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The Status of Innovation in Africa's Development Strategy: Where Should Science and Technology Fit In?

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Introduction and Origin of Innovation Policy in an African Context

This chapter sets out the importance of knowledge systems in promoting economic development in African countries. Such relationships vary widely across countries given their unique histories and interrelationships. One especially important problem concerns the pattern of institutional development through which knowledge is produced, validated, and used, and how this pattern has evolved in recent years in many economically poor countries. National policies have tended to focus on established bodies such as those concerned with publicly financed

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education and research, but have paid little attention to the use of the resultant knowledge. This is especially so in Africa where the comparison with many South Asian countries shows poor effective knowledge-based development. A significant amount of recent research has begun to show that this happens because of excessive orientation to formal science in comparison to the kinds of knowledge related to investment, production, civil society goals, incomes, and employment possibilities for the bulk of populations.

The origin of the chapter goes back to early 2015, speaking to a group of donors on the topic of Africa's long-term strategy organised by the African Centre for Technology Studies (ACTS) in Nairobi, Kenya. The presentation was entitled *"The African Development Agenda and Strategic Priorities for Foreign Aid Post 2015: The Case for Aid for Science, Technology, Innovation and Sustainable Development"*. In preparation for the talk, we came across the official documents produced by the African Ministerial Council on Science and Technology (AMCOST). Their policy statements discussed innovation and innovation policy in a manner that hardly made any reference to economic production and employment. Instead, the discourse by AMCOST was dominated by reference to scientific research conducted in scientific institutions. The message clearly resonated with the 1970s view that innovation is really all about formal R&D conducted in universities and such like bodies.

The arguments were presented in a way that focused on what to policymakers appeared to be a new concept in the policy literature of relevance to African economic development, namely the conflation of Science, Technology and Innovation (STI) as the focus of national and international interventions designed to boost African growth. We say "new concept" advisedly because most of the documents consulted mentioned just Science and Technology. The insertion of "Innovation" after "Science & Technology" seems to have occurred in an African context around 2006. Prior to that, "Innovation" was hidden in most of the official texts read. The presentation then was mainly about a Department for International Development (DFID) programme the first author had been closely involved with, called the *Research into Use* (RIU). In an

earlier paper by Clark and Frost (2015), the authors had expressed the view that by using the term "STI", policymakers were consciously, or unconsciously, focusing on strategies for innovation policy that have little to do with nuts and bolts of what is really needed in an African context: namely, how to raise the productive capacity of African economies and, by extension, provide jobs and incomes for their citizens.

Revisiting Africa's Innovation in Development Strategy

Two reasons contributed to revisiting innovation in development strategy in Africa. First, on reflection we have realised that this focus on STI as the centre of gravity for innovation policy in Africa shows every sign of permanence and could actually be quite harmful. For policy is all about actions for social and economic change. To commit scarce resources in wrong directions in conditions of underdevelopment is something that Africa cannot afford. Moreover, the danger is that this could well take place if powerful scientific lobbies award themselves little gifts that are not justified. A second reason for revisiting the topic is that it raises an issue of the importance of links between higher education (HE) and economic production. For in a sense the relative inability of the HE system in Africa to assist in securing jobs for its graduates is by now clearly a continental problem.

Based on this, the chapter covers four points for discussion in the following sections:

1. Theoretical overview of innovation development and their application in Sub-Saharan Africa (SSA)
2. Institutional developments of African STI initiatives
3. The DFID Research into Use (RIU) Programme
4. Relevance of DFID/RIU and innovation policy for African Higher Education

Theoretical Overview of Innovation Development and Their Application in SSA

In contrast to the supply-led approach of the 1970s and building on analysts such as Freeman (1987), Lundvall (1992), Nelson (1993), Edquist (1997) and others, most modern treatments of innovation now conduct analysis as a systemic activity. Due to the globalisation and intensification of knowledge in production systems, many countries including those in Africa now routinely use science, technology, and entrepreneurship policies to stimulate economic transitions through innovation and entrepreneurship (Robson et al. 2009). Such transitions have comprised multiple shifts in government policies and strategic plans (Amankwah-Amoah 2016). In this way, a substantial body of work has been dedicated to understanding the circumstances under which an innovation can help countries to develop faster (Verspagen 2005; Hasan and Tucci 2010). However, many developing countries, especially in Africa, have not fully benefited from the positive externalities of STI. This has been ascribed to the failure of some states to direct their innovation policies to the most vital areas of necessity and address the critical needs of its people, particularly employment generation for youth.

Two recent approaches to the study of innovation have been those of Innovation Systems and Triple Helix. The central theme of innovation systems thinking highlights how private firms, government organisations, and institutions of higher education collaborate, create, diffuse, and apply knowledge for commercial benefit. This knowledge can be new or an enhancement of an existing product or process or a combination of both. Innovation System approaches have been adopted by many developed countries to promote competitiveness and economic growth. However, implementations of such policies in developing countries, especially those in SSA, have been insufficiently analysed (Lall and Pietrobelli 2003; Jauhiainen and Hooli 2017).

Representing a departure from the System of Innovation approach, the Triple Helix Model stresses interaction among university, industry, and government institutions. These emphasise distinct but complementary intersection and overlapping of roles between the three institutional

spheres (Etzkowitz and Dzisah 2007). With the emergence of a knowledge-based economy, the adoption and application of Triple Helix in the knowledge production and application both in developed and developing countries have become widespread. It emphasises the easy flow of actors across organisational borders, which can smooth knowledge flow and stimulate regional development (Liu and Huang 2018). The model considers the university as a key player that leads in the transition to knowledge-based economy by combining teaching, research, and commercialisation of research through academic spin-off facilitated by Technology Transfer Offices (TTOs).

However, according to Etzkowitz and Dzisah (2007), the higher education system in many developing countries (especially those in Africa) inherited colonial education arrangements, which have tended to weaken institutional capacities of universities in performing this role effectively. They argue that colonial education was not intended to prepare individuals for the service of the country. It was rather inspired by the need to instil the values and standards of the colonial society, and to train individuals for the service of the colonial state. The study by Saad and Zawdie (2011) in developing countries to explore the theory and application of the Triple Helix in innovation strategy found a challenge in operationalising the Triple Helix due to the low volume of institutional interactions.

Additionally, Africa has generally shown poor industrial performance because the majority of industrial sectors are state-owned and oriented towards local markets (Lall and Pietrobelli 2005). The region also remains technically backward and has failed to build competitive advantage in many export markets. It has attracted very little of the types of export-oriented foreign direct investment that has driven the growth of many East Asian economies (Lall and Pietrobelli 2005). It is this broad issue that has led to the Agenda 2063 to fast-track Africa's transition to an innovation-led, knowledge-driven economy (AU 2014b). This first agenda intends to accelerate the development of human capital, entrepreneurship, innovation, and industrialisation that will lead to social transformation and competitiveness of the continent (AU 2014a).

There is evidence to suggest that this ten-year STI strategy may have contributed to some limited innovation improvements. According to the Global Innovation Index 2019, the top three innovation economies in

Table 2.1 Top 20 SSA Innovation Performance (GII 2019)

Country/Economy	Rank	Region SSA Rank
South Africa	63	1
Kenya	77	2
Mauritius	82	3
Botswana	93	4
Rwanda	94	5
Senegal	96	6
Tanzania	97	7
Namibia	101	8
Uganda	102	9
Côte d'Ivoire	103	10
Ghana	106	11
Ethiopia	111	12
Mali	112	13
Nigeria	114	14
Cameroon	115	15
Burkina Faso	117	16
Malawi	118	17
Mozambique	119	18
Madagascar	121	19
Zimbabwe	122	20

SSA, shown in Table 2.1, are South Africa (63rd), Kenya (77th), and Mauritius (82nd) (GII 2019). In addition, the innovation landscape in Africa is changing. Out of the 18 innovation achievers identified, five SSA countries—Kenya, Rwanda, Mozambique, Malawi, and Madagascar—stand out as being innovation achievers relative to levels of development in the previous eight consecutive years (GII 2019).

According to Vallejo et al. (2019), over two-thirds of SSA countries have implemented STI policies at different levels though most countries still lack the requisite capacity to improve the potential of STI to develop structural transformations of their economies. In addition, most states in the region have immature and underdeveloped STI institutions, and have failed to produce and deploy knowledge effectively. According to ACBF (2017), for example, major barriers preventing SSA countries to promote growth and competitiveness include lack of relevant critical skills and weak higher education systems.

Institutional Developments in African STI

There was very little focus on S&T and African development before 1980. What generally happened was that countries tried to copy the West and build OECD-like bodies. The beginnings of change occurred in 1979 as a result of a high-level meeting of countries leading to the Lagos Plan of Action (LPA) for the Economic Development of Africa (1980–2000). The LPA was essentially a blueprint of how to foster collective self-reliance and sustainable development of the continent. It led to a number of subsequent regional conferences (such as CASTAFRICA II) organised by UNESCO/OAU/ECA which brought together 26 African ministers and experts of science and technology, for the purpose of developing strategies for the economic recovery of Africa.[1]

This was followed ultimately by the formation of the Africa Union (AU) and the *New Partnership for Africa's Development (NEPAD)* established in 2001. The AU subsequently adopted NEPAD in 2002 as a set of development programmes whose aims were to eradicate poverty, promote sustainable growth and development, integrate Africa in the world economy, and accelerate the empowerment of women. One of these programmes was about S&T whose implementation was passed to a Council of Ministers in charge of Science and Technology (AMCOST). This body met in 2003 and agreed to produce a consolidation plan of action (CPA) designed to embed S&T within the African region. The CPA was finally published in 2006. It is in this document that "innovation" (I) really appears for the first time and it does so as an add-on to science (S) and technology (T), becoming of course STI. As such, it now appears routinely in all texts and conversations relevant to economic development.

[1] Others include OAU: Africa's Priority Programme for Economic Recovery (1986–1990), The African Alternative Framework to Structural Adjustment Programme for Socio-economic Transformation (AAF-SAP)–1989, The African Charter for Popular Participation in Development and Transformation (ECOWAS 1990), The OAU Re-launching of Africa's Economic and Social Development: The Cairo Agenda for Action (1995) and the New Partnership for African Development (NEPAD), IISD (2006) 'AMCOST Bulletin – EXTRAORDINARY CONFERENCE OF THE AFRICAN MINISTERIAL COUNCIL ON SCIENCE AND TECHNOLOGY – 20–24 NOVEMBER 2006'. Available at: https://enb.iisd.org/africa/vol03/arc0301e.html, AU (2015) 'Agenda 2063: the Africa we want', *African Union Commission*, Ayittey, G. (2016) *Africa unchained: The blueprint for Africa's future.* Springer.

Close inspection of the CPA document shows that its analysis and recommendation followed precisely this template. Its recommended programmes were set in terms of five S&T "clusters" as follows:[2]

Cluster 1: Biodiversity, Biotechnology, and Indigenous Knowledge: (a) Conservation and Sustainable Use of Biodiversity; (b) Safe Development and Application of Biotechnology; and (c) Securing and Using Africa's Indigenous Knowledge Base

Cluster 2: Energy, Water, and Desertification: (a) Building a Sustainable Energy Base; (b) Securing and Sustaining Water; and (c) Combating Drought and Desertification

Cluster 3: Material Sciences, Manufacturing, Laser and Post-Harvest Technologies: (a) Building Africa's Capacity for Material Sciences; (b) Building Engineering Capacity for Manufacturing; (c) Strengthening the African Laser Centre; and (d) Technologies to Reduce Post-Harvest Food Loss

Cluster 4: Information and Communication Technologies: (a) Information and Communication Technologies and (b) Establishing the African Institute of Space Science

Cluster 5: Mathematical Sciences: including the next Einstein Initiative.

Each cluster would be managed by and through centres of excellence whose projects would be developed and implemented over the (coming) five years. Their "flagship" programmes would be research-organised on their "relationships and potential of establishing inter-related networks of implementing institutions". Advisory services would be orchestrated by high-level scientific committees who would ensure adequate "peer review" status to all programmes. Coordination would be effected by an AMCOST steering committee at overall level and by the NEPAD office in South Africa at the "technical" level. S&T then metamorphs into STI as the document proceeds. Thus, little mention of innovation can be seen in the first 50 pages or so of the text. The section on clusters is effectively on science policy strategy. For example, Cluster 2 on Energy, Water, and

[2] See Mugabe and Ambali (2006) Section 3, pp. 14–50.

Desertification is partly a wish list of things that need to be done to ease climate change problems, research on fact-finding about clean energy sources, making scientific assessments on subjects related to water quality and access, and improving "scientific understanding of causes of drought and desertification" (pp. 24–32). These initiatives are worthy as far as they go, but they are portrayed as a series of projects to be carried out and validated mainly by research bodies.

It is when we get to Sect. 4 entitled *Improving Policy Conditions and Building Innovation Mechanisms* that the CPA gets into discussing innovation as such. This primarily took the form of a programme designed to develop STI indicators. These were held to be "crucial for monitoring Africa's scientific and technological development. They are useful for formulating, adjusting and implementing STI policies. Indicators can be used to monitor global technological trends, conduct foresight exercises, and determine specific areas of investment" (p. 51). They were to be used to enable data to be gathered that would allow statistics to be calculated on regional activities connected to topics such as R&D and capacity-building that would provide an international platform for planning and dialogue.

It is noteworthy that even here very little is said about "innovation" as such, or about what practical measures could be taken to improve it. The remainder of the CPA is concerned with the creation of institutional mechanisms in matters such as regional contacts, science policy formulation at government level, and other matters. The nearest we get to innovation on a practical level is an abbreviated discussion on S&T parks at the end of the 75 pages or so. What started from the CPA was then continued with detailed survey work funded largely by international aid agencies at country level up until 2014 when the NEPAD produced a series of reports on indicators of innovation and related aspects of STI. The main published result of this work is *On Wings of Innovation* published in April 2014. Effectively, this document summarises what the AMCOST had done in response to the dictates of the CPA.

It may help to look at some of this indicators work using Nigeria and Ethiopia as exemplars. Ministries in 15 countries carried out detailed

survey work on indicators, which the NEPAD had determined as relevant measures of innovation in their economic systems. Not surprisingly these measures centred on R&D, much of which turned out to be conducted in universities and national R&D institutes. In the Nigerian document (2012), the report begins by talking only in terms of STI. For example, on page 15 it is stated that "*the transformation of the Nigerian economy based on science and technology is therefore the transformation of the Nigerian people, organizations and institutions into science and technology thinking entities*". Little attempt is made to specify how this relates to innovation potential and the document devotes most of its recommendations to (a long list of) measures to expand R&D and related public sector institutions. There are some general statements about the need to involve firms but little offered on how exactly this will be done.

Similarly, the 2006 Ethiopian document treats innovation much as a science-led activity. The 2012 document spends more time on issues of technology development (including foreign technology) but concentrates mainly on broad strategic objectives. The part on policy instruments appears in four pages at the end (out of 24 in all) and is unspecific about how in practice goals are to be achieved. Thus what we are seeing is arguably a resurrection of the old (1970s) view of innovation, one sometimes labelled the "pipeline model"; in this view, all (or most) innovation starts with formal science where new knowledge is formally produced through rigorous research in R&D departments (mainly in the public sector). This is then published in academic papers or related grey literature taken up by entrepreneurs, possibly privatised under forms of IPR (e.g. patents) and then used to produce new products and processes. In this new form, the pipeline has been subsumed under the moniker STI but it is still fundamentally a supply-led phenomenon. By extension in the Africa case, associated policies are essentially science policy ones. There is a nod in the direction of the twenty-first century but by and large this amounts to a series of projects designed to mobilise and update knowledge that already exists (perhaps in accessible forms).

The DFID Research into Use (RIU) Programme

This programme, worth some £40 million, concerned the natural resources (NR) sector (RNRRS);[3] it was established in 2006 to improve the roll-out of big sums of money spent by DFID in the previous ten years or so. Between 1995 and 2004 some £220 million had been invested in research designed to further economic development, the bulk of which went to UK public sector bodies (sometimes in collaboration with overseas partners in recipient countries). There was little evidence of this research being used, so the DFID approach was to invest a further £40 million to make the use of the research forthcoming. Clearly, pipeline thinking predominated since the underlying hypothesis was that relevant innovation in the natural resources sector needed a little more effort to get the productive show on the road. In other words, the DFID view had clearly been the traditional one to start with R&D projects.

When resultant production impacts did not materialise, the next step was to work out what had been missing and to fill the gap with more resources; but to be fair there was also a science policy agenda, to explore what else might be missing from the underlying technology transfer process and structure. It would take too long to describe in detail the RIU programme. Those interested are invited to consult other texts referenced here, in particular Clark et al. (2011 and 2013), Frost (2013), and Gildemacher and Mur (2012). In outline, the RIU identified a series of NR sectors in African and South Asian countries where resources could be allocated. A range of techniques was deployed to achieve this. For example, attempts were made in selected countries to identify "innovation coalitions" of relevant bodies; these would work together to propose relevant investments in sectors that were deemed to be key for development. The Tanzania case focused on poultry management while the Nigeria case covered cowpea. In every case a proposal was made to the RIU and, after modifications, resources were provided.

Another technique was the "Best Bets" programme in six African countries designed to fund a range of technology development projects to the tune of £5 million. The fund was a venture capital resource to be

[3] RNRRS stands for Renewable Natural Resources Research Strategy.

accessed competitively by consortia that would include partners who could be from publicly funded bodies. All were required to include private sector inputs and all were asked to provide an exit strategy on project conclusion. The call generated some 125 proposals which were vetted by a panel of senior African personnel that included venture capitalists, financial experts, and others involved in technology development. The resulting 15 or so projects produced some interesting outcomes.

In the "Best Bets" programme the funding call was set up as a competition that mirrored the British TV show "Dragons Den". Each applicant was given a short time to sell their venture followed by an interrogation from the panel of around 20 minutes or so. The successful shortlisted ones were then asked to prepare a formal business proposal that was subsequently vetted by other professional bodies before RIU management released the funds. In the event, some seemed to be successful and others not. By the end of 2013, the results were mixed with some failures, some successes, and some showing positive elements.

The main conclusion drawn from the RIU programme as a whole was that innovation has had very little to do with its portrayal in the AMCOST/NEPAD strategy documents. All the RIU projects were highly innovative but took the form of systemic interventions in which formal science played only a small part among many other knowledge agents. Where it helped was as a secondary input into a much more complex set of operations as outlined in Fig. 2.1. This illustrates the finding that each "innovation" has many components, ranging from acquiring pre-investment financial resources, managing risk and uncertainty, mobilising disparate knowledge elements, applications engineering, negotiations with government regulatory bodies, accessing products through imports (in the absence of local production capacity), and dealing with the many problems that always plague new innovative ventures.

There were also significant network links across different types of organisations such that, for an innovation to be successful, relevant flows of knowledge and resources needed to be coordinated and facilitated. It also showed ways in which the private sector can make a major contribution to international technology development for the rural poor. It became clear therefore that the idea of innovation should not be summarised under the generalised concept of "STI". Doing so is not only

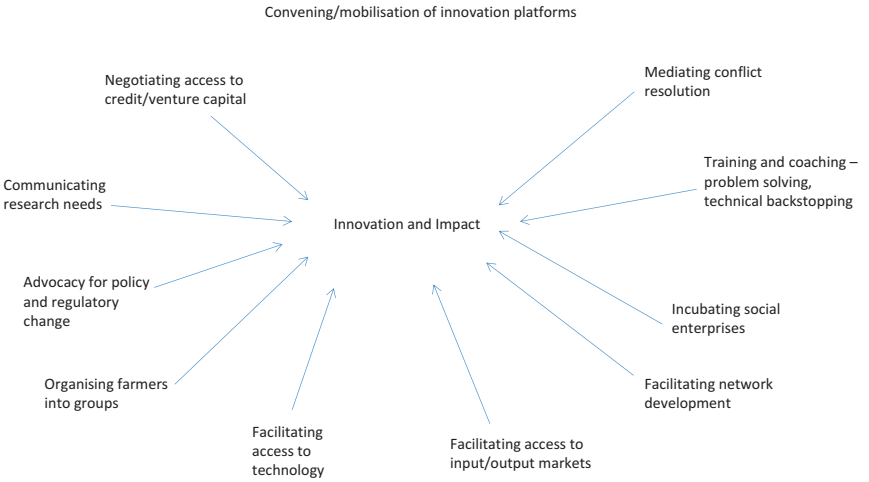

Fig. 2.1 Innovation Management/Brokerage Tasks Undertaken by RIU. (Authors' compilation)

misleading, it also distracts from what we need to understand about necessary policy and practice in low-income countries. For example, it allows policymakers to park complex policy issues in bureaucratic terms as a "science funding" problem that can be subcontracted to specialised institutions and "measured" using R&D statistics.

Relevance of DFID/RIU and Innovation Policy for the Africa Higher Education (HE)

What the DFIF/RIU case means for SSA can be summarised more generally as follows. The effectiveness of a viable knowledge system is to do with the ease with which relevant information can be organised and introduced into economic production, distribution, and associated activities, so as to improve performance. It has important institutional and policy dimensions (both at national and international levels) since such information is usually held in proprietary form by organisations that have interests in using it to achieve their own objectives. This means that issues of competition and co-operation may intrude into the effectiveness of

national policies of relevance. Much of the recent research on "innovation systems" has been oriented to manage such systems in more effective and efficient ways. What this implies for innovation policy can already be seen from Fig. 2.1. It comprises policies for everything from national fiscal and investment, foreign trade, international markets and technology transfer, finance and higher education and training to employment, international aid, and much else besides. Science and technology have of course a contribution to make, but there is very much more.

As already pointed out earlier, it is useful to highlight the HE sector not only because it is central to the theme of this book, but also because it is clear from the DFID experience that HE institutions have the capacity to play a central role and indeed did so in the RIU programme. For it is here that young people obtain the practical skills needed if they are to play useful roles in African development. There is a history here but it has never really taken root in developing countries. The EARTH University in Costa Rica was an early example. All students were required to establish their own business as part of a degree programme that concentrated on agricultural science. Failure to do so adequately would compromise the final quality of the degree awarded.

A more recent example was a major EU project on SSA regional fish trade carried out by World Fish, a CGIAR centre.[4] The project financed Master's degree students to work on cognate dissertations designed as part of the overall set of innovative activities designed to boost regional trade. Although academic supervision was standard, the students would also be supervised by a government official in a relevant ministry. A more recent innovation is the creation of a pan-African Master's degree programme by COMESA and currently managed by Kenyatta University in Kenya. This programme admitted its first cohort in September 2017 and has been designed to build capacity in managing trade policy across SSA. It is an online programme, but students are required to research their dissertation projects based on live work by their governments to promote continental trade.[5]

[4] Consultative Group for International Agricultural Research.

[5] For information, see http://www.ku.ac.ke/schools/economics/

A good example of one of the RIU projects was the approach taken by the Faculty of Veterinary Medicine at Makerere University in the Sleeping Sickness project.[6] It created a new *Institute for Strategic Animal Resource Services (AFRISA)* linked to (but financially independent of) the University of Makerere. Part of this new institute programme was designed for in-training community service delivery. The University saw this as a generic mechanism for equipping graduates for a labour market that is no longer satisfied by the supply of traditional university degree-holders. Instead the demand is for graduates who not only possess saleable business skills but are also capable of actually generating their own jobs virtually from scratch. Under this programme, veterinary students spent the final year of an undergraduate degree entirely in economic production activity producing at the end a project report that was assessed as a key component of the final degree.

In this case and in co-operation with a private veterinary company, final-year undergraduates participated in block treatment of cattle and ancillary spraying activities. In addition, a small number of these undergraduates were encouraged to set up small "agro vet" businesses (3 V Vets) under the supervision of a local private veterinary company. Undergraduate vets were trained in community animal health services and gained a three-month "short course" practical experience. Three years into the project, seven businesses had been established with 100 additional employment opportunities created—each vet had a shop assistant and between 90–100 spray persons were employed by these seven vets. On top of this, farmers began buying drugs for helminths, *trypanosomiasis*, and tick-borne diseases from the 3 V network of vets and a PPP vet service was now available in all districts. Twenty-seven BVM students were trained in Phase 2 in Soroti. Initially there were governance problems that related to perceived conflicts between academic and commercial roles. But these were quickly ironed out. By the end of the project, the RIU team had evidence that the AFRISA approach had started to be examined by other African universities and cognate work had begun in Nigeria.

[6] See Clark et al. (2013) chapter 6, pp. 108–114.

Conclusions and Policy Implications

We began this chapter with an emphasis on the use of the term STI as a focal point for Africa's development policies. It has struck us for many years now that more needs to be done to link education with economic production. Juxtaposing the empirical data to the theoretical lenses of the Triple Helix theory of innovation, it is clear that programmes like the DFID/RIU are beginning to fill the funding gap. They are doing this by promoting an entrepreneurial spirit and influencing innovation through innovation brokering, which promotes investments and institutional change. However, in many of the developing countries, especially in SSA, weak institutions of higher education and low investment in human capital present a chronic challenge to the full implementation of a Triple Helix network.

Indeed, in our experience of high-level senior management, academic, and researcher on Africa university interactions, one of the conclusions reached very quickly has been how little interaction exists between academic study and the world of work. This was the case in most higher education institutions that the authors experienced and observed. In science and engineering faculties, relevant equipment and materials were often absent (or at best inadequate) and very little seemed done to train students for the working world.

In contrast, many universities have become degree machines, churning out young people with paper qualifications but little else. The inevitable results follow. In the first author's own university in Africa,[7] very few graduates were successful in local job markets; most went on if they could to study for a higher degree at "Master's" level; even then, direct future employment was uncommon. Instead, what we have seen portrays a knowledge market, which in many parts of Africa appears to be getting out of control, turning out increasing numbers of graduates who have little hope of gaining useful work.

An important part of the problem lies in our view, in treating innovation policy as fundamentally science-related when in most cases the role of formal science is much more nuanced. What the RIU programme

[7] He spent a short period as Vice Chancellor in a Kenyan private university.

pioneered by DFID appears to have shown empirically (and really for the first time) is that effective technology development (and related innovation), at least in the natural resources sector, depends upon science being drawn into a complex systemic context as and when needed, not "pushed out" by R&D bodies in the hopes of finding a market. This systemic context is directly concerned with production, investment, and the creation of jobs and incomes for disenfranchised young graduates. In our view, if Africa's decision-makers do not get a grip on this, it will come back to haunt them as patterns of inequality harden into severe forms of political backlash across the region.

As pointed out in the DFID RIU programme, we are beginning to see some realisation of this on the part of relevant international agencies, especially in relation to Africa. For example, a relatively recent study of the medical sector in a range of countries has explored prospects for innovation-led pharmaceuticals production within the country.[8] Using a series of detailed national case studies, it sets out a series of policy programmes that governments are advised to adopt to ensure the growth of a sustainable medical sector in the region. Another recent project (again promoted by DFID) has been set up to identify practical areas for change to enhance the impact of government and external investments in science, technology, and innovation.[9]

This study is part of a wider partnership programme which includes the Science Granting Councils Initiative, a partnership between Canada's IDRC, South Africa's National Research Fund, and 15 Science Granting Councils across Africa. It also includes Accelerating Excellence in Science in Africa (AESA), a collaboration between the Africa Academy of Sciences and NEPAD, funded by the Wellcome Trust, Bill and Melinda Gates Foundation, and DFID.

The purpose of this research is to propose practical actions and recommendations for effective investments in science, technology, and innovation by these countries. Examples like these indicate strongly that policy changes are needed to shift the centre of gravity back towards those that link science and engineering training directly to economic production as

[8] See Mackintosh et al. [eds], (2016).

[9] See Atela et al. (2019).

an intrinsic part of higher education curricula. This is not easy to accomplish as it threatens power structures within academia. Nevertheless, there are now inspirational examples of institutional change that can act as templates for the future. These changes place the centre of policy gravity on the acquisition, deployment, and adoption of knowledge that is useful in a directly productive sense. It is probably now too late to get rid of the "STI" label but at least its flaws can be made clearer to those who have the responsibility of promoting balanced economic development in SSA.

References

ACBF. 2017. *Building Capacity in Science, Technology and Innovation for Africa's Transformation: The Role of Higher Learning and Research Institutions*. African Capacity Building Foundation (ACBF). Accessed 1 Aug.

African Union. 2014a. *On the Wings of Innovation, Science, Technology and Innovation for Africa 2024 Strategy, STISA-2024*, April.

———. 2014b. *Science, Technology and Innovation Strategy for Africa 2024 (STISA-2024)*. Science & Technology African Union Commission, Ed.

———. 2015. *Agenda 2063: The Africa We Want*. African Union Commission.

Amankwah-Amoah, J. 2016. The Evolution of Science, Technology and Innovation Policies: A Review of the Ghanaian Experience. *Technological Forecasting and Social Change* 110: 134–142.

AMCOST. 2006. *AMCOST Bulletin – Extraordinary Conference of the African Ministerial Council on Science and Technology,* 20–24 November 2006. Available at: https://enb.iisd.org/africa/vol03/arc0301e.html

Atela, J, F. Marshall, N. Ndege, J. Chataway, A. Frost, and A Hall. 2019. Unpacking Knowledge Systems for Sustainable Development in East Africa: Practical Perspectives from Kenya, Rwanda and Tanzania. *Knowledge Systems Project*. https://steps-centre.org/blog/how-can-knowledge-systems-in-east-africa-contribute-to-sustainable-development/

Ayittey, G. 2016. *Africa Unchained: The Blueprint for Africa's Future*. Springer.

Clark, N.G., and A. Frost. 2015. It's not STI: It's ITS – The Role of Science, Technology and Innovation (STI) in Africa's Development Strategy. *International Journal of Technology Management and Sustainable Development* 15 (1): 3–13.

Clark, N.G., A. Frost, I. Maudlin, P. Steward, H. Wainwright, and A. Ward. 2011. Putting Research into Use: A Market Failure Approach. *International Journal of Technology Management and Sustainable Development* 10 (3).

Clark, N.G., A. Frost, I. Maudlin, and A. Ward. 2013. *Technology Development Assistance for Agriculture: Putting Research into Use in Low Income Countries*. London: Routledge, April.

Earth University. 1990. See https://en.wikipedia/wikiEarth_University

ECOWAS. 1990. *The Charter for Popular Participation in Development and Transformation*. Available at: https://oldsite.issafrica.org/uploads/POPULARPPARTCHARTER.PDF. Accessed 6 Aug 2019.

Edquist, C. 1997. Systems of Innovation Approaches—Their Emergence and Characteristics. In *Systems of Innovation: Technologies, Institutions and Organizations*, ed. C. Edquist. London: Pinter.

ESTA. 2012. *Science, Technology and Innovation Policy.* Ethiopia.

Etzkowitz, H., and J. Dzisah. 2007. The Triple Helix of Innovation: Towards a University-Led Development Strategy for Africa. *ATDF Journal* 4 (2): 3–10.

FMST. 2012. *National Policy on Science, Technology and Innovation.* Nigeria.

Freeman, C. 1987. *Technology Policy and Economic Performance: Lessons from Japan*. London: Pinter.

Frost, A. 2013. *Final RIU Report.* http://r4d.dfid.gov.uk/pdf/outputs/ResearchIntoUse/RIU_Final_Report.pdf and r4d.dfid.gov.uk/pdf/outputs/ResearchIntoUse/RIU_Annexes_except_Annex6_to_Final_Report.pdf

Gildemacher, P., and R. Mur. 2012. *Bringing New Ideas into Practice: Experiments with Agricultural Innovation. Learning from Research into Use in Africa*. Amsterdam: KIT Publishers. 184 pages, ISBN 978-94-6022-233-7ESTA.

Global Innovation Index (GII). 2019. Available at: https://www.globalinnovationindex.org/gii-2019-report#

Government of Ethiopia. 2006. *National Science, Technology and Innovation (STI) Policy of Ethiopia*.

Hasan, I., and C.L. Tucci. 2010. The Innovation–Economic Growth Nexus: Global Evidence. *Research Policy* 39 (10): 1264–1276.

IISD. 2006. *AMCOST Bulletin – Extraordinary Conference of the African Ministerial Council on Science and Technology*, 20–24 November 2006. Available at: https://enb.iisd.org/africa/vol03/arc0301e.html

Jauhiainen, J.S., and L. Hooli. 2017. Indigenous Knowledge and Developing Countries' Innovation Systems: The Case of Namibia. *International Journal of Innovation Studies* 1 (1): 89–106.

Lall, S., and C. Pietrobelli. 2003. *Putting Africa First: The Making of African Innovation Systems, Chapter Manufacturing in Sub-Saharan Africa and the Need of a National Technology System*. Aalborg Universitetsforlag.

———. 2005. National Technology Systems in sub-Saharan Africa. *International Journal of Technology and Globalisation* 1 (3–4): 311–342.

Liu, Y., and Q. Huang. 2018. University Capability as a Micro-Foundation for the Triple Helix Model: The Case of China. *Technovation* 76: 40–50.

Lundvall, B.-A. 1992. *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Pinter.

Mackintosh, M., G. Banda, P. Tibandebage, and W. Wamae, eds. 2016. *Making Medicines Work in Africa*. Basingstoke: Palgrave Macmillan.

Mugabe, J., and A. Ambali. 2006. *Africa's Science and Technology Consolidated Plan of Action*. Johannesburg: NEPAD Office of Science and Technology.

Nelson, R.R. 1993. *National Innovation Systems: A Comparative Analysis*. Oxford: Oxford university press.

NEPAD. 2019. *Advancing Science and Technology in Africa|AUDA-NEPAD*. Available at: https://www.nepad.org/news/advancing-science-and-technology-africa

NEPAD Planning and Coordinating Agency (NPCA). 2014. *African Innovation Outlook*. Pretoria: NPCA.

Robson, P.J.A., H.M. Haugh, and B.A. Obeng. 2009. Entrepreneurship and Innovation in Ghana: Enterprising Africa. *Small Business Economics* 32 (3): 331–350.

Saad, M., and G. Zawdie. 2011. *Theory and Practice of Triple Helix Model in Developing Countries: Issues and Challenges*. Hoboken: Taylor & Francis.

Vallejo, B., et al. 2019. Open Innovation and Innovation Intermediaries in Sub-Saharan Africa. *Sustainability* 11 (2): 392. https://doi.org/10.3390/su11020392.

Verspagen, B. 2005. Innovation and Economic Growth. In *The Oxford Handbook of Innovation*. https://doi.org/10.1093/oxfordhb/9780199286805.003.001.