Inventing Science and Technology Information (STI) Databases in Africa

Status, Rationale and Emerging Theoretical Support

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INTRODUCTION

In a previous article, we have examined the evolution of science and technology databases and their roles in development and globalisation of national information resources. We also looked at the strategies, which African countries could adopt in instigating the creation of such databases, in addition to the possible roles of various other stakeholders and the factors that are likely to militate against STI databases (Nwagwu, unpublished). In this article, we examine the status of science and technology databases, the rational for STI databases, as well as emerging theoretical understanding that give impetus to national STI databases in Africa.

STATUS OF SCIENCE AND TECHNOLOGY INFORMATION DATABASES IN AFRICA

Whether the consideration is based on biodiversity, mineral resources or precious stones, Africa is a rich continent. In addition, Africa is rich in traditional knowledge, especially knowledge associated with indigenous medicinal plants as well as technology. However, Africa is also a poor continent, inhabited by roughly 13% of the world's population, and enjoying only 1% of the world's wealth (Gaillaird, 2002). What accounts for Africa's impoverished state? The answer may be located in the political, socio-economic and environmental factors such as centuries of colonialism followed by decades of home-grown authoritarian governments; a chronic lack of transparency in economic transactions, often accompanied by corruption; unsustainable use of natural resources; and marginal participation in the global economy. There is another crucial factor that may not be as visible as those mentioned above but which plays a central role in the continent's inability to adequately participate in the global economic level, protect its environment and devise sustainable strategies for economic growth. This factor is Africa's woeful shortcomings in science and technology (S&T) (UNESCO, 2000). An extension is also true; science and technology information in the region is not organized.

At the end of the colonial regimes in the 1960s, the European colonial governments bequeathed modern science and technology to Africa. However, the construction of S&T information databases as a strategy to strengthen decision making for development postdated the colonial regimes. The development of science and technology databases worldwide coincided with the early stages of the new era of 'national science' and technology institutions in Africa. The implication of this observation is that African science and technology did not acquire scientific databases from their colonial governments, and therefore conducted their science within the confines of the scientific and technology space created by the colonial governments. This might partly account for why African scientists have depended upon the databases of the West in order to carry out research. International databases such as *Medline, Thompson's SCI*, even the very recent Latin American *Scielo* appear to be very commonly known among scientists in Africa. The scientists also routinely draw information from such databases to support their research activities. But one could ask, how adequate is the information contained in those databases in solving local problems in Africa? Much of the existing S&T database initiatives in Africa have been largely based on aid, the amounts varying according to the country involved and also diverse forms: fellowships for training, research grants to individuals and teams, institution building, strengthening and twinning, North/South partnership research programmes and so on. How long can African countries depend upon aids in order to conduct science? Will aids-driven databases work optimally in Africa? Perhaps, governments in Africa and their science and technology institutions need to understand the rationale for an STI database to stimulate them to action in this regard.

RATIONALE FOR INVENTING SCIENCE AND TECHNOLOGY DATABASES IN AFRICA

It is generally believed that there is an ongoing information revolution for which reason modern society is now known as knowledge society, knowledge economy, among others. Furthermore, there is an ongoing globalisation of world economies, and information has proved to be the golden currency of this process. This development presents unprecedented challenge to human civilization. For instance, the movement towards globalisation implies that, among others, all human communities are expected to make contributions to the stock of world economy, while the knowledge society calls for a reexamination of our value systems and indices. Specifically, an emerging challenge is how to address the new balance of power that is bound to attend these new developments. For instance, deliberate efforts have to be by African countries to ensure that the inequities that have characterized the agrarian and industrial revolutions do not persist. Ironically, there is an emerging asymmetry in the pattern of global information resource control within the global information infrastructure (GII) in which the South seems to remain at the margin of global information chain. A major challenge is in the application of information and communication technologies – the major engine driving the change – to the identification, organization, and dissemination of science and technology information.

While it is a fact that science is a universal language, it is also true that science is highly dialectical, often clearly reflecting locale-specific problems. Scientists are naturally expected to focus, at least, first, upon problems in their environments whose results might not apply to other communities. Hence, a local focus of S&T databases design can address the true state of development in a community. This fact is supported in Africa by several studies that have shown that the publication pattern of African scientists is intra-African. Making this case, Galliard (1996) showed that over sixty five percent of African research products are published in local journals, which are not listed in the international databases. This point has been demonstrated with evidences from different African countries (Nwagwu, 2005).

Creation of science and technology databases in Africa is justifiable. We need to provide an indigenous basis for assessing and monitoring science in Africa. Africa is blessed with rich indigenous knowledge systems, which, although work, differ in characteristics with modern science, and are therefore often left out of the international reckoning. Zeleza captures this succinctly;

> *The marginality of African knowledge is evident even in the Africanist intellectual system, which is firmly rooted in a western epistemological order and an academic culture driven by a ruthless ethos of publish and perish and consisting of multinational publishing houses, university presses, peer review networks, citation and bibliographical conventions, and has little room to accommodate the alien views, voices and vision of emanating from Africa itself. In this scholarly threadmill Africa appears nothing more than a research object to verify faddish theories that emerge with predictable regularity in the channel surfing intellectualism of Northern academics (Zeleza 1998b, p17).*

More and more, Western science and technology are presently encountering serious challenges, such as the scourge of HIV/AIDS, which are pointing to the need for alternative strategies. Hence, African and other than modern scientific exploits that were not accepted today might be the way out tomorrow. Certain activities of the world bodies presently suggest that indigenous knowledge that works might be the basis for assessing problems solving options and not necessarily knowledge that is scientific or modern. In the absence of scientific databases, such inventions that could not contend favourably with the realities of yesterday based on what was accepted and known might be lost to posterity.

Many African countries have benefited from development assistance from developed countries and their agencies, and a true account of the output of these supports does not seem to exist. Moreover, there is an indication that the huge investments have not translated to improved living standards, improved economic management, among others. Are there deficits in the deployment and management of infrastructure? Are there systemic leakages and weaknesses that could be responsible for the non-effect of investments in science and technology in the region? Much of the studies that address these issues can be considered merely speculative. At most data are sourced from developed countries databases, which contain those research outputs that meet the standards of developed countries.

Africa needs to show evidence of the resources invested in research in different facets of its existence. For several decades, institutions in developed countries and development assistance agencies have supported the evolution of information infrastructures in developing countries. Except probably in South Africa, the idea of database of research outputs is still a very novel one. There does not seem to be any consciousness about the extent to which an index of research activities in research institutions actually contribute to the empowerment of people, the accountability and responsibility of the institutions and scientists. The absence of indigenous initiative to collect, organise and index and link sources of scientific and technical information in the researches, and disseminate same to the various users, show that information is actually accorded limited status in Africa, and suggests further that its potential value is not yet self-evident. There is a need to widen awareness of what information, both published and unpublished, is available in Africa. Ignorance of previous research efforts may result in needless duplication and a wasting of precious scarce resources.

Crucially, science and technology information in Africa is inadequately covered in the databases of the developed countries. This question of adequately representing third world science in international databases was the main issue at a 1985 conference organized at the ISI in Philadelphia. The title of the final conference report, "Strengthening the Coverage of Third World Science," pointed to a glaring gap (Moravcsik, 1985). The conference participants estimated that only about half of the science produced in the third world that meets international standards of excellence is included in the ISI database. Frame (1985) suggested that;

> *If the purpose of the bibliometric indicators is to help in the building of a national scientific inventory, telling us what kind of research is being performed at different institutions, then coverage of local as well as mainstream publications would seem important. On the other hand, if one is primarily interested in investigating Third World contributions to world science, then publication counts taken from a restrictive journal set would seem most appropriate (Frame, 1985).*

As sympathetic as the above reference might seem, it is still biased. For instance, which science is called 'world science'? Is contribution to science considered to have merited the 'world science' baptism only when scientists in the West have read or used it? Would scientific endeavours of the West, which are not read by scientists in the South, be considered not to have made 'world science'? Would it be acceptable if scientists in the South map world science, like Garfield (1983) has done, based on the sources used by the scientists in the South? Scientists in the developing countries develop scientific outputs, which are read and used by their scientists, and which inform decision-making at their various levels. The kind of picture painted by the West about science in the South account for some sloppy conclusions such as;

> *A comparison with the production of scientific institutions in the OECD countries shows that a country such as Egypt produces less than the Harvard University Medical School (Frame 1985).*

This kind of conclusion cannot be true except for the fact that there are no databases for assessing science in Africa. It would rather appear that developed countries invent databases in order to make a caricature of the developing regions. Several studies have suggested a revision of this exaggerated but widely held – ridicule of science production in the periphery (Chattelin et al 1988, Davis 1989). They substantiate the thesis that the bibliometric indicators based on international databases do not accurately assess the scientific output from the periphery, especially from the developing countries. International databases do not provide enough information to measure accurately the science produced in Africa. Databases at the local level would not only serve to better measure scientific output in Africa, but would also, in time enhance South-South and North-South documentation exchange, as well as enhance the visibility and accessibility of developing countries' scientific output.

The assessment of the development efforts in social, economic and political circles have relied mainly upon evidences of improved GDP of nations, improved living conditions, development of physical infrastructure facilities, among others. We need supplementary evidences from the primary scientific outputs of scientists and other stakeholders to gauge information with regards to who, what, where and when- about scientific activities. But there is no systematic and empirical evidence as to the characteristics-content, sources, of the primary research basis for policy and development plans and programmes in most African countries. The challenge is therefore to identify meaningful parameters of indicators, qualitative or quantitative - local realities of science, and local quality criteria by which the overall research in the region can be assessed.

In the era of information technology, getting publications indexed in databases increases the demand for the information, since database searching is one of the primary methods by which references are located. Stimulating greater demand for African research through the Internet is perhaps the single most important strategy for raising the profile of science in Africa, and increasing her competitiveness and flow of information both from and into the continent. With greater awareness about science in Africa can even come opportunities for increased funding for the scientific enterprise.

Elsewhere, this author has shown that the poor standing of African countries in international scientific ranking hinges partly on lack of local sources for evaluating African science (Nwagwu, 2005). Local sources will sympathise with local realities whereas international sources will be constrained by economy, language, political and cultural realities. Scientific information may be considered to be a national resource, as useful in its own right as any other national resource, material or intellectual, provided it is wisely exploited and planned. Once this concept is accepted, it follows that the development of this national resource is a national responsibility, although not necessarily the exclusive responsibility of the central government. At any rate, the government should be the prime mover in any efforts to creating databases for STI. The strategy of government intervention in STI in Africa can be supported by the structure of scientific community that emerged in Africa during the 1970s which postulated that science is a public good; the main fund provider is the state; the researchers (and their scientific communities) have a nationalist ethos; research scientists are employed as civil servants; besides the peer community, the end-users consist principally of public authorities. In the recent years, the science base of many African countries have been weakened by the intrusion of then government into university administration, increasingly low educational budgets, flight of intellectuals from Africa, among others. These circumstances seem to reinforce existing perspectives as well as emerging ones that other than government roles in direct initiation of scientific information databases may not be very fruitful. These perspectives include the (i) market failure theory (ii) the question of state security and economy which have been discussed extensively by Gathegi (1993). We also discuss (iii) the holy trinity, and (iv) the triple helix which did not primarily focus on science and technology databases, but provide some impetus for suggesting that STI should have be focus.

SOME EMERGING THEORETICAL FACTS

We can identify two categories of theoretical facts supporting national science and technology databases. The first relates to the fact that science and technology information fits government intervention while the second relates to the fact that national science and technology databases represents critical natural resources for national development that should be 'controlled' by the national government. We now examine these two categories of perspectives.

The market failure theory

Left to the market forces alone, organizations might not be willing to invest in scientific databases because research is always a long-term investment with unpredictable returns. Furthermore, the fact of the 'free rider' and 'public good' status of information quantifies it in terms of publications, and this seems to make information a superficial good (Brausntein, 1981; Forster, 1988; Smith, 1981). The Market Failure Intervention Theory itself was propounded by Nelson (1959) and Arrow (1962) in different studies, in which they argued that information is inappropriable, uncertain and indivisible. In this view, information is viewed to assume value with difficulty. Gathegi (1992) has shown that the problems of market failure will be most real in developing countries, which have largely imperfect markets. The market failure perspective relates to another question namely that of political agenda of government for state security and national autonomy, which benefits from science and technology databases.

The question of state security and national autonomy

When information is organized in a databases, a crucial attribute of information namely its ability to destroy or build, becomes boosted. Even without the database, most governments are concerned about who should do research, what kinds of research should be done and where the research should be carried out, among others. This is why ethical clearance is very crucial in research endeavours, and most countries enforce its observance. The question of security is also highlighted by the fact that lack of critical information could make a country very vulnerable to social, economic and political malaise. On the basis of these two theoretical perspectives, the government has a critical role in facilitating the creation of S&T databases. However, in a democracy while government intervention is recognized, the creating of a STI database will devolve on many individuals and bodies; the scientists themselves, government departments, universities, research organisations and professional societies, all should play their parts in coordinating existing information and initiating any new services.

The Theses of the "Holy Trinity"

In his book in 1997 entitled The Regional World, Michael Storper argued that technology, organization, and territory could be considered as a 'holy trinity' for regional development (Storper, 1997). According to Storper, this trinity should not be studied as an aggregate of the composing elements, but in terms of the relations between and among these elements. Storper formulated as follows:

> Technology involves not just the tension between scale and variety, but that between the codifiability or non-codifiability of knowledge; its substantive domain is learning and becoming, not just diffusion and deployment. Organizations are knit together, their boundaries defined and changed, and their relations to each other accomplished not simply as input-output relations or linkages, but as untraded interdependencies subject to a high degree of reflexivity. Territorial economies are not only created, in a

> globalizing world economy, by proximity in input-output relations, but more so by proximity in the untraded or relational dimensions of organizations and technologies. Their principal assets—because scarce and slow to create and imitate—are no longer material, but relational (Storper, 1997, p28).

The 'holy trinity' is to be understood not only as elements in a network, but also as the result of the dynamics of these networks shaping new regions. These regions emerge as densities of relations that can be developed into a competitive advantage, when and where they materialize by being coupled to the ground in regions.

Although Storper's thesis was not focused on S&T databases, the thesis conforms to the observed structure of national database and literature control activities in the world today. It appears that the pattern of scientific indexing follows the path of "holy trinity" in which a region or country gives priority to the outputs of its scientists based on technology, organization, and territory consciousness (Nwagwu, 2005). That is, a country or region recognizes that its technology or its level of technology diffusion; its organizations and its territorial identity are intertwined. Hence, the scientific output of a country or region, irrespective of its quality and standards, are considered and accepted by scientists in that country as indicators of the level of development of researchers, research and science in the research institutions, and by implications, 'qualifies' the scientific and technological capacity of that 'territory'. Countries that would want to posture their local research activities appropriately therefore develop their own databases and also develop own criteria to select articles that should be indexed in those databases.

The "Triple Helix" Theory

On their own part, Etzkowitz and Leydesdorff (1997) have, in their Triple Helix theory, shown that the structure of the knowledge-based society can be visualized from the perspective of university, industry and government configuration. The university represents the scientific discoveries and all research activities that are expected to emanate from the academe. These discoveries are applied and developed independently by the industry under the control of the government. Today we find the roles of the university, industry and government intertwined in an inseparable manner, and these are expected to foster innovation, production and creation of wealth. The evolutionary interpretation of the Triple Helix model assumes that within specific local contexts, the university, government and industry are learning to encourage economic growth through the development of generative relationships, "… a loosely coupled reciprocal relations and joint undertakings that persist over time and induce changes in the way agents come to conceive their environment and how to act in it" (Etzkowitz and Leydesdorff, 1997, p45).

What is the implication of these theories for S&T databases? Scientific literature represents a definitive evidence of what the university as an archetype of research and innovation institutions, is doing with the financial and other investments of both government and non-government agencies. In a sense, and with respect to the subject under discussion, both the 'Triple Helix' and the 'Holy Trinity' theses teach one lesson, namely a reliable understanding of the research activities that go on in any community can only be rationally based on the literature control services in that community. It is only in this way that the relationship among technology, territory and organization can be understood. It is only in this way that appropriate interrelationship among university; industry and government can be described. Any cross-country evaluation should be defined on the ground that we want to know how a certain community stands in relation to others.

The pattern of literature control globally seems to follow the observation that national databases focus on their local sources, and then apply some criteria to sieve out materials from other communities. This pattern supports the expectation that countries that have national databases will then probably rate higher in international reckoning. The corollary is also true. Those countries that do not have national databases will suffer the subjection of their national sources to quality and other standards criteria set by host countries of international databases. We posit that whatever are the conditions of science in any country; it is sufficient to consider the scientific outputs emanating from that country as an evidence of the country's science. Even when the question of quality is considered, whatever factors constitute shortcomings of publications from developing countries can become indices for monitoring the development of science. For instance, if journals are considered irregular, as it actually is in many developing countries, a crucial question that could guide action in improving science could be 'how irregular are the publications'? This strategy will help Africa monitor its science development.

The point being made here is beginning to manifest in global ranking of scientific output. In the recent years, a cursory observation is that countries, which have national databases, always base the assessment of their resources on the content of their databases, and this has tended to shift the visibility of scientists in different countries. For example, based on local indexes, Holmgren et al. (2004) have shown that Latin America and China, although representing, respectively, only 1.8 percent and 2 percent of scientific publications worldwide, have increased the number of their publications between 1990 and 1997 by 36 percent and 70 percent, respectively, which is a much higher percentage than the increments reached by Europe (10 percent) and industrial Asia (26 percent). The percentage of global scientific publications from North America actually decreased by 8 percent over the same period. This and many other studies that were based on national/regional databases show that the statistics of publications of developing countries as often contained in the popular databases are actually misleading. It will be unacceptable today to read evaluations of China's, India's or South Africa's science based on a database that is located elsewhere, because these countries have successfully organized their data resources.

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CONCLUDING REMARKS

In this article, we have examined the status of science and technology databases in Africa in addition to the rationale for proposing that African countries should develop local databases of their science. We have suggested that information should be considered a central natural resource, which plays an intermediary role in every national development activity; its organization should therefore be accorded appropriate national attention. This suggestion coincides with some recent perspectives about the holy trinity of technology, organization, and territory and the triple helix, which reinforce the fact that countries deliberately identify and control the resources within their national boundaries for the purpose development programmes. Both at national and regional levels, Africa will need to address some specific issues if the objective of developing a virile dataset system would be realized. We itemize here some of the issues that deserve serious attention.

Funding

Where will the fund for the development of the databases come from? Funds for a one-time investment may not be problematic and may even come from funding agencies. A more crucial consideration should be given to how to sustain funding until the database projects would be self-financing. Although the primary purpose of databases is not for profit-making, databases yield often financial benefits after a relatively long period of time. Funds for the development of the databases should come from the national purse, through the Ministry or Department which supervises the databases. International funding agencies should also be depended upon to support pockets of activities required in managing the databases.

Infrastructure

Heeks (2002) has pointed out lack of technological infrastructure is one factor that contributes to the unsustainability of projects in developing countries. Infrastructure should be viewed from the perspective of a heterogeneous collection of different technologies, components, protocols and applications to support different and varying application areas and use over time across large geographical distances (Rolland, 2002). Technology infrastructure refers to of computers and communication devices; and digital infrastructure are the content available from digital sources; human resources are skills needed to be able to use computers and digital technologies; and finally, social resources refer to the support structures in the community. Westtrup et al (2005) have also discussed the need for legal infrastructure. Each of these resources ought to be carefully planned. Infrastructures should be extended beyond technologies to embrace examining social structures, social problems, social organisation and social relations. Hanseth and Monteiro (2004) describe IIs to be characterized by three features. First the infrastructure is shared by a larger community of users and cannot be reduced and used independently without calling into play the other interconnected parts. Infrastructure should also be open in the sense that there are no pre-defined limits to the number of users and stakeholders. Finally, the technology infrastructure should be enabling rather than being designed for particular singular purposes, playing a supporting or enabling function for a variety of different application domains. Attention should be paid to other environmental requirements such as electricity and telecommunication infrastructure; vehicles, among others.

Human Resources

A major setback in information systems and databases development and management in Africa is lack of adequately trained manpower (Heeks 2002). The problem of weak human resource capacity in LICs is reported in a number of publications (see, Walsham et al. 1988; Bhatnagar, 1992; Waema, 2002; Sahay, 2001; Sahay and Avgerou, 2002). It is not uncommon to find a health manager with limited computer skills (Waema, 2002) and a lack of time and motivation to learn. This could be a result of unconducive environments and lack of training resources (World Bank, 1999a; Paul, 1995). Ideally, capacity building is not limited to basic skills only but also to technical, planning, policy analysis and formulation, and management of ICTs. It involves activities related to the development of human resources through training, education and promotion (Targowski and Deshpande, 2001, Ball, 2001). It is also a continuous process whereby people and organizations develop their abilities individually and collectively with aim to perform activities, deal with problems and formulate and achieve objectives (UNDP, 1994; Paul, 1995). Human capacity building depends on the institutional capacity to provide a conducive environment for learning. Institutions with unclear objectives, inadequate structures and resources, lack of incentives or weak practices are unlikely to achieve productive and motivated human resources (Paul, 1995) because these factors do not lead to a conducive environment. Thus, local governments and donors need to create an enabling environment, supportive of capacity building to ensure the development of sustainable ICTs.

Sustainability

Sustainability of ICT projects such as databases implies the ability to identify impacts and manage risks threatening the long-term viability of the system (Reynolds and Stinson 1993; Korpela et al. 1998). The failure rate of ICT projects in least industrialized countries is 75 per cent higher than in developed countries (Heeks, 2002) mainly due to the lack of appropriate skills and knowledge to identify and deal with the risks associated with ICTs on a long-term basis (Odedra-Straub, 1990; Heeks 2002, Mursu et al. 1999, Korpela et al. 2000). The development of knowledge and skills requires learning and training to use and support ICTs which is critical for the sustainability of ICTs (World Bank, 1997; Braa et al. 1995; World Bank, 1999a). Databases can have an impact on organizational work practices when the people have the necessary capacity to use, maintain, develop and sustain it (Braa et al., 1995; Walsham, 2000). Traditionally, donors have used foreign experts to fill in professional gaps and transfer skills to LICs (Kimaro and Nhampossa, 2004; Korpela et al. 2000). The process of transferring skills often is not possible due to the nature of the projects, which place little emphasis on learning. Donor projects are typically used to mobilize resources (e.g. vehicles, computers), and not developing human resources capacity (Wood-Harper and Bell, 1990; Sahay and Avgerou, 2002; Paul, 1995). Donor projects generally include poorly designed and short term training programmes (Wangwe and Rweyemamu, 2001), which are not culturally compatible with the local situation. The availability of ICTs needs to be complimented by the availability of well designed training and practices to develop human capacity with appropriate skills and knowledge to sustain ICTs over time. The databases are a combination of people, tools (e.g. ICTs) and routine procedures to provide and use information (Boerma, 1991). A sustainable STI database system can be simply defined as the one that meets the information scientific and technological information needs of the country over time. However, sustainability of the database is a complex process as it involves the capability (skills and knowledge) of humans to collect, analyze, use and disseminate information as well as to deal with risks threatening the database project.

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