD the Oslo Manual. The fourth edition, 2018 http://www.oecd.org/fr/publications/oslo-manual-2018-9789264304604-en.htm.
35. Q&A Sci-Dev The rise of Algeria's Scientific Capacity: Interview of the Director General of DGRST; November 14 2016.
36. Tashani O. The scientific research in Libya: The role of the new generation of researchers. Libyan J Med. 2009;4(4):129-30. doi: 10.4176/090716, PMID 21483531.
37. OECD Guidelines for collecting and reporting data on research and experimental development the Frascati Manual. Paris: OECD; 2015.
38. Malerba F. Sectoral systems of innovation and production. Research Policy. 2002;31(2):247-64. doi: 10.1016/S0048-7333(01)00139-1.
39. Moulaert F, Sekia F. Territorial innovation models: A critical survey. Regional Studies. 2003;37(3):289-302. doi: 10.1080/0034340032000065442.
40. Djeflat A. The governance of territorial innovation systems and the Role of Intermediate Institutions. Proceedings of the 5th international conference, Sep 19-23; Saratov, Russia; 2007.
41. African Union. New partnership for African development. African Innovation Outlook 2014. Pretoria.
42. UNESCO Institute of Statistics 2010; technical, Report N° 5. Available from: http://uis.unesco.org/sites/default/files/documents/measuring-rd-challenges-faced-by-developing-countries-2010-en.pdf.
43. Hoogeveen J, Pape U. Editors Data Collection in Fragile States: Innovations from Africa and Beyond. Palgrave Macmillan; 2020;1-11.
44. Necib S. Working backstage: the challenges of data collection within the Algerian higher education context. Proceedings of the Annual Conference. Ayr, United Kingdom: Scottish Educational Research Association; 2017.
45. Hassan E. Diagnostic du Système national de recherche et d'innovation en tunisie [Diagnosis of the national research and innovation of Tunisia Fr]. European Union, Ministry of Industry, Tunisia; 2015 [report].