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France and the Intersection and Challenges of Science, Technology and Innovation in Africa after the Second World War: The Panacea to Future Armed Conflicts

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Abstract

Africa has often been regarded as a recipient of science, technology and innovation rather than a maker of them. Many of the scientific and technological advances introduced by France after the Second World War have been transported to former French colonies in Africa. The paper treats the intersection of science and technology in Africa engineered by France and looks at the conflicts and challenges posed by these great initiatives. It further argues that, although many scientific innovations and technologies came to the former French colonies with the process of French colonization, it was only after the Second World War that Africans in former French colonies experienced the full potential of new weapons, engineering innovations, transformation of raw materials, as well as transportation methods. To encourage the intersection of science and technology in Africa, the French government has empowered African institutions and trained scientists, engineers, physicians, architects, planners, and other technical professionals in Africa and France. In addition to the challenges faced by France, the most serious challenges to the development of science and technology aspirations in Africa had been poor and unsteady funding to scientists, brain drain of engineers, inadequate infrastructure, insufficient levels of literacy and a shortage of skills and competencies, and above all post-independence interstate and state wars. Using essentially the qualitative approach and consulting both primary and secondary sources, the study concludes with evidences from the case studies that, France has contributed immensely to the development of science and technology in her former African colonies.

Keywords

Science, Technology, Innovation, Conflicts, Intersection, Challenges, World

War II, France, Africa

1. Introduction

Africa has the world's oldest record of Science, Technology and Innovation (STI). The oldest human technological achievement of stone tools in the world has been found in eastern Africa, and later evidence of tool production by hominin ancestors was found across Sub-Saharan Africa (Davidson, 1971: p. 149). Yet, the history of STI in Africa since then has however, received relatively little attention compared to other regions of the world, despite notable African developments in mathematics, metallurgy, architecture, agriculture and other fields (Ehret, 2002: p. 22). This explains why many of the scientific and technological advances introduced by France after the Second World War were transported to former French colonies of West Africa (Senegal, Mauritania, Mali, Guinea, Ivory Coast, Niger, Burkina Faso, Benin and Togo), Equatorial Africa (Gabon, French Cameroun, Republic of Congo, Chad and Central African Republic), North Africa (Algeria, Tunisia and Morocco), and East Africa (Madagascar, Comoros, and Djibouti) (Stuchtey, 2011). As such, former French colonies in Africa have often been regarded as a recipient of science and technology rather than a maker of them.

The image of Africa in the science and technological imagination was Hegelian; as most scholars feed and subsidize it by ending only with the trivial and the negative. Hegel (2007) himself described the continent as having "no movement or development in science to exhibit" and belonging to "the Unhistorical, Undeveloped Spirit still involved in the conditions of mere nature". In Heart of Darkness, Joseph Conrad captures well Western man's movement silhouetted against Africa's undeveloped spirit (Conrad, 1902). Toward the end of the century, Hugh Trevor-Roper declared: "perhaps in the future, there will be some African history of science to teach. But, at present there is none: there is only the history of the Europeans in Africa. The rest is darkness" (Philips, 2006). Historian of technology Jack Goody (1971) singled out the absence of horse, plow, and wheel as a marker of Africa's technological inconsequence. For Walter Rodney (1972), the blame was elsewhere: in the export of Africa's human capital as slaves and its mineral and agricultural resources as industrial raw materials. Europe's technological development took place at the direct expense of Africa's. That led Marxist scholars to conclude that Africa was "preindustrial" before European colonization (Marks & Atmore, 1980). Although there is now a large body of social science and humanities literature on technology design and use relating to the Global North, Africa is made conspicuous by its absence from the discussion. When it is included, it comes into the story only as a recipient of technology transfer from the North or as a victim of (Western and colonial) technology or its appropriators. That, or Africans, are portrayed as just recipients or tinkering

(that horrible word!) and responding without initiative or inventing anything.

Since the post-World War II period, especially from the 1980s, Africa has been at the crossroads between the history of science and technological studies. Also, research on the development of science and its diffusion have changed our understanding of the ways in which the relations between science in French metropolises and science in their African colonies, or relations between science and imperialism, and those between colonization and independence movements (Shillington, 2005). In all, they have converged to construct present-day former French colonies in Africa. In this respect, an international group working on Science and Empire—set up in 1990 in Africa, India, Great Britain, the United States, Spain, Mexico, Brazil and France—has established the limits of the contribution of colonial scientific activities to the emergence of national sciences (Petitjean, Jami, & Moulin, 1992). Southern historians have raised the question of the reception of colonial knowledge (Prakash, 1999), that of the emergence of national sciences (Saldaña, 2005b) that of their confrontation with non-European sciences, that of the participation of local actors in colonial scientific institutions (Raj, 1997), that of revolt against modernity and science (Alvares, 1992), and that of the role of so-called vernacular knowledge, for example in writing the history of ethno-sciences (Hunn, 2007) or in putting into perspective the industrialization of developing and emerging countries (Krishna, 2017). An international comparative perspective has highlighted the importance of social, economic and political dynamics in understanding the contributions of STI in the African (Oreskes & Krige, 2015), Arab (Rashed, 1997), Indian (Raina, 2003: p. 234), Chinese (Needham, 1977), pre-Hispanic (Saldaña, 2005a) and colonial experiences of the British, French, Spanish and Portuguese empires.

It is important to note that STI is integral to Africa's enduring drive for self-determination, development, and democratization, for the continent's transformation, and the restructuring and reimagining of its engagement with the world. Ultimately, it represents a search for African modernity in a world dominated by "instrumental reason" and characterized by the growing importance of "knowledge economies" and "knowledge societies" (Zeleza, 2020). It poses challenges that are simultaneously political and philosophical, concrete and conceptual, about the social and structural conditions and imperatives of Africa's development in a world that rewards scientific and technological progress and punishes those lagging behind.

Across the African continent, there has been a proliferation of national, regional, and continental STI policies and plans. African governments and universities are more aware, and even seem more committed, than ever for their countries and institutions to invest and become producers of scientific knowledges, not just consumers of technological products (AU-NEPAD, 2010). In addition to France's efforts to encourage STI, there has been substantial effort and achievement by the African Union (AU) and its member states over the past years in establishing critical institutions that can support an enabling environment for STI in former French colonies in Africa. These include: African Scientific Re-

search and innovation Council; African Observatory for Science, Technology and Innovation; Pan African Intellectual Property Organization; Pan African Quality Assurance and Accreditation Framework; Africa Centres for Disease Control; Committee of Ten Heads of State and Government (C10) championing Education, Science and Technology; Africa Virtual and E-Learning University; and Pan African Private Sector Trade and Investment Committee (NEPAD OST, 2006). The progress of these institutions is monitored to ensure the future success. While STI are of course not a panacea for all the challenges of human and social development and by themselves will not solve Africa's stubborn legacies of underdevelopment, without them those legacies cannot be overcome.

After the Second World War, broadly speaking, there have been different approaches relating to STI in former French colonies in Africa. The first of these, equating technology with industrial technology as evolved in France, saw the establishment of modern technology in former French Africa territories as primarily a legacy of colonial intervention, a boon bestowed by technologically advanced civilizations on societies considered "backward", even "primitive" (Austen & Headrick, 1983). Conceived and created in France, such technologies were diffused to the rest of French African colonies almost entirely through French agency and without significant local input. These technologies were seen to be modern, progressive and largely benevolent: they constituted a supposedly objective rationale, if not for a dying colonialism, then for the intervention of a superior civilization.

French science was not spread from Europe into a scientific vacuum abroad: the context mattered. Colonial science was much more than a matter of gathering, exploring and developing. Moreover, its role cannot be reduced solely to the pursuit of European scientific activities in the colonies themselves. This perspective converges more with the analyses of Joseph Needham (1970) and Michael Adas (1989) than with George Basalla (1967).[1] Daniel Headrick has produced a fruitful analysis of science and technology for imperialism, but science and technology were not only tools for conquest, control and development.

In order to make the broad parameters of this paper clear, it is necessary at the outset to identify, however schematically, how the history of STI as it relates to Africa, has developed in former French colonies in Africa after the Second World War, highlight the different aspects of STI introduced in former French colonies in Africa by France, examine the ways in which France has encouraged the in-

[1]See George Basalla, "The Spread of Western Science", Science, 1967, 156: 611-622. But see also Joseph Needham, "The Roles of Europe and China in the Evolution of Oecumenical Science", first published in the Journal of Asian History, 1967, and reprinted in Joseph Needham, Clerks and Craftsmen in China and the West (Cambridge: Cambridge University Press, 1970), 396-418. Needham's oecumenical science has seen an important shift from Eurocentric conceptions of science and the narrow vision of universality; see the discussion by Aant Elzinga (1999), "Revisiting the Needham Paradox" in S. Irfan Habib and Dhruv Raina (eds), Situating the History of Science. Dialogues with Joseph Needham (New Delhi: Oxford University Press, 1999), 73-113. See also Michael Adas: Machines as the Measure of Men. Science, Technology, and Ideologies of Western Dominance (Ithaca and London: Cornell University Press, 1989), which is a most stimulating and detailed study in scientism and colonialism.

tersection of STI in Africa and tackle some case studies, as well as the challenges encountered by French African colonies and France to advance STI in Africa.

2. Meaning and Conceptualization of Science, Technology and Innovation in Africa

If STI is defined, conceptualized, and understood as a mechanism that is, for example, useful in converting African history, stories and folklores, crafts, culture and traditions, and so on into world-class arts, music, movies, cartoons (printed, computer, and TV-based), apps, books, merchandise (clothes, toys, accessories), resulting in some form of Silicon Valley–styled network of actors, businesses, incubators, and venture capitalists and creating millions of jobs (e.g., computer graphics work, designers, programmers, marketers, distributors), then STI may take on a different conceptual meaning, value, and relevance (Gault, 2008). This change can help diffuse the tension between "mission-oriented" and "grassroots" innovation policies and contribute toward a balanced innovation policy approach that strives to increase national innovation capabilities, inclusive growth, and sustainable development while reducing poverty levels, inequality, and exclusion of all forms and at all levels.

Our definitions of STI after the Second World War originate from countries and cultures that have acquired their dominance of others through global empires—military, capital, and media—and are able to purvey to or even impose upon those without such power their definitions (Carr, 1961). Generally, the question is neither what the concepts of science, technology, and innovation mean universally or all the time nor what Western STI transferred (Adas, 1989) or diffused to Africa means to Africans. Instead, we seek to put the concepts of STI up for grabs, on sale epistemologically, so that there is no universal or spatiotemporally transcendent definition. We seek to explore what the technological, the scientific, and the innovative might mean from Africa in lieu of outside introductions or influences. It is important to do this now because we feel that the importation and consumption of rigid Western meanings of STI are a serious and dangerous threat to a self-determined African path to emergence in the nearest future (AOSTI, 2013).

Are we certain that what we call "Western" science, technology, and innovation is indeed Western in origin, ingredients, and rationality? After all, from the Greek occupation of Dynastic Egypt of 323 BCE to the European colonization of the nineteenth century and now to this era of "big data", there has been a long history of translation and mobility of African, Asian, and Islamic knowledge and practices via the medium of colonial occupation and domination (Diop, 1974). We should not be shocked that Europe's scientific revolution occurred after, not before, the colonization of the Americas and India. Given all that, Africans are coming to "Western" STI not as outsiders looking in but as coauthors of a knowledge store monopolized through imperialistic power. It is an empowering feeling: Imagine a positive Africa—creative, technological, and scientific in its

own way. The problem is not with STI but how it is defined in alienation, such that Africans are made to enter as unsure and trembling visitors to other societies' achievements.

Merton (1973) defined science as "certifiable knowledge"—that is, statements of regularity that are empirically confirmable and logically consistent. In short, what made science scientific was its method—including disinterestedness, peer review, a reward system, competition, and intellectual property. For Bloor (1991), science can only be examined within the social context of its production; the "natural" of science is not devoid of social content, nor is the laboratory a site of pure objectivity unpolluted by interests. Thus, Feyerabend (1959: p. 14) rejects method as a marker for separating science and its others. Science, he says, is "one view among many and not...the one and only road to truth and reality", and "the success of 'science' cannot be used as an argument for treating as yet unsolved problems in a standardized way". Despite these protestations, Western scientific practice continues very much to be a privileged method, the source of all true knowledge.

Meanwhile the word technology comes from the Greek root techne (an art or craft) and *-ology* (a branch of learning). Nobody really asks: Where did the Greeks get that definition? Or: What did other civilizations, like the Egyptians for instance, call similarly denoted phenomena? Rather, the conversation moves too quickly to the term's first English translation, referring to the mechanic arts as a field, not an object. Technology only became a salient term at a specific moment in American history—the 1840s, when concepts like the useful arts and mechanical discovery, improvements, and invention became inadequate to describe steam power, electricity, the railroad, the telegraph, and myriad other new markers of "progress" (Bigelow, 1829). The impetus for the concept drew from the so-called second industrial revolution of the Western world (1880-1910) and its products, like the electric light, the radio, the telephone, the X-ray, the airplane, the motion picture, and the automobile (Marx, 2010).

The term innovation itself emerged out of *novation*, a thirteenth-century legal term referring to the process of redrafting a contract to renew a debtor's obligations. We love to be called innovators today, but until the nineteenth century a *novator* was a very distrusted person (Godin, 2008). With the advent of the patents regime, imitation became theft (Hilaire-Perez, 2000). The technologization of innovation began in the 1860s, with economists increasingly seeing technology as a cause of economic growth, a spur to industrialization, social change, crisis, and revolution. Thus, from the 1920s to the 1930s, technology was seen as labour and capital saving and a sign of measurable efficiency; productivity became an indicator of technology usage (Gilfillan, 1935). The science policy model that emerged in the post-1945 period was a Maclaurinian one and illustrates the synergistic roles between theorists, research institutions, and governments (Godin, 2008). Can Africa follow these models of STI given its specific conditions? When since slavery the West has used Africa as a mere source of raw ma-

terials (including cheap labour) for its development, a market for its finished goods, and a dumping ground for its disused products? Moreover, how exactly does African STI history help Africa to embrace STI after the Second World War?

3. Historical Background of Science, Technology and Innovation in Africa

In Africa, STI began as early as the ancient days of the early man who produced fire from sparks of stones which he used for cooking and heating as a means for survival (Steven, 1989). In this Paleolithic age, stone was the material used for most of the items they produced (Plummer, 2004). Even though an explanation on how this happened was unknown, the application was very vital for their sustenance. Since then, man continued to acquire knowledge on how to exploit his natural environment for survival until the Neolithic days of early civilization in Africa with a rise in technology where blacksmith used metal such as iron, zinc to produce weapons against wars (Alan, 2007).

With the gradual rise of civilizations in the river valleys of Egypt, Babylonia and other kingdoms, knowledge on STI became too complicated to transmit directly from person to person and from generation to generation (Hugh, 1910: p. 708). For man to thrive in this complex society, he needed some way of accumulating, recording, and preserving his cultural heritage and pass up to his generations. However, with the rise of trade, government, and formal religion, man invented writing as a way to document his activities and culture (Thomas, 2001).

After the Second World War, there have been many attempts to boost STI activities in support of the socio-economic transformation of Africa. This has been summarized by President Kwame Nkrumah, during his first speech at the foundation summit of the Organization of African Unity (OAU), Addis Ababa, 24 May 1963. He stated that:

> We shall accumulate machinery and establish steel works, iron foundries and factories; we shall link the various states of our continent with communications; we shall astound the world with our hydroelectric power; we shall drain marshes and swamps, clear infested areas, feed the undernourished, and rid our people of parasites and disease. It is within the possibility of science and technology to make even the Sahara bloom into a vast field with verdant vegetation for agricultural and industrial developments (Nkrumah, 1963: pp. 46-50).

The 1980 Lagos Plan of Action for Economic Development could be cited as one of the frameworks which elaborated the roles that STI would play in solving problems including energy deficiency, food insecurity, environmental degradation, disease and water scarcity as well as boosting industrial productivity. The target for African countries to spend at least 1% of their Gross Domestic Product (GDP) on Research and Development (R&D) stems from the same Lagos Plan of Action. Subsequent decisions underscored the importance of investing in STI

among others include: the 1987 Kilimanjaro Declaration, the 1988 Khartoum Declaration, and the 1989 Abuja Statement. The attention paid to STI put more emphasis on higher education and R&D by increasing research networks in the African Continent.

Among many conferences that followed the Lagos Plan of Action was CASTAFRICAII organized by the United Nations Educational, Scientific and Cultural Organisation (UNESCO), OAU and Economic Commission for Africa (ECA), which brought together experts and 26 African ministers responsible for STI, to develop strategies for the economic recovery of Africa. The adoption of the Abuja Treaty in 1994 to achieve mutually beneficial economic integration through establishing an African Economic Community (AEC), constituted an important and forward-looking act by the African Heads of State and Government. The transformation of OAU to AU in Lusaka, Zambia in July 2001 was envisioned to build an integrated, prosperous and peaceful Africa, an Africa driven and managed by its own citizens and representing a dynamic force in the international arena.

Realizing that Africa can also benefit from STI activities, in 2005 the African Ministerial Council on Science and Technology (AMCOST) adopted Africa's Science and Technology Consolidated Plan of Action (CPA), which articulates the African Union (AU) agenda for harnessing STI to boost economic growth and improve the lives of African people (NEPAD, 2021). The CPA was developed through a series of regional consultations on the needs of the African STI community.

The AU is committed to achieve its vision of "an integrated, prosperous and peaceful Africa, an Africa driven and managed by its own citizens and representing a dynamic force in the international arena" through its Agenda 2063. The AU Agenda 2063 recognizes STI as multi-functional tools and an enabler for achieving continental development goals. Also, the African Union declaration marking 2007 as the "Year of Scientific Innovation for Africa" stimulated several developments in the areas of STI. This included: re-emphasising the investment of 1% of GDP in R & D by the year 2010; the establishment of centres of excellence in Science and Technology at country and regional levels; the revitalising of African universities; and the 2007 adoption in Maputo, by the first intergovernmental meeting on STI indicators, of the Frascati & Oslo manuals. This marked the launch of the African Science, Technology and Innovation Indicators Initiative (ASTII).

The Science, Technology and Innovation Strategy for Africa 2024 (STISA-2024) document "On the Wings of Innovation" STISA-2024 contributed to the achievement of the AU Vision. Due to the cross-cutting nature of STI, STISA-2024 was designed to meet the knowledge, technology and innovation demands in various AU economic and social sector development frameworks. STISA-2024 has as leading role to play in increasing efficiency (and eliminating duplication of effort) in the design and implementation of national, regional and AU policies on

STI.

In 2014, the AU issued a Science, Technology, and Innovation Strategy for Africa. The Science, Technology and Innovation Strategy for Africa 2024 (STISA-2024) places science, technology and innovation at the epicentre of Africa's socio-economic development and growth, and situates it as a multi-functional tool and enabler for achieving Africa's development goals. The mission of STISA-2024 was to "accelerate Africa's transition to an innovation-led, knowledge-based economy". This would be achieved by: improving STI readiness in Africa in terms of infrastructure, professional and technical competence, and entrepreneurial capacity; and implementing specific policies and programs in science, technology and innovation that address societal needs in a holistic and sustainable way. The AU, in STISA-2024, identifies some of the STI priority areas for Africa:

> Eradication of Hunger and Achieving Food Security; Prevention and Control of Diseases; Communication (Physical and Intellectual Mobility); Protection of our Space; Live Together-Build the Society; and Wealth Creation. The strategy further defines four mutually reinforcing pillars which are prerequisite conditions for its success. These pillars are: building and/or upgrading research infrastructures; enhancing professional and technical competencies; promoting entrepreneurship and innovation; and providing an enabling environment for STI development in the African continent (STISA, 2021).

As Africa seeks to harness and adopt innovations and emerging technologies to achieve social and economic development, several obstacles on the continent are threatening the aspirations of STISA-2024. Some issues which need to be addressed to support the development of Africa through STI include:

> bridging the technological divide through access to technologies by promoting productive and absorptive capacities, sharing experiences and successes on the continent and promoting inclusive innovation within African countries. Secondly, African Union Member States are encouraged to reduce structural vulnerabilities through the financing of innovation and build a strong science culture which encourages collaboration within and between states in the area of science, technology and innovation (STISA, 2021).

One thing is clear—despite the challenges the African continent is facing in adopting innovation and emerging technologies, the continent has the requisites to turn things around and capitalize on its potential to achieve STISA-2024. To achieve STISA-2024, African Governments, including policy and decision-makers must:

> Create a strong political will and trust in the intellectual capacity of the sons and daughters of the continent, revamp STI infrastructure in African countries, enhance technical and professional competencies, take measures to curb brain drain so that the limited means of the continent are not trans-

formed to investment in other continents, achieve the necessary critical mass of human capital needed, provide enabling environments for STI, build a strong science culture and encourage collaboration within and between states in the area of innovation and entrepreneurship (NEPAD, 2022).

The United Nations University-Maastricht Economic and Social Research on Innovation and Technology (UNU-MERIT), together with two specialised organizations under the African Union Commission (AUC)—the African Observatory for Science, Technology and Innovation (AOSTI) and the Pan African University-Institute for Basic Sciences, Technology and Innovation (PAU-ISTI)—organised a training course in Nairobi, Kenya, 6-10 October 2014. The training course on the "Design and Evaluation of Innovation Policies for Africa (DEIPAfrica)" was attended by representatives from the AUC, 11 countries from Southern and Eastern Africa, the New Partnership for Africa's Development (NEPAD), as well as two regional institutions: the Southern African Development Community (SADC) and the Common Market for Eastern and Southern Africa (COMESA). Ethiopia, although not part of these two regions, was also represented. This unique event provided a platform to identify common challenges of implementing STI policy in a group of highly heterogeneous countries.

4. Ways in Which France Has Encouraged the Intersection of STI in Africa

Most scientific innovations and technologies came to the former French colonies in Africa through the process of French colonization. However, it is important to emphasize that, it was only after the Second World War that Africans in former French colonies experienced the full potential of new weapons, engineering innovations, transformation of raw materials, as well as transformative transportation methods and medicine possibilities. France engineered the intersection of STI in Africa in many areas and ways.

French government empowered African institutions and governments. This was made possible after the Liberation of France, when the Ministry for the Colonies in France was split into two ministerial departments: one for "associated States" and the other for overseas France. Their authority extended over all of French Africa south of the Sahara and French territories in the Pacific. In 1950 a ministry was set up for France's departments outside Europe (i.e. the four present-day overseas departments plus three departments in Algeria), its protectorates (Morocco and Tunisia) and the associated States of Indochina. In 1954 it took quarters in a building specially built for it on Rue Monsieur in Paris, where it would be succeeded in 1959 by the Ministry of Cooperation. Civil servants ranked as *administrateurs coloniaux* were dispersed, mostly between the Ministries of Cooperation and Foreign Affairs, but also, to a lesser extent, to the *Caisse centrale de coopération économique* (CCCE).

France has trained scientists, engineers, physicians, architects, planners, and other technical professionals in Africa and has also encouraged partnerships

between the ParisTech[2] graduate engineering schools and institutions in North Africa and French-speaking areas of Sub-Saharan Africa. Five schools—Agro-ParisTech, Chimie ParisTech (PSL), Ecole des Ponts ParisTech, Institut d'Optique Graduate School and MINES ParisTech (PSL)—have joined the French-African Cooperation for Engineering in Africa (FACEA) project, which has the support of the French Ministry of Europe and Foreign Affairs (MEAE) and its operational arm, France Education International. The project aims to strengthen cooperation with the University of Nairobi and the University of Mines and Technology (UMaT) in Kenya and the Kwame Nkrumah University of Science and Technology (KNUST) in Ghana. This STI project has several objectives: train African engineers in Africa, for Africa, so that they can contribute to the social and economic development of their country; support local businesses and French companies working in Africa, promote engineering courses which meet the standards of excellence characteristic of French schools (theoretical and practical knowledge, soft skills, entrepreneurial spirit, management skills, awareness of standards, quality, etc.) in rapidly developing areas of English-speaking Africa; and above all, establish long-term academic and scientific partnerships in countries with high growth potential in Africa.[3]

To promote the intersection of STI after the Second World War, French technology was transferred to her former colonies in Africa. Some of the French technologies transferred were developed and used during the interwar years (Baxter III, 1946: p. 142). They were developed in response to needs and lessons learned during the war, while others were beginning to be developed as the war ended. French technology also played a greater role in the conduct of World War II than in any other wars in history, and had a critical role in its final outcome (Roberts, 2004). Many types of technology were customized by France for military use, and major developments occurred across several fields including:

> weaponry such as ships, vehicles, submarines, aircraft, tanks, artillery, small arms; and biological, chemical, and atomic weapons; logistical support such as vehicles necessary for transporting soldiers and supplies, such as trains, trucks, tanks, ships, and aircraft; communications and intelligence devices used for navigation, communication, remote sensing, and espionage; technology in medicine such as surgical innovations, chemical medicines, and techniques; and rocketry such as guided missiles, medium-range ballistic missiles, and automatic aircraft. Many of these scientific technologies introduced by France after the Second World War were transported and used in former French colonies in Africa (Septimus, 2000).

To further harness the intersection of STI in Africa, Free France in 1941, set up the *Caisse centrale de la France libre* (CCFL) to manage revenues, the circulation of currency in several lands, encourage innovation, mostly in Africa (Bridier,

[2]ParisTech is a consortium of prestigious higher education institutions, which collaborate on joint training, research and innovation projects in the fields of Science, Technology and Management.
[3]For more information, visit https://www.paristech.fr/en/Africa, accessed 27 September 2021.

1991). The CCFL later helped in formulating a reconstruction policy for overseas France and devise the financial instruments for carrying out this policy, while continuing to enjoy the right to issue currency in overseas departments (including Algeria) and territories (including French West and Equatorial Africa) (Hayter, 1965). In 1944, after its name changed to *Caisse centrale de la France d'outre-mer* (CCFOM), its authority extended to the field of development (Cooke, 2003). The 46-860 Act of 30 April 1946, inspired by Postel-Vinay, foresaw the establishment, funding and execution of ten-year development plans for the territories under the Ministry of Overseas France. This Act set up the *Fonds d'intervention pour le développement économique et social* (FIDES), a fund for distributing grants to overseas territories from the State's budget and encouraging STI. By the late 1940s its core activities were defined. It became the *Caisse centrale de coopération économique* (CCCE) in 1958 and then, in 1992, the *Caisse française de développement* (CFD), till 1998 when its name changed to *Agence française de développement* (AFD) (Pacquement, 2010).

France has also inspired new skills and competencies in the fields of STI in Africa through research in different domains. Scientific research was part of colonialism from an early date. In addition to investment programmes, FIDES financed research and development establishments in overseas territories. The aim was to better understand African peoples and thus facilitate colonialism. Research in agronomy, medicine, geography, demographics and anthropology was supported by setting up research centres, Pasteur institutes and even museums (Gaugue, 1999) or by laying out botanical gardens, like the one in Kew, for identifying tropical plants with the most economic potential.

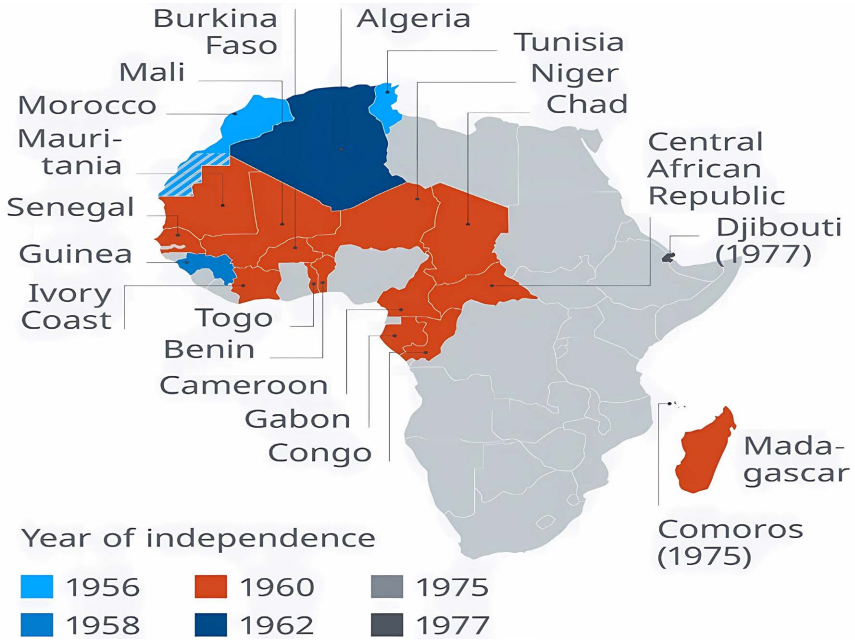
In the domain of health, France's role in promoting STI by providing better health in Africa has been enormous. This has been one of the colonial legacy of the French Army Medical Corps and the bilateral system put in place by the Ministry of French Technical Cooperation from the early days of independence in Africa until the end of the 1990s. France built and equipped hospitals and clinics, trained health personnel, helped combat major endemics, sent French doctors and technical assistants in every specialist field, conducted clinical research and social science projects in former French African colonies (Keroue-dan, 2012). Still in the field of medical technology, France invented Penicillin and made it available to millions of people during and after the Second World War. It was mostly used to treat the venereal diseases gonorrhea and syphilis, which had been the scourge of armies for thousands of years. In addition, Africans were trained as medical experts to produced and administer Penicillin in French former colonies (Tobey, 2018).

5. French Role in STI in Africa: Case Studies in French North Africa

Historical instances of French role in STI in French North Africa show that, France was out to encourage, protect and promote STI before and during the post-World War II period. It is important to note that, French North Africa is

the term often applied to the territories controlled by France in the North African Magreb during the colonial era (Hoisington, 1991). It encompassed French Algeria, Morocco and Tunisia (see **Map 1**). In all three countries, French role in STI in each country is interdependent, and interconnected to the higher education and research systems (Oukil, 2011). In these north African countries, France has encouraged individual researchers, research groups, research institutions, universities and high educational institutions, research communities, enterprises, inter-governmental and governments programmes in STI (Rossi, 2010). The role of France in STI in her French North African countries like Tunisia, Algeria and Morocco shall be briefly examined.

The French played a serious role in the development of STI in Tunisia before and after World War II. Modern research in STI in Tunisia could be traced back to the late 19th Century, under the French protectorate. To encourage STI, the French founded the *Institut de Carthage* (health) in 1893, opened the *Ecole Protectorale Agronomique* in 1898 and the *Institut des sciences océanographes et de la pêche* in 1924 to transform Tunisia (Renaud, 2007). After independence, the French encouraged the establishment of a new institutional framework to promote STI that led to the setting-up of the University of Tunis, the *Ecole Normale Supérieure* (training of professors) and the Tunis Engineering School. The creation in 1978, of the Ministry of Higher Education and Scientific Research with the collaboration of the French, achieved a first step in the construction of the Tunisian system of scientific research, technology and innovation (Crehant & Chaabouni, 2004). The political change of 1987 gave second wind to the scientific research and technology sector by the setting up of the National Scientific



Map 1. Former French Colonies in Africa by year of independence. Source: Silja Fröhlich, "Africa and France: An unfulfilled dream of independence?" Available at https://p.dw.com/p/3gKjv, 3 August 2020.

Research Foundation and the State Secretariat for Scientific Research and Technology (SERST). This structure that was created with the assistance of the French government, was reformed in 2001 by integrating research into the Ministry of Scientific Research and Technology (MSRT) and again in 2005 into the Ministry of Scientific Research, Technology and Competency Development (MSRTCD) (Hatem et al., 2007). About 80% of co-publication of STI in Tunisia are done with France and a growing number of Students (estimated at 8000 in 2002) study STI abroad, with France as the first choose before Germany (1500) and the US (500) (Arvanitis, 2003).

The role of France in the co-production of science and diplomacy was also highly felt in Algeria during the inter-war and post-World War II periods. Algeria is a case where French research in STI has been through very hard times, with a strong emergence followed by collapse and renewal after what can be qualified as a "civil war" (Moussaoui, 2006). Since the independence there has been stability only in very few occasions although the government with the encouragement of France has been a strong promoter of STI. From independence to 1971, French research in STI in Algeria was limited to some public institutions and some specialized centers. In 1974 after the reform of higher education (which had begun in 1971) the French encouraged the creation of the *Organisme National de la Recherche Scientifique* (ONRS). It was dissolved in 1983 by the Algerian government without any institutional substitute. The Higher Commission on Research created in 1986 with the assistance of the French government resulted from the fusion of two coordinating institutions: the former *Commissariat à la Recherche Scientifique et Technique* and the *Commissariat aux Energies Nouvelles* (Crehant & Chaabouni, 2004). Again, the Higher Commission was dissolved and replaced in 1990 by the Algerian Delegate Ministry to Research, technology and Environment. Two years later it was transformed with the assistance of the French government in a State secretariat inside the Ministry of Higher Education (Ferfera & Ziour, 2006). Finally, nine research centres cofounded by France have a specific status of institutions specialized on research in STI with their personnel serving as full-time researchers (Benguerra et al., 2007).

Morocco has witnessed a complete modification of its institutional setting with the assistance of France since the inter-war and post-World War II periods. In the process of opening of the economy, the country experienced a whole series of changes in educational institutions, public health institutions, research centres, the economy and above all in STI orchestrated by France (Kleiche & Laaziz, 2007). In 1986, the first large seminar on research known as *Premières Assises de la Recherche Scientifique* was organized with part of the funding from France. The period of the eighties saw the creation of many public research institutes with the expertise of France: *Institut National de Recherche Agricole* (INRA) created in 1982; *Institut National d' Urbanisme et d' Aménagement du Territoire* (INUAT) created in 1985; *Centre National de l' Energie, des Sciences et des Techniques Nucléaires* (CNESTEN) created in 1986; and *Laboratoire de Géophysique* created in 1988 (Assad, 2007). The decisional structure of the science

and technology policy was profoundly marked by the sub-secretariat to research (1998) which finally became a Ministry in 2002. Following the advice of the French government, it was dissolved in 2004 and since then a direction of science and technology (Crehant & Chaabouni, 2004) has been existing in the Ministry of Education, Higher Education and Research (Amable, Barré & Boyer, 1997). Finally, the creation of an Academy of Science has fostered developments in technological innovations in Morocco.

6. Challenges of Science, Technology and Innovation in Former French Colonies in Africa

Former French African colonies in Africa faced overwhelming challenges that hampered its development of STI after the Second World War. They lacked the basic infrastructure to develop new scientific technologies and innovations. Worse still, they lacked clear policies and capacity to adapt, absorb and diffuse imported technologies from France for their STI advancement and development (UNCTAD, 2007). To address these developmental challenges in the entire Africa and other regions, governments, multilateral institutions and developmental partners set up the Millennium Development Goals (MDGs) and the successor, the Sustainable Development Goals (SDGs) (United Nations, 2015). However, despite the efforts of France, governments and stakeholders to encourage the intersection of STI in Africa, there still exist numerous challenges that have tended to hinder the development of STI in the entire continent.

The first major challenge concerns the fact that former French African colonies lack funds or most often experience poor and unsteady funding to scientists and innovators. Science and technology are capital intensive, it requires large sum of money to execute (NEPAD OST, 2006). Unfortunately, former French colonies lack funds or capital needed to purchase and establish heavy and large industries that could speed up STI growth in the countries. The lack of fund needed for essential developmental policies and projects has led many poor nations to borrow from the developed countries (Pouris & Pouris, 2008).

The second challenge deals with constant brain drain of engineers and lack of expertise in the field of STI in former French colonies in Africa. Most African countries lack high profile professionals who are competent in the fields of science and technology. The few scientific innovators and engineers available are not experience enough to make lasting developmental impression that can compete with that of the developed countries (Gault, 2008). Currently, Africa needs more qualified and professional scientists and technologist who are willing to sacrifice their resources, energy and time for the growth, development and advancement of science and technology in the continent (Siyanbola et al., 2016). In addition, the challenge posed by brain drain of African best scientists to Europe, America, China and other developed nations is alarming. Africa needs policies and developmental agendas that could encourage accredited engineers in different fields to return and invest in Africa (Anderson, 1984).

Another major challenge is directly linked to the absence of inadequate infrastructure to boost STI advancement in former French colonies in Africa. Most basic infrastructures needed for the development of STI is lacking or is inadequate in most former French colonies in Africa (FMST, 2011). For instance, most industrial and technological workshops lack necessary and appropriate tools and machines needed for scientific and technological works. To ensure scientific and technological growth and development in these countries, the governments should provide and make available all the necessary infrastructures such as good roads, tools, machines and other raw materials necessary for the establishment of STI industries (AU-NEPAD, 2010).

There is also the problem of insufficient levels of literacy and political instability. Most former French colonies in Africa are politically unstable due to sociocultural crisis caused most often by political crisis (World Bank, 1989). Political instability has also affected the growth and development of science and technology in these countries. French colonies in Africa have been battling between military governments and democratic governments. This political instability discourages internal development and scares away foreign investors and developers who would have contributed to the growth and development of STI in these countries. In addition, low level of education contributes against the growth of science and technology in these countries.

Interstate and state conflicts are still Africa's biggest challenge. In addition, France constant engagement and military intervention has served as an impediment to STI in most former French colonies in Africa. France's military engagement in Africa has been deep, especially after the Second World War. It intervened militarily in the continent 19 times between 1962 and 1995. But gradually, budgetary concerns and a changed strategic climate have encouraged France to adopt a new multilateral approach (Joyandet, 2008). Structural changes to the armed forces, including sharp reductions in the size of the military and base closures between 1997 and 2002 meant France could no longer maintain the dominance that it had in the 1960s and 1970s. Still, according to the French Ministry of Defence, in February 2013, of 10,025 military personnel deployed overseas, 4610 were in West Africa, 2180 in central Africa and 270 were involved in anti-piracy operations in the Gulf of Aden (Melly & Darracq, 2013).

Africa enables France to still command global authority and influence to an extent not offered anywhere else in the world and this has hampered development in STI in Africa. The continent continues to supply France with raw materials and consume most of French finished products, which is not normal (Gomez, 1998). For instance, Sub-Saharan Africa accounts for 3 per cent of France's exports and also remains an important supplier of oil and minerals—uranium from Niger is particularly strategic for its energy security as about one quarter of France's electricity production depends on it, fuelling nuclear generation. The market share of French merchandise exports and imports to Africa has significantly decreased since 1960 but there are bright spots: sub-Saharan Africa is an important market for French logistics, service, telecoms and infrastructure com-

panies (Carney, 1996). The increasing demand in China and India for raw materials has boosted many African economies and has contributed to a new "Afro-optimism" in France, with the expectation that the continent might become the new frontier market (Severino & Ray, 2010). This is going to pose another serious challenge to African countries.

7. Conclusion

This paper has demonstrated that France through international politics has contributed immensely to the way science and technology have been coproduced in her former African colonies after the Second World War. We argued that, despite French contributions to STI, the time for African countries in former French colonies has come for them to embrace STI, especially as the importation and consumption of rigid Western meanings of STI serve as a serious and dangerous threat to a self-determined African path to emergence in the nearest future. The paper highlighted that, the French government has empowered African institutions and trained scientists, engineers, physicians, architects, planners, and other technical professionals in Africa as a means to encourage the Intersection of STI in her former French colonies in Africa. However, the challenges of STI in Former French Colonies in Africa were many and included poor and unsteady funding to scientists, brain drain of engineers, inadequate infrastructure, insufficient levels of literacy and a shortage of skills and competencies, and above all post-independence interstate and state wars. In addition, this paper recommends and calls on the population and governments of former French African colonies to rise up to the challenge of taking their proper place in the ongoing global STI revolution. The time has come for them to address the current unbalanced global governance of STI which has entrenched knowledge dependence for too long. They need to move away from the current binomial, linear, unequal partnerships where the funding for scientific research, knowledge and technology generation largely flow from North to South or from France to their countries. Also, they must move away from imported, supply driven, scientific processes forced in through development funding packages or through poorly negotiated international agreements, by which recipients acquire no specific knowledge or skills during the process.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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