Harnessing knowledge to achieve

the Millennium Development Goals in Africa

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Abbreviations

AfDB	African Development Bank
AIDS	Acquired Immunodeficiency Syndrome
AU	African Union
AUC	African Union Commission
APRM	African Peer Review Mechanism
CEF	Commonwealth Education Fund
CRRVA	Regional Committees for Agricultural Research and Extension
CT	Convergence Technology
ECCE	Early Childcare and Education
EDND	Economic Development and NEPAD Division
EGM	Expert Group Meeting
GDP	Gross Domestic Product
HIV	Human Immunodeficiency Virus
ICT	Information and Communications Technology
IFAD	International Fund for Agricultural Development
LADEP	Lowlands Agricultural Development Programme
LDCS	Least Developed Countries
OECD	Organization of Economic Cooperation and Development
MDGs	Millennium Development Goals
MENA	Middle East and North Africa
NEPAD	The New Partnership for Africa's Development
NERICA	New Rice for Africa
NSF	National Science Foundation
PPP	Purchasing Power Parity
PRSPs	Poverty Reduction Strategy Papers
PTAs	Parent-Teacher Associations
REC	Regional Economic Commission
RELC	Research-Extension Liaison Committee
R&D	Research and Development

R4D	Research for development
SSA	Sub-Saharan African Countries
STI	Science, Technology and Innovation
SWAC	Sahel and West Africa Club
WARDA	West African Rice Development Association
WUAs	Water User Associations
UNCTAD	United Nations Conference on Trade and Development
UNECA	United Nations Economic Commission for Africa
UNIDO	United Nations Industrial Development Organization

Introduction

Africa's average economic growth has been positive and relatively high in the first decade of the third millennium. This economic expansion should have enhanced the ability of governments to improve the welfare of their people, including reducing poverty and improving health. However, according to all recent assessments, the continent is unlikely to meet the targets of the MDGs by 2015.

One of the key missing variables in Africa's growth and development is the coherent, organized application of knowledge. According to endogenous growth models, the principal force driving long-run economic growth is technology in a broad sense. One of the major ways in which less developed countries differ from the industrialized and newly industrializing countries is in their level of knowledge. Successful development entails not only closing the gap in physical or even human capital, but also in closing the knowledge gap. This was the point of departure for having a meeting with experts providing valuable deliberations on the topic.

This document seeks to provide answers to the following five concrete questions:

1. What is knowledge and how is it important for development?
2. Why is knowledge not contributing enough to development in Africa?
3. Who are the relevant stakeholders, and what are their roles?
4. How can knowledge be made to contribute to the development of Africa?
5. What are the steps, prerequisites and requirements necessary for this to happen?

The report is organized along the points that follow. Following the introduction, Section 1 deals with the first question above by introducing the various approaches to knowledge together with its transmission into development. The section also presents comparative indicators of regional research spending and patents. Section 2 deals with the second question above and presents available analysis and indicators for the reasons why knowledge is not fully utilized in the African development context. Section 3 provides a presentation of relevant stakeholders and their roles in terms of producing and transforming knowledge into development outcomes. Section 4 provides the understanding in harnessing knowledge, especially innovations in terms of development needs. Section 5 utilizes the information in the previous sections and points out the necessary steps to transform knowledge, especially innovations into development outcomes. Section 6 provides numerous concrete case examples, from several countries in innovations that have been successful in meeting development agenda, especially in terms of MDGs. Section 7 is the last section and concludes and provides short and concise recommendations on the issue of harnessing knowledge to achieve the Millennium Development Goals in Africa.

1

Knowledge for development

While there is currently no universally accepted definition of knowledge, a few definitions stand out in literature. Notable among the myriad of definitions is one by North (2005) who defines knowledge as "the accumulation of regularities and patterns in the physical and human environment that result in organized explanation of aspects of those environments". This is a somewhat dynamic definition, contrasting the traditional static definitions that perceive knowledge as being acquired in an instant. This definition situates knowledge in a particular context, gives primacy to change and time as well as the possibility that knowledge is a not a universal commodity that could be simply acquired. It is also broad enough to accommodate a wide variety of activities. However, this paper is concerned specifically with scientific and technological knowledge, the dynamics of accumulating it and how it relates to the economic development process.

Knowledge creation and dissemination are very closely related to the growing role and speed of innovation in all sectors and across all societies, with both low and high

incomes. Innovation is the ability to exploit systematically the effects produced by new combinations and use of pieces in the existing stock of knowledge (David and Foray, 2002). This triangular relationship between innovation, knowledge and development extends to all sectors in a knowledge-based economy, although science and technology are at the heart of the rising new sectors (David and Foray, 2002). Sectors from pharmaceuticals to aquaculture have all been profoundly transformed by the changing nature of science and technology. Continuous innovation that forms the basis of technology-led development feeds on persistent knowledge generation, whereas new knowledge builds on previously accumulated knowledge. The knowledge underlying technological change leads to a rise in the rate of return on investment while continuous innovation promotes sustained economic growth. Underdevelopment is therefore in part rooted in low rates of innovative activities that characterize very late development even in the presence of seemingly limitless labour and capital

Innovation has been defined in several ways. It is generally defined as a change in the process of doing something better or the useful application of new or old ideas, inventions or discoveries. This could refer to incremental or radical and revolutionary changes in thinking, products, processes, or organizations that lead to improvement in doing things or better results. Schumpeter (1943) defines innovation as something that brings about a change in a way that is substantially different from the original situation. Such a change, in the realm of economics, must increase value to both customers and/or producers. In the Schumpeterian sense, innovation leading to increased productivity is the fundamental source of increasing wealth in an economy. Therefore any factors driving such innovations are of critical value to policymakers. This is why proponents of innovation economics stress using public policy to spur people on to innovation to drive growth and development. Johnson, et al (2003) define innovation as a continuous cumulative process involving not only radical and incremental innovation but also the diffusion, absorption and use of innovation, which includes interactive learning taking place in connection with ongoing activities such as the MDGs.

The key question is how knowledge is reproduced in the context of late development, and the varieties of knowledge as well as the nature and institutions that support knowledge production. There is a distinction between information and knowledge and the different modes by which they evolve. As Foray (2004) points out, the vehicles for reproduction and transmission of the two are quite different. First, the growth of knowledge takes place through the heuristic process of learning

while information reproduction is carried out by duplication. Second, knowledge is costly because learning is a complex process that could be formal or non-formal, tacit or difficult to replicate and process. On the other hand, information which takes the "shape of structured and formatted data" (Foray 2004) is easily replicated through copying. Table 1 presents a simple summary of the contrasting conceptions of the complex notion of knowledge.

Table 1: Conventional and Evolutionary Conception of Knowledge

Conventional Theory	Evolutionary Theory
1. Knowledge is a stock subject to a linear process of information processing.	1. Knowledge formation is a heuristic process that is different from information.
2. Knowledge is easily transferable in a codified form.	2. Knowledge has both codified and tacit nature.
3. Knowledge is universally available and freely accessible information to all as public good.	3. Knowledge is embedded in historical, economic and cultural contexts and for this reason, local

There are four broad functional economic categories of knowledge. The first three are linked to the highly formalized and often investment-intensive form of knowledge, i.e. research and development (R&D). R&D is routinely classified into basic, applied and experimental research and this is commonly regarded as the totality of knowledge when formal measurements are used.

Basic research is undertaken to gain insight into the nature of a subject without a specific application in mind. It advances scientific knowledge but it does not aim at an immediate commercial application. **Applied research** has an objective of meeting an immediate commercial objective of a recognized need. **Industrial research** makes use of new scientific knowledge to develop new products, processes and services. The next component is the **systematic usage** for products (new or improved) like devices, services, systems, as well as the design of prototypes and processes.

Fig. 1 Knowledge Cycle

Source: - Adapted from Huysman, 2003

Although it is difficult to draw the lines conclusively, basic research tends to be the domain of universities and highly advanced public organizations while firms tend to focus more on applied and developmental research. Private firms tend to have little incentive to engage in socially relevant basic research due to problems of appropriation of the benefits of their investment and uncertainty about the regulatory environment governing such activities. In recent times, trends that promote the commercialization of university and public sector research have blurred the boundaries between basic and applied research, as well as tended to promote the privatization of some basic research.

The specialization of actors as well as complementarities involved is further demonstrated through some examples. The United States spent an estimated US$54 billion on basic research, $66.4 billion on applied research and $187.3 billion on development. In proportional terms, these are 18.7 per cent, 21.3 per cent and 60.0 per cent, respectively, of total R&D spending. Out of these, private firms in the US spend three times more on applied than on basic research. Industrial research is in fact dominated by developmental research which accounts for 90.2 per cent of development work carried out in the country in 2004, while universities and related actors spend less than two percent on development research (National Science Foundation, 2006).

Table 2: R&D expenditure and share of world total by region: 2007

Region	R&D Expenditure (US$ Billion)	Share of World Total (%)
Asia (East, South & West)	343	31.0
Pacific	18	1.6
North America	393	35.5
Latin America/Caribbean	26	2.4
Europe (Western, Central, Eastern)	313	28.2
Africa & Middle East	15	1.5

Source: National Science Foundation, NSF (2010), Science and Engineering Indicators

The dynamics of R&D

Regional and cross-country comparisons reveal basic divisions in production and growth of knowledge. Table 2 presents a picture using global R&D expenditure as a proxy for knowledge.
There are six broad patterns that can be gleaned from the R&D expenditures provided in the table.

The first pattern points to the fact that R&D spending is highly correlated with the wealth of nations; the highest spending is found within the OECD countries although a number of Asian countries are beginning to spend substantial amounts on R&D. For instance, countries in Southern and Eastern Europe in general have R&D/GDP ratios equal to or less than 1.5 per cent, while the wealthier Nordic countries and Western European countries have ratios equal to or greater than 1.5 per cent. R&D spending pattern points to the distribution of innovative/inventive activities which has been concentrated in a small group of high income countries. Of course, as will be pointed out later, R&D does not represent the totality of innovative activities; equally more important are reverse non-formal inventive activities such as learning-by-doing, reverse engineering and engineering design that advance the complex routines of firms in the direction of increasing productivity growth (Kim, 1997; Kline and Rosenberg, 1986). In recent times, the rate of growth of GDP has been more closely correlated with national level innovative activities, the rate of growth of investment capital equipment and more increasingly with knowledge.

With the second pattern, there is the issue of **patterns of sectoral specialization.** Countries specializing in so called high-tech goods and services tend to invest proportionally heavily in R&D activities.

Table 3: Regional Science and Technology Indicators

Regions/Countries	GERD as % World GERD*	GERD as % of GDP	GERD per Inhabitant (PPP $)	Researchers as a % of World Total	Researchers Per Million Inhabitants	GERD Per Researcher (thousands of PPP$)
Developing countries	15.6	0.6	20	28.4	347	57.9
Developed countries	84.4	2.2	377	71.6	3,033	124.2
Asia	27.9	1.3	46	34.5	537	85.1
Latin America & the Caribbean	3.1	0.5	34	6.7	715	48.2
SSA	0.5	0.3	6	1.0	113	49.1
North Africa	0.2	0.2	7	1.5	489	14.9
Arab States (in Asia)	0.1	0.2	11	0.1	52	211.4
Arab States (All)	0.4	0.2	8	1.6	356	23.6
China	3.9	0.6	17	10.6	454	38.3
India	2.0	0.7	11	2.8	151	75.8

GERD stands for Gross Domestic Expenditure on Research & Development
Source: Computed from UNESCO statistics published in The State of Science and Technology in the World, Paris, UNESCO Institute of Statistics, 2001, p. 7

The third pattern involves public-private R&D spending. Private firms in high income countries are the dominant R&D players, and the industrial firms are the locus of innovation activities. In lower income countries with low concentration of high-technology industries, private spending and for that matter overall R&D intensity tends to be low. What sets firms apart even within the same countries and industries is the technology they employ. Persistent differences across sectors and across countries have become the norm that show up in differences in innovation capacities of countries at different levels of economic development. Private R&D spending has been rising in latecomer countries, but public spending was the dominant instrument in early industrialization and remains so even now.

In the fourth, there is the pattern of basic research investment. Spending on basic research is also concentrated in high income countries and is underpinned by incentive structures and institutions that promote

advanced scientific knowledge. This in turn, partly explains the leadership of high-income countries in new technologies such as biotechnology, chemicals, pharmaceuticals and ICTs. The high ratios of basic research/GDP are also indicative of the structure of knowledge infrastructure such as world-class university research and private laboratories. For instance, while Switzerland has basic research/GDP ratio of 0.7 per cent, China, in spite of its impressive increase in R&D spending, has only 0.07 per cent in basic research/GDP ratio. China spends roughly the same amount as Germany on R&D but much of the spending, following the earlier pattern of Japan, South Korea and Taiwan is devoted to development and applied research with a focus on short-term commercial goals.

Table 4: Regional Distribution of Number of Scientific and Technical Publications, 2000-2005

Region	2000	2001	2002	2003	2004	2005	Average 2000-2005	Growth Rate, 2000-2005
East Asia & Pacific	20,116	22,818	25,101	30,812	37,075	44,064	29,998	119
LAC	14,786	15,776	17,126	17,889	19,361	20,045	17,497	36
MENA	3,689	4,017	4,379	5,154	5,551	6,243	4839	69
South Asia	10,796	11,334	12,262	13,162	14,086	15,429	12,845	42
SSA	3,355	3,279	3,438	3,331	3,517	3,563	3,413	6
World	629,230	628,047	637,041	660,304	687,174	708,086	658,314	13

Source: World Development Indicators Database

The fifth pattern concerns the **differential investment in skills acquisition**. There is a significant difference in the quality of skills and knowledge of scientists between developing and developed countries. The notion of the "star" scientist has entered into the lexicon of innovation literature (Olivier, 2004) and they are found exclusively in high income country environments even when they are foreign nationals. This is part of the **"brain drain"** mechanisms taking place.

Finally, there are the **drivers of innovation success.** Innovation capacity-building effort in latecomer countries has concentrated on three key components which are: (1) R&D inputs including

development of scientists and engineers; (2) cluster-specific innovation environment, by which is meant highly specialized focus on key sectoral activities often geographically localized; (3) drawing from accumulated knowledge capacity. This is a global pool of knowledge that latecomer countries have successfully exploited through learning and technological capability-building in local firms and public organizations. This is in contrast to the experience of the OECD countries which build innovation capacity on a wider range of sources. For instance, patents as a means of building the knowledge stock has only gained importance in East Asia since the mid-1980s.

These six stylized realities, coupled with the knowledge typologies discussed in the previous section, have three major implications for development. First, there are apparent risks in comparing countries at different levels of industrial maturation and equally different industrial structures. Advanced latecomer countries such as Taiwan, China and Malaysia that have built strong export sectors in electronics and telecommunications have raised their levels of GDP/capita considerably. This high level of specialization by a small number of East Asian countries in electronics, semiconductors, and IT, highlights the need to focus on meso and micro level variables in comparing countries at different levels of industrial maturation. In early stages, these catch-up countries have succeeded not in R&D as a driver of growth but rather on imitation and incremental innovation (Amsden, 1989). For instance, the focus on R&D to raise national knowledge stock is a relatively recent phenomenon dating from the 1990s that follows from intense period of learning. This is also evident in the rising level of patent stock in these countries. Patenting and public R&D funding have been the key instruments for fostering specialization.

2

Barriers to knowledge for development

The MDGs and knowledge formation are connected in very profound ways. As is well known, low levels of human capital tend to slow down the rate of income growth. This is because in addition to contributing directly to skills formation, high literacy rates tend to influence positively all sectors of the economy, including the growth of financial services, industry and formal banking systems, all of which have important implications for industrialization.

There are therefore several dimensions to the nexus between the MDGs and knowledge. The first is that knowledge is closely linked to both formal and informal education, and in some respects, education is sometimes used as a proxy for knowledge, as noted in the previous section. Clearly, there is a strong correlation between basic education, economic growth, and industrialization as well as innovation capacity. Therefore, the first reason why there has been such a weak link between knowledge and MDGs is because while African countries have made progress in primary schooling they

have not done nearly enough to fully realize the educational goals of the MDGs. In other words, although education has received relatively more attention and has recorded more progress than other MDGs, the educational quality and scope (i.e., emphasis on primary schooling) do not constitute an adequate basis for a knowledge-driven economy.

Secondly, most African leaders tend to rely too much on donor funding in order to finance schooling. However, schooling, according to human capital theory, is an investment that directly enhances the productivity of workers (Wolff, 2001; Oyelaran-Oyeyinka and Gehl Sampath, 2010). Education should therefore be regarded as a public investment that enhances the welfare of the country and the strength of the economy.

Thirdly, many of the institutions needed to promote knowledge growth, draw directly on strong educational bases which are poorly developed or absent in Africa. For instance, an educated workforce without the necessary prerequisites of investment, training, research and development (R&D) located within a dysfunctional political structure, and situated within an unmanageable and chaotic urban sprawl may retard rather than foster economic growth and development. In this respect, the relatively weak performance of the less developed countries in Africa may well be ascribed to the lack of institutions to absorb and utilize new technological and product information. In other words, technological change drives the demand for more knowledge intensive and skilled labour, the absence of which will erode a country's capacity to capitalize on technological advances. Underdeveloped economies perform poorly as a result of underdeveloped institutional frameworks for innovation, which fail to absorb, diffuse and adapt knowledge through imitation, or other modes of process and product innovation.

Fourthly, the low impact of knowledge on education and vice versa, and the lack of visible gains in technological change within the various African national systems, will have long-term structural constraints on economic progress. There is a direct correlation between schooling in the appropriate form and content and a country's ability to master new technologies. Empirical justification for this assertion, albeit inconclusive, is evidenced by the high literacy rates in Western Europe and North America from the 1850s.

Evidently the combination of neglect dating back to colonial times and the lack of significant African involvement in education policy formulation earlier on resulted in an education system that still remains elitist in ethos and does not cater to the employment and skills needs of the continent. The education system, specifically at the tertiary level,

produces an inappropriate mix of skills. African institutions of higher education enrol 60 per cent of students in the arts and humanities and 40 per cent in science and engineering. Enrolment in technical subjects presently lags behind that of other regions. In 1995, only 0.04 per cent of the population were enrolled in technical subjects such as engineering and mathematics; the figure for the four Asian Tigers was 1.34 per cent. In a technical enrolment index constructed by Harbison-Myers, Norway ranked first with 73.52 per cent, whereas South Africa, the most industrialized country in SSA, had a total of 23.61 per cent, Nigeria, 5.85 per cent, and most of SSA ranged from 1 to 5 per cent.

Policies of the past that limited emphasis on technical enrolment may have been appropriate in the early independence period when most African countries were faced with a paucity of administrative staff. However, this skills mix has remained unchanged for the past four decades despite the declining labour market demand for arts and humanities graduates and the rising and unfulfilled demand for science and engineering graduates.

Finally, scientific disciplines have not focused enough on Africa. For instance, while diseases such as malaria and tuberculosis affect large swathes of the African populations, considerably lower levels of health spending globally has been devoted to scientific and policy studies of these killer diseases. While the Gene Revolution in Asia has helped to eradicate famine and mass death from hunger, African staple crops are probably the least studied in terms of scientific understanding of their genes as well as the policy implications of their uses in development. In other words, knowledge for African development does not occupy centre stage in scientific fields, a situation that needs to be urgently addressed.

Moreover, African countries themselves have not paid enough attention to the study of knowledge and they have not allocated enough resources to the development, accumulation and dissemination of knowledge.

In addition, African leaders do not seem to recognize the central role that knowledge plays in the development process, hence, they have neither closed the knowledge gap nor built knowledge economies— that is, economies in which knowledge creation, use, adoption and flow leads to economic development.

Table 5: Quality of African Universities[1]

African Ranking	University	Country	World Ranking
1	University of Cape Town	South Africa	340
2	Stellenbosch University	South Africa	538
3	University of Pretoria	South Africa	539
4	University of The Witwatersrand	South Africa	808
5	University of Kwazulu Natal	South Africa	904
6	Rhodes University	South Africa	1 024
7	University of The Western Cape	South Africa	1 124
8	University of South Africa	South Africa	1 219
9	University of Johannesburg	South Africa	1 422
10	University of Cape Town	South Africa	340
61	Obafemi Awolowo University	Nigeria	5 756
66	University of Jos	Nigeria	5 882
68	University of Lagos	Nigeria	5 936
77	University of Benin	Nigeria	6 324
79	University of Ibadan	Nigeria	6 425
99	University of Nigeria	Nigeria	7 170

Source: http://www.webometrics.info/top100_continent.asp?cont=africa (2010)

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1   *This measurement simply captures the presence of academic outputs at the university's webpage.*

Table 6: Patent Filing by Region

Regions	Number of registered patents
Europe	57 435
North America	54 570
Asia	44 747
Oceania	2 307
Middle East	2 010
South America	832
Africa	511
Caribbean	287

Source: OECD (2008)

The limitations of African knowledge systems are visible through the two examples given above, in terms of university quality and the number of patents registered.

3

Stakeholders of knowledge for development

It is important to identify the key actors involved in knowledge creation, validation and dissemination and their various roles in the national knowledge systems. This is because the nature and extent of knowledge are intricately linked to actors (stakeholders) and institutional arrangements. In this regard, we conceive knowledge creation, validation, and dissemination as a social process where groups of scientists and engineers could be seen as a community. From the classification of functional knowledge provided in the background paper, we provide examples of potential stakeholder actors, networks or communities within the Science, Technology and Innovation (STI) community.

The role of the state and policy for harnessing knowledge

The markets have generally failed to provide knowledge inputs such as extension services for standards setting, testing, metrology, quality and information, intellectual property, vocational, technical and skills training, and scientific and technological laboratories institutional mechanisms to bridge the knowledge gaps. The work of Greenwald and Stiglitz (1986) demonstrates that whenever markets are incomplete and/or whenever information is imperfect (which is literally the case in almost all latecomer economies), governments are required to intervene to enhance the efficiency of markets through various institutional interventions.

The literature on development tells us that market imperfections are pervasive and widespread particularly in developing environments (Rodrik, 2007). Rodrik, actually, goes as far as to declare that development economics is constructed around resolving the problems of market imperfection. To address market imperfections, states in East Asia and Latin America employed industrial policies extensively in the catching-up processes as a means to remove obstacles to structural transformation. In general, low levels of development have been associated with a need for greater state action and policy competence.

Low levels of development are manifested in a number of ways: the absence of strong and competent state institutions, weak entrepreneurial business firms, relatively low level of skilled engineers and technical personnel and a lack of well-educated and abundant low-cost managers (Amsden, 1989; Amsden and Chu, 2003). Although Gerschenkron (1962) observes that in catching up, latecomers would potentially have access to a basket of proven technologies, much of what development requires is embedded in the realm of tacit knowledge with significant preconditions for interpersonal learning. In other words, access to such knowledge sources is not automatic and even if it were so, the institutions that mediate knowledge acquisition (whether markets or networks) are to a large extent absent in developing countries. Lastly as Amsden and Chu (2003, p. 13) observe, market forces are unkind to the weakly organized economies ("the more backward the country, the harsher the justice meted out by market forces") with its inherent and often contradictory requirements.

The role of governments is therefore critical not only in developing policies and institutions, but also in ensuring their effective functioning. State action manifests in the capability to identify market failures and

opportunities, strategic choices that are made in the form of policies and the apparatus put in place to implement such policies. The application of the state-led development discourse and lessons learnt from East Asian successes need to be broadened to include factors specific to latecomer contexts, in order to understand how states can, in latecomer contexts, develop the capacity to promote stronger domestic economic integration. The capacity for policy design and institutional enforcement constitutes a key challenge for latecomers.

Innovation policy is purposive and strategic actions have to be taken by governments and their agents to foster industrial structural transformation by creating new processes, new products, new markets, new sources of supply and new forms of organizations. This follows the Schumpeterian tradition that nations derive their economic capacity from the extant modes of organizations, as well as the capabilities and knowledge infrastructure that coordinate actors and systems.

An economy is made up of a wide variety of economic and non-economic actors that are coordinated within a system involving both markets and non-markets transactions. Coordination is effected by means of institutions that are both formal and informal (rules, norms, social conventions, laws and statutes). Where these institutions are missing or inadequate, the role of industrial and innovation policies is to provide institutional compensation to enable parties to engage in socially beneficial exchange, as though there were no missing institutions. Within the context of the particular country, structuring such institutional compensations involves making a choice among a host of contending alternatives.

Institutions for innovation and technological development are extremely important to long-term economic growth precisely because technology mediates the introduction of new products and processes in the economy. In an industrially dynamic context, changes to machinery and equipment, introduction of new forms of industrial organization will be accompanied by 'new institutions, the institutionalization of… new social technologies may require new laws, new organizational forms, new sets of expectations' (Nelson and Sampat, 2001: 49). The role of the state in latecomer development is to provide institutions that mimic the market mechanism, in so far as they create conditions that minimize uncertainty, socialize risk inherent to industrial activities, and encourage entrepreneurship and local technological advancement.

As Johnson (1987) states, "One of the things a state committed to development must do is develop a market system and it does this to the extent that its policies reduce the uncertainties or risks faced by

entrepreneurs, generate and disseminate information about investment and sales opportunities, and instill an expansionist psychology in the people. Once a market system has begun to function, the state must be prepared to be surprised by the opportunities that open up to it, ones that it never imagined but that entrepreneurs have discovered" (p. 41). This means that the state will not only regulate political and economic relationships to focus on sustained technological development, but also engage in institutional innovation and adaptations that will enable local entrepreneurs to capitalize on the new opportunities that they have discovered over time.

In sum, the role of the state is (1) to build institutions to attenuate uncertainty - this can be done by providing information to help firms and organizations make short and long-term investments; (2) to provide incentives and establish organizations (or strengthen existing ones that are performing poorly) - this includes intermediary organizations that mediate transfer processes and ensure pay-off to innovation, and those that take the risk element from the process such as venture capital; and (3) to provide the tools and environment for learning.

The role of the academic community and private R&D firms

The **academic community** is organized largely around those creating new knowledge through intensive R&D activities and creative design that initiate entire processes of innovation. **Private R&D firms**, on the other hand, are a set of actors driven largely by the commercial motive of translating inventive or design work into products, processes and services; they are made up in the main of engineers, scientists, software experts, designers and technicians among others. Both these communities may overlap at times in their functions and are found in networks created to advance technological innovation. In the context of innovation studies, what underlines these two communities is the commonality of knowledge creation.[2]

The two communities constantly interact through innovation networks to tap into the heterogeneous sources of technological knowledge that needs to be constantly created, updated, applied

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2   *David and Foray (2000) similarly identify four different communities, namely, the scientific community which is concerned with the "capture, storage, analysis, and integration of experimental and observation data" (p.7). Another is a community of programmers involved with the open source movement. They create new knowledge and information with no profit motive. The third is the business community whose modus operandi is cooperative and organizational such as education and research consortia and networks. Another science-driven community is the health and medical profession whose practices are being increasingly science-driven.*

and coordinated. Functioning networks enhance the creation and dissemination of knowledge although there is still not much clarity on how African countries and scientists will gain a sustained foothold in the frontiers of knowledge that is essential for catching up. Clearly access to knowledge has not often translated into use of knowledge in innovation activities, and this is because the two communities are not connected through well-functioning innovation networks in Africa. Formal education, especially tertiary education tends to play a prominent role in promoting networks of scholars through research, conferences and so on but this is not quite enough to promote innovation. There is a need to build channels that allow actors in the two communities interact constantly within institutional frameworks in national knowledge systems. This in turn, stresses upon the need to move away from indicators of knowledge activity (such as patents) to indicators of knowledge use and knowledge linkages.

Other actors include local **private associations and the business community**, which influence the processes of making laws favourable to the scientific and engineering communities. In addition, **multilateral institutions,** who provide funding and technical support in knowledge processes, are relevant actors.

4

Enhancing the contribution of knowledge to development

In order to enhance the contribution of knowledge to the development of Africa it is important to understand the specific steps necessary to make knowledge an integral part of production and services in Africa. From the preceding, the following steps and knowledge about knowledge are necessary.

First, policymakers and practitioners need to understand that knowledge has heterogeneous sources including those coming out from existing knowledge, new discoveries and arrived at through design or production.

Second, it is important to understand the relationship between science and technology and economic change, while bearing in mind that innovation is not synonymous with invention. As was widely discussed at the EGM, invention culminates in the supply (creation) of knowledge, but innovation encompasses the factors affecting demand for and use of knowledge in novel and useful ways. While

the notion of novelty is synonymous with invention, the process of creating local change is fundamental to innovation.

Third, these heterogeneous sources of inputs and capabilities feed into the creation of knowledge bases of firms and organizations and recent literature acknowledges the changing characteristics of knowledge bases, in terms of knowledge specialization and integration activities amongst firms worldwide.

Fourth, the process of building differentiated knowledge bases amongst firms and organizations depends critically on access to extensive knowledge networks, as well as the presence of capabilities within the sector/economy to absorb and apply the knowledge to coordinate activities, thus further challenging traditional approaches that seek to explain firm behaviour through input-output characteristics. In other words, policymakers must go beyond their preoccupation with R&D and public research to engage all actors in the economy in order to harness all sources of knowledge.

Fifth, while knowledge is increasingly codified, much of the technical knowledge in developing areas is tacit in nature and transmitted through informal human channels. Some knowledge is easily subjected to algorithmic format, or elaborated in simple or complex formulae in manuals or guidebooks. But a large part of knowledge created through innovative activities is embedded in the human capital of the people who perform the routine tasks, who acquire it consciously as a part of their duties or unconsciously along with the other activities they undertake. This kind of tacit knowledge is not so easy to acquire and requires the help of organizations such as firms and institutes within which individuals operate. Unfortunately as we observed earlier, African countries have been unsuccessful in building institutions, while private firms are small and ineffective. Much effort is required on the part of policymakers to create the right kinds of incentives and structures for development-driven knowledge accumulation.

Lastly, African countries need to make human and financial investments to transform codified global digital knowledge to local use. This is because only a portion can be transferred by formal technology transfer mechanisms, while the rest often requires a long heuristic process of imitation, reverse engineering, learning-by-doing and apprenticeship.

The convergence of technology

Knowledge is increasingly convergent. For instance, if we take the biological sciences and biotechnologies, there is a convergence of techniques and practice that encompass genomics, molecular biotechnologies, agricultural and industrial biotechnology. Material sciences and technologies include advances in nanotechnology, smart materials, high-performance materials and advanced catalyst materials. The emergence of ICTs and other new technologies has helped combine several technological techniques to provide wider applications in industry and society (see figure 2). The term "convergence technologies" (CT) has been used to describe this phenomenon defined as "the synergistic combination of nanotechnology, biotechnology, information technology and cognitive sciences" (Roco and Bainbridge, 2003). The benefits accruing to convergence include new organizational production structures and gains in communication, although a full elaboration of the phenomenon is outside the scope of this paper.

The main point to stress in the analysis of knowledge is that this observed scientific and technological convergence has brought fruitful advantages to the different fields of science. In addition, these technologies are being applied in traditional sectors in ways that could not have been imagined a decade ago (Sagasti, 2004). Relatively technologically backward countries have gained a foothold in regulated and competitive markets and are realizing significant export revenues from traditional sectors such as fish, cut flower and fruits. DNA techniques are being applied to convert oil palm, once known only as a consumption item to produce bio-diesel; molasses from sugarcane is used to produce ethanol and methanol all of which have great potential to reduce reliance and replace petroleum based fuels. These new and emergent *distributed knowledge bases*[3] will translate into new forms of industrial organizations in developing countries as well as new institutional arrangements. For instance, the fish farming sector employs new materials, design concepts employed in satellite communications, and sonar technologies among others.

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3   *A distributed knowledge base is "a systematically coherent set of knowledge, maintained across an economically and/or socially integrated set of agents and institutions" (Smith 2002: p.19).*

Figure 2. High-technology exports by region (as % of manufactured exports)
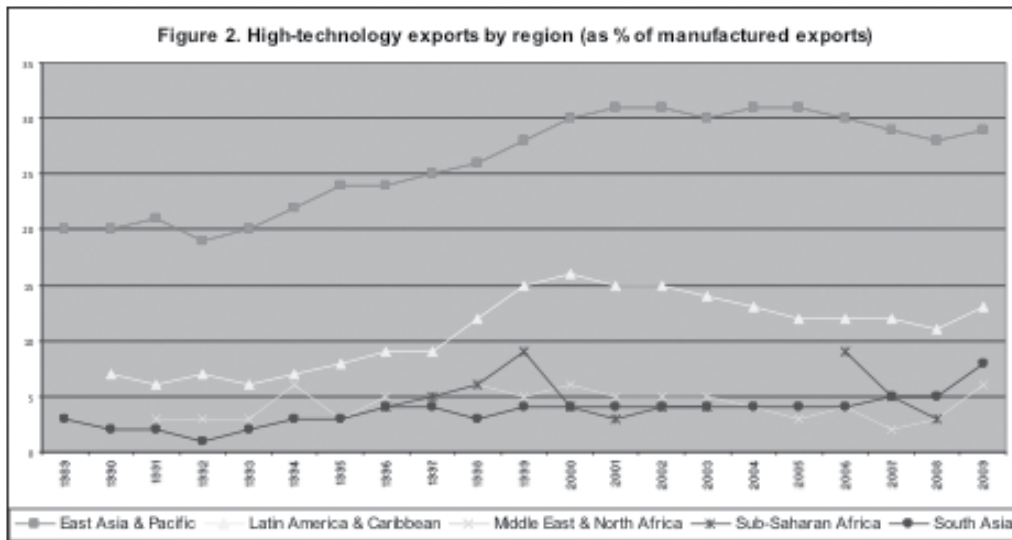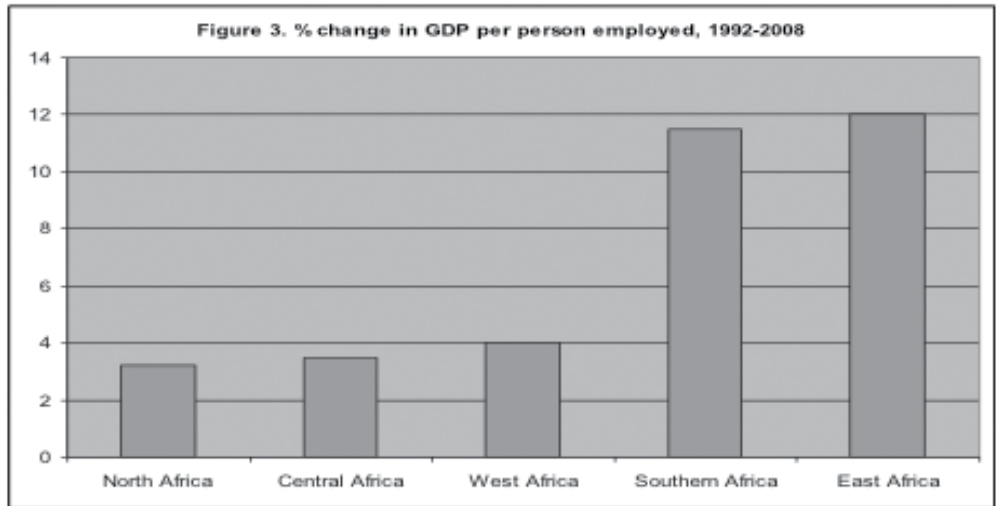
Source: World Development Indicators, World Bank

Another area of significant change is the inclusion of advanced digital techniques in what used to be purely mechanical instruments. While scientific instruments may have become costly in certain respects, they provide opportunities for transforming traditional sectors in which developing countries have comparative advantage.[4]

The emerging evidence tends to suggest that achieving the MDGs in the region requires a substantial reorientation of development policies and institutions to focus on the use of new and established processes and practices that have propelled progress towards the various goals in countries in Africa.

The figure below shows that GDP per person employed grew in all subregions over 1992-2008, denoting an increase in labour productivity. Growth has occurred in over 84 per cent of the 48 countries with data. However, the employment to population ratio has stagnated over the period under review and employment creation remains a major challenge.

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4   *Mechatronics, the integration of mechanical devises with electronics components has for instance made a major impact on the manufacture of precision machines, automobile, among others and has led to greater efficiency and pollution reduction in industry both in developed and developing countries.*

Figure 3. % change in GDP per person employed, 1992-2008

Source: UNECA data from World Bank World Development Indicators (WDI) 2010

Policy and institutional innovations, when effectively implemented, could manifest in a number of ways. First, they could empower individuals, increase people's capacity to tap effectively into markets and hold governments more accountable. Second, when innovations are targeted at enhancing the production process and better service delivery, such gains in productivity often lead to higher economic growth and facilitate poverty reduction as well as make development more sustainable. Third, the synergy between improved accountability and enhanced productivity improves the capacity of a nation to meet the needs of its people and accelerate progress towards the MDGs (education, health and livelihoods). Innovations, when effectively managed, facilitate knowledge transfer and encourage further innovations, and catalyze the emergence of new technologies and businesses as well as create joint ventures and other income-generating activities. Innovation ensures continuous and collective learning, nurturing and willingness among innovators to connect and make innovation continuous and additive. Promoting better knowledge and approaches of doing things is central to achieving the MDGs and other development ambitions in Sub-Saharan Africa.
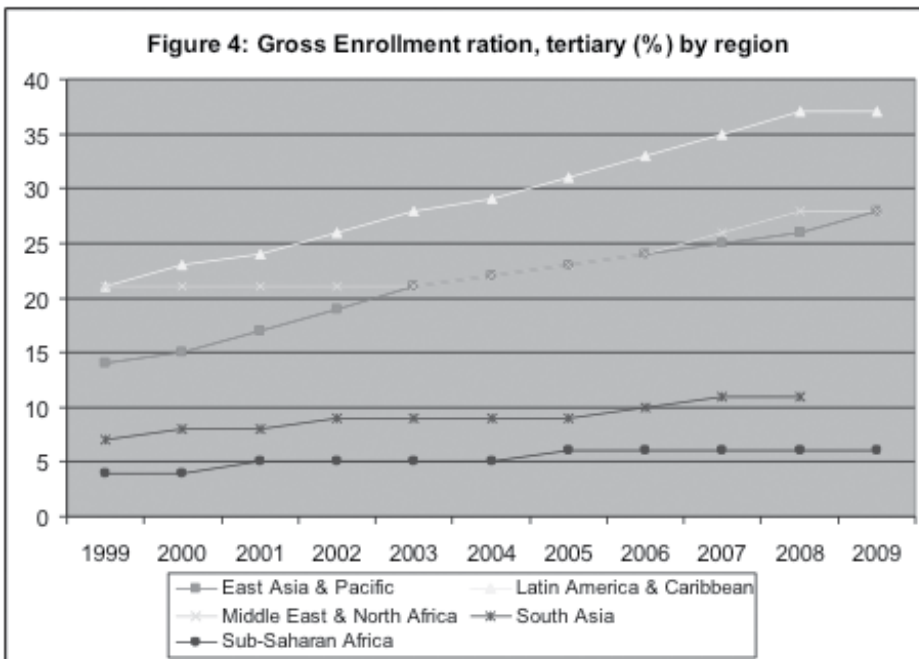
5

Requirements of knowledge for development

There are a few key prerequisites for African countries to benefit from innovation-led development. Since innovation is a social process shaped by the institutional structures in which it is embedded, the first prerequisite is for the states in Africa to ensure that **institutions** work and to strengthen or build these institutions where they are weak or absent. It is also important to design and enforce a range of policies that promote human capital formation for science and technology development, as well as general infrastructure. Institutional coordination is also a very critical issue in ensuring that the domestic agents have the appropriate incentives to interact optimally in order to translate research/incremental innovation efforts into entrepreneurial ventures. This includes policies that focus both on primary research as well as extension services that will help to build up/foster the enterprise sector to collaborate with public sector institutions to commercialize products based on ongoing inventive activities. Policies that focus on financial mechanisms are equally important in order to promote the growth of the sector. But in latecomer countries, lack of

incentives to interact amongst the various agents, especially between researchers and enterprises, again owing to lack of funding, finances and strategic vision for the sector remain one of the biggest problems (see Oyeyinka and Adebowale, 2010).

The second prerequisite is **to build and sustain schools and training systems** that support the growth of human capital. It is important to stress that as countries advance and there are changes to production, new institutions, skills and job mixes are demanded. The resistance to change in Africa and the slowness to institutionalize industrialization have in part resulted in a situation of economic backwardness.

Figure 4: Gross Enrollment ration, tertiary (%) by region

East Asia & Pacific
Latin America & Caribbean
Middle East & North Africa
South Asia
Sub-Saharan Africa

Source: Education statistics database, World Bank

The third, **finance** is key to the achievement of the different knowledge–driven goals set out in national plans and in the MDGs. It is important to harness the different financing options that are present in both public and private domains. Experience shows that funding demand for the scale-up of R&D and inventive efforts increase exponentially from prototype to commercialization. The success rate of scaling-up outputs and/or inventions is generally low (less than 20 per cent in US and Canada, more than 50 per cent in China where government support is most significant) even in the best of circumstances, defined in terms of adequate physical and knowledge infrastructure, technology

and funding. Several support models are available to help agents overcome financial constraints and engage in innovation. In much of the developed world, venture capitalists along with governments generally provide the necessary funding. In countries like China, Israel, Malaysia, South Korea and USA, the government provides the necessary funds in the form of take-off grants and low interest loans payable if the business succeeds. Some countries such as Israel have gone a step further by funding the R&D and incubation stages of selected technologies. This is measured in terms of an innovation incentive in this paper.

The fourth**,** a strong **physical and knowledge infrastructure** is a prerequisite of the national systems of knowledge and innovation. Physical infrastructure includes power and energy, telecommunications, roads, railways among others. Knowledge infrastructure includes other kinds of Information and Communications Technologies (ICTs) as well as metrological and standards that are required for competitive economies. Knowledge infrastructure also refers to aspects of human capital that characterize the knowledge system at various stages of innovation. It spans technological know-how and scientific and engineering skills to marketing acumen as well as legal and project management capacities, all of which play a role in ensuring the migration of innovations from the laboratory to the market. Human capital includes scientists and engineering personnel with the appropriate kinds of knowledge, experience and skills. Unfortunately, these conditions are lacking in latecomer countries, due to a number of factors including weak scientific infrastructure, inadequate human resources, weak capacity of domestic public research institutes and universities to assist firms to develop appropriate sector-specific skills, disillusion of scientists and researchers, and lack of focus amongst core university faculties that do work on new technologies (see Gehl Sampath, 2007).

Furthermore, knowledge infrastructure is often required at the most basic level of education (training scientists and engineers), as well as at the level of public scientific research and development. These roles are fulfilled by universities and Public Research Organizations (PROs). One of the fundamental functions of these institutions is to promote R&D learning and thereby enhance the absorptive capacity of nations (Teubal, 2001).[5] The state has historically played a leading

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5   *Teubal considers two mutually reinforcing phases, namely inter-firm learning about R&D (applicable largely to the early innovation phase such as searching for markets and technical information, identifying and generating new projects, learning to screen, evaluate, and choose new projects, and learning to manage the process); and collective learning, which in addition to inter-firm learning, includes managerial and marketing functions that are crucial to the innovation process.*

role in both the early "industrializers" as well as in the more recent dynamic economies, such as South Korea and Taiwan (Mowery, 2005). For example, the role of universities has received considerable attention as a source of trained personnel and streams of scientific and technological knowledge, and as a facilitator, for example, through the mobility of scientists between university and industry, diffusion of new knowledge, and human capital.

The Challenge of Institutional Linkage: How R&D Translates into Innovation

One of the most persistent criticisms of academics is the lack of success in translating inventions to innovations. Countries need to develop domestic scientific capabilities suited to their own context so that both codified and tacit skills are locally available. Moreover, in a latecomer context, most of these assumptions of how individuals and organizations interact do not hold and the process of translating R&D efforts into a market product is characterized by significant financial, skills, technical and institutional barriers. Taken as a group, latecomer countries spend considerably little on R&D (UNCTAD, 2006). There is also generally a difference in the types of R&D spending and the sectoral composition of R&D activities in the latecomer economies. Public sector driven R&D unfortunately ends up largely at the initial stage due to shortcomings in the institutional framework. Goldemberg (1998) demonstrates that research must be conducted with aim of getting to the market (figure 3), identifying three phases:

Phase 1 – Pure Research
Phase 2 – Technological Development
Phase 3 – Production and Marketing

Regardless of whether the initiating step is the incremental design or the laboratory-based R&D stage, these phases are critical in order to harness the fruits of investments in knowledge processes.

5

Knowledge and real life developments

Policies have been major drivers of success in a number of countries. High level awareness and advocacy emanated from series of policy innovations. MDGs based planning and development strategies have gained clout over the past decade and have driven the development of Poverty Reduction Strategy Papers (PRSPs) in a number of countries. A few countries have established MDGs ministries (e.g. Women Affairs), commissions or special units while some formed Presidential and Parliamentary Committees to advocate for, implement or monitor MDGs related interventions. Some are sectoral based policies such as the Universal Primary or Basic Education in Benin, Ethiopia and Swaziland; Educational Fund/Tax in Nigeria and The Gambia; School Feeding Programmes in Namibia; Emergency Obstetric Care and Safe Motherhood Initiative and others are broad-based such as livelihood and empowerment programmes in Ghana and virtual poverty funds in Nigeria. The explicit recognition of a social welfare system in Seychelles' constitution makes protection of the vulnerable and the underprivileged a direct responsibility of government which contributes to absence

of extreme poverty in the country while education is constitutionally recognized as a fundamental human right. Policy based initiatives have also served as key drivers in a number of countries like Ghana, Malawi, Nigeria and Rwanda, to mention a few.

Access to physical infrastructure

Countries with improved network of physical infrastructure have also impacted positively on the MDGs in Africa. Mauritius is a case in point. To a large extent, substantial expansion and maintenance of road and rail networks, electricity generation and coverage, water reticulation and distribution, communication and provision of low-cost housing have had spillover effects on the progress towards the MDGs, especially poverty reduction and empowerment of the poor.

Infrastructure bottlenecks are a serious constraint to the delivery of social services in a number of African countries including Nigeria, South Africa, and Uganda. The infrastructure deficit is even more acute in post-conflict countries such as Angola, Burundi, Democratic Republic of Congo, Liberia and Sierra Leone. To address this challenge, Ghana for instance devoted substantial resources into capital spending, focusing on rehabilitating and construction of roads, water, schools and hospital facilities. This resulted in an increase in development expenditure rise from 0.63 per cent of GDP in 2002 to 5.83 per cent of GDP in 2008. This contributed to the translation of economic growth into rapid poverty reduction in the country. A similar trend of investing in infrastructure is emerging in South Africa with particular focus on road, rail and water reticulation expansion.

The establishment of the African Peer Review Mechanism (APRM) in 2003 is systematically changing the landscape of development management on the continent. Although it is an instrument voluntarily acceded to by member States of the African Union (AU) as a self-monitoring initiative for good governance (conformity to the values, principles, codes and standards enshrined in the Declaration on Democracy, Political, Economic and Corporate Governance), the findings from the efforts are shaping national and regional debates and decision-making policy. The APRM approach is lengthy because of the extensive process of planning and consultations among multiple stakeholders (which has allowed for credibility and successes) and recommendations that drive national programmes of action. This African home-grown initiative has substantially generated high level political dialogue at the country and regional levels, strengthened the

institutions and systems of governance, with member States learning from each other, and strengthened partnership on development.

Several countries have also introduced effective tracking of development outcomes through the involvement of broad-based stakeholders in monitoring and evaluating development outcomes along the key deliverables indicated in annually appropriated budgets. Mali provides a good example on participatory planning and monitoring processes especially on PRSP using 60 multi-sectoral indicators of impact and outcomes disaggregated on gender basis, that have been fully mainstreamed into the national statistical system. The General Office of National Control was established to ensure relevance, coherence and governance of the initiative. As espoused by Diarra and Ndamobissi (2010), the monitoring and evaluation system has led to improvement in policies and programmes, evidence-based and result-oriented approaches to planning, budgeting and reporting. The shift away from poverty monitoring to budget and performance monitoring for accountability is changing the landscape of development management in the country (Smith et al, 2010).

The innovative idea of the civil society budget work is yielding substantial results: findings from education budget are being used to challenge government over education budget in order to hold them accountable. In Malawi pre- and post- budget analysis is providing information for budget advocacy, district–based budget tracking and increased share of education in national budgets. Education budget tracking has led to exposure of corrupt district education officials, head teachers and contractors in Uganda, while in Ghana, community scoreboards have been used to track school budgets, assess education service delivery, expose 'hidden' cost of education in spite of the free education policy and increase parental participation in school management. Information generated from local education budget tracking was used at national level advocacy and ensured public display of schools budgets in Kenya (CEF, 2008).

Innovative cases in reducing poverty and hunger

In order to promote rapid economic growth that will be needed to finance poverty reduction efforts, many countries have increased the share of development spending in recent times to deal with identified socio-economic and physical development challenges. Ghana for instance increased the share of development spending on the total budget from 0.63 per cent of GDP in 2002 to 5.83 per

cent of GDP in 2008 to support such programmes as small-scale projects in agriculture, industry and mining, rural energy, micro credit, employment generation, and specific nutrition improvement initiatives. South Africa's nationwide investment on the expansion of physical infrastructure in the past three years, acclaimed to be one of the largest in the world, substantially increased spending on development programmes. A similar development is occurring in many other countries.

Furthermore, many African countries have established **social protection schemes** to support the vulnerable segments of the population. For instance, protection of the poor and the marginalized is a fundamental right as enshrined in Seychelles' constitution; while South Africa's expansive social protection (covering, as at early 2010, about 13 million people – including a monthly pension of US$109 for women over 60 years and men over 65 years) also has strong policy and legal support. The virtual poverty fund in Nigeria also provided strong support for poverty reduction and MDGs related spending (leading to recruitment of 45,000 teachers and training of 145,000 teachers in 2008, among many other outputs). Other countries that have established social safety nets of one form or another include Lesotho (provision of about $40 per month to persons of 70 years and above), Swaziland (bursary scheme for orphaned and vulnerable children), Ghana (capitation grant and nutritional supplement), and Cape Verde (provision of €27 per month as pension to 7 500 people considered to be the most vulnerable).

In addition, enhanced capacity for knowledge application has improved the use of **agricultural input services**. Countries such as Ghana, Rwanda, Tanzania and Uganda were able to use agriculture to reduce rural poverty because of some level of innovations through availability of inputs, extension services, credit and output markets that positively enhanced farm level productivity growth. This has enhanced innovation capability for accessing, adapting and applying worldwide and local knowledge that have transformed agricultural practices in Africa (Kim et al, 2009).

In relation to this, the use of **informal approaches of service delivery** to supplement orthodox and formal approaches has produced remarkable progress in a number of countries regarding the MDGs. For instance, countries where smallholder farmers' access to credits from the formal financial system has proved very difficult have adopted approaches that led to the emergence of informal services deliveries linked to a value chain process that have produced excellent results. Input suppliers and output buyers provided loans

and credits to smallholder farmers during the cultivation and planting seasons and recovered their investments when farmers delivered farm products. This model has worked excellently in Kenya's Central Province and Kilimanjaro region of Tanzania (Odame, Musyoka and Kere, 2008; Lynam and Theus, 2009). A similar initiative, called contract farming[6], in Nigeria has ensured guaranteed sustainable supply of raw materials, promoted standards and quality of products, boosted the rural economy and promoted pro-poor growth. As pointed out by Olomola (2010), contract farming increased per capita income of smallholders.

There are more of these agricultural innovations, for instance the **demand-driven research and growing partnership between agribusiness firms and farmers associations**. A review of these various approaches by SWAC (2005) reveals that specific agricultural innovations present regional opportunities that could be explored to address poverty and hunger as well as generate income to increase access to services relating to the other MDGs. The implementation by the West African Rice Development Association (WARDA) of high-yielding rice varieties NERICA (New Rice for Africa) and the technological development of post-harvest processing using materials made by local blacksmiths in Mali and Niger have helped productivity rise significantly. For instance in Mali, yields rose from 3 tons per hectare in the 1990s to about 6 tons in 2005. Besides, strengthening of partnerships between producer organizations and agribusiness has encouraged the adoption of new high-yielding technologies in agricultural production. For example, Ghana's pineapple yields have increased by approximately 20 per cent and exports increased ten fold between 1993 and 2004. The partnership between agribusiness firms (oil palm) and family farmers in Nigeria helped farmers to acquire more productive and profitable palm planting materials. For instance the Okomu Palm Oil Company has been able to reduce costs linked to expanding palm oil production plantations by working with a large number of small family farms (SWAC, 2005).

Resuscitation and refinement of fertilizer subsidy programme is another African agricultural innovation. The need to enhance agricultural productivity and reduce poverty in the region contributed to this renewed interest in agricultural subsidy. While some countries introduced a refined fertilizer distribution programme, others, based on lessons from past mistakes, adopted voucher distribution for purchase of fertilizers, seeds, and other agricultural

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6   *Contract farming is a contractual arrangement between input suppliers/output buyers and smallholder farmers where the former provides inputs and/or finance to the latter primarily for dedicated farming activities and the latter pays back the former by selling the farm produce to the former.*

inputs (e.g. in Ghana, Kenya, Malawi, Nigeria, Tanzania and Zambia). As opposed to the past universal distribution of fertilizer through public monopolies, the new approach adopted a temporary intervention targeted at poor smallholders and implemented through conscious efforts to support private fertilizer markets. As argued by Banful (2010) the use of agricultural input vouchers has become a multi-dimensional mechanism for targeting subsidies to smallholder farmers, developing demand for private fertilizer markets and building relationships between agricultural input dealers and financial institutions.

In some countries, public-private partnership has been used to exploit private sector efficiency and avoid distorting private markets. Government programmes used market-based innovations such as bid-tender system to source fertilizer through the private sector. The adoption of one or more of these innovations, both in programme design and implementations, is aimed at avoiding the problems that plagued the past programmes. The programmes have boosted fertilizer use, increased productivity and in some situation developed private fertilizer markets. There is an avalanche of evidence that effective use of fertilizers leads to higher productivity. For instance, evidence from Ayoola (2010), shows that fertilizer use in Nigeria multiplies returns to farmers by a factor ranging between 2.1 and 14.6.

There is also a transformation taking place in some African countries regarding **land tenure systems**. Devolution of land to local communities has led to better distribution of and access to cultivable agricultural land and increase in economic activities in a number of countries. The Gambia provides a good example. The country has a comparative advantage in the production of rice, mostly done by women. Arising from the failure of the strategy to build capital-intensive production systems using high-input technology in the 1980s, due to non-sustainability (heavy reliance on imported technology, scarce foreign exchange, and weak agricultural institutions), a policy of engaging poor rural communities in the planning and implementation of rural land holding was initiated. Between 1997 and 2005, Lowlands Agricultural Development Programme (LADEP) worked as a catalyst to bring about this change in the traditional land tenure system. LADEP held discussions with communities to devolve land ownership from the founder-settlers to those landless poor farmers (mostly women) willing to participate in the reclamation of inaccessible land.

The arrangement created a win-win situation for founder-settlers and farmers. Individually owned land was first devolved to the community, which distributed it equitably among those individuals, mainly women, participating in land reclamation. Through the programme, LADEP

invested in infrastructure that opened up the inaccessible lands for use: the founder-settlers had access to 'idle lands' with difficult physical access while presently accessible lands were distributed to landless farmers, especially women farmers who agreed to provide labour, as a group, to the founder-settlers. This gave people a clear incentive to contribute labour for reclamation in return for a secure landholding, and to assume responsibility for infrastructure operation and management after the end of the programme. These discussions with communities gained legal value under traditional law. The change in the traditional landholding system has allowed the 'labour force of women without land' to unite with 'landowners without labour' for enhanced rice production, women empowerment (about 22,000 women now have access to land), increased livelihoods and reduction in poverty and inequality. The LADEP approach to land tenure is now widely accepted in the country and is ready for scaling up to the national level.

Another important example of simple, locally-owned technology comes from Burkina Faso and the Niger, where traditional **soil and water conservation practices** are changing lives. The use of *Tassa* (traditional planting pits in drought prone areas) in the Niger based on lessons from Burkina Faso after a tour by 13 farmers from the Niger was instrumental in bringing a total of 4,000 hectares back into production. In so doing, agricultural risk was mitigated while household food security was improved for many impoverished families in the Niger. The adoption of this local technology, through the help of IFAD, is spreading quite fast within the region as a result of doubling of yields, rehabilitation of barren land, easy maintenance and easy weeding and thinning. This approach is now common place in Burkina Faso, Cape Verde and the Niger. The Tassa technique has become an integral part of local farming in these countries and it is adding an additional 2-3 hectares per year to some holdings. It has led to the emergence of a new industry of young day-labourers, who have mastered the technique, and now work for local farmers. The suitability of the technique to the changing local context, its simplicity and cheapness made it very attractive for adoption.

There is also a case where the adoption of **participatory approach to irrigation development** in Tanzania is generating rewards to farmers. The Government in collaboration with IFAD, in 2000, as part of its six-year programme to support the development of smallholder irrigation schemes in semi-arid, marginal and drought prone areas, rehabilitated some 12,000 hectares of land, for the benefit of more than 15,000 people for an enhanced livelihood of poor rural people. The project was undertaken to harness the strengths of communities

to fully participate in the planning, construction and, ultimately, the operation and maintenance of the irrigation schemes; choose simple designs and construction methods that could easily be operated and maintained by farmers; ensure a good return on investment (in terms of productivity and income) and promote cost recovery.

The programme targeted the poorest farming families, particularly those headed by women, whose crop yields were low and depended on income from casual labour for up to eight months a year. The programme led to the construction of 42 irrigation schemes (with many others underway); construction of over 327 kilometres of roads and about 50 village road groups formed to oversee road maintenance. In addition, the capacity of 12 district councils and government officers was developed leading to the training of about 24,000 farmers. The Water User Associations (WUAs) were involved in the process. The proportion of women with plots and membership in WUAs is now over 30 per cent. The project demonstrated that supplementary irrigation of paddy could be financially viable and economically attractive; each irrigation scheme was at an average cost of US$1,000 - 2,000/hectare as opposed to the approximately US$10,000/hectare required at that time to build larger irrigation schemes. In contrast with an annual average yield of about 1.8 to 2.3 tons per hectare, as at 2004, this project led to average rice yields of 4 tons/hectare and farm incomes grew proportionately as well. A review of the programme in 2005 showed an improvement in household food security for the most impoverished as a result of increased crop yields.

Innovative cases in education

The 2001 Dakar Framework of Action for Education is believed to have influenced many countries to increase attention and resource allocation to the education sector. In Ethiopia, for instance, annual budget allocation to education averaged 20.6 per cent between 2002 and 2008; it rose from 15 per cent in 2007 to 20.0 per cent in 2009/10 in Zambia; it ranged between 23.7 per cent and 29.6 per cent between 2005 and 2009 in Kenya; it averaged 25 per cent of total budget between 2000 and 2006 in Swaziland; it was as high as 23 per cent in Benin while in Namibia it has been about 20 per cent since 1990. Part of these resources were devoted to upgrading and expanding infrastructure, training of teachers, provision of learning tools and creating incentives for teachers.

The **decentralization of the management and administration** of primary education (and in some countries, secondary, technical and vocational schools) has resulted in higher efficiency and effectiveness (Ethiopia, Mauritania, Nigeria and South Africa). In countries like Rwanda, Seychelles and Tanzania, the involvement of **Parent-Teacher Associations** and communities in the management of schools (especially in monitoring and evaluating school performance) has reinforced success due to improved governance. **Tracking of education spending** in Tanzania for instance yielded positive results.

There have been some notable innovative processes in terms of enrolment from rural areas. This takes the form of **mobile and pastoral educational programme** (e.g. Ethiopia, the Gambia and Nigeria), which also included adult literacy programmes. Both formal and informal educational systems have been integrated into one in a number of countries while special funds were created for education: **education tax fund** in Ghana and Nigeria, as well as **Girls Education Trust Fund** in the Gambia. These innovative ideas facilitated access to a large number of children in remote areas where the formal school system could not reach, while the various funds bridged education funding gaps in many countries.

Many countries such as Benin, Democratic Republic of Congo, Mauritius, Namibia and Nigeria adopted compulsory primary education. Uganda for instance **introduced compulsory education in the vulnerable and trouble-torn region** of Karamoja. For countries that could not afford nationwide compulsory education, the Ugandan targeted approach could be a viable option. These were complemented with additional policies such as **School Feeding Programme** (e.g. Kenya and Namibia), **Girls' Friendly Education Programme** (the Gambia) and **special focus on children with disability** (Ghana and Seychelles).

Introduction of **free education across almost all African countries** has positively influenced rapid enrolment rates in many countries. However, **indirect education expenses still serve as an impediment** to poor families sending their children and wards to school. Several innovative approaches have been introduced to tackle this in some countries. For instance, the **free feeding programme** has been introduced in several countries (Angola in 2005, Ghana in 2006). Ghana introduced **free bus ride** for pupils in uniform for those schooling far away from their residence (where more than 25,000 pupils benefited from the programme daily). Countries such as Malawi, Tanzania and Zambia are **doing away with the requirement for school uniforms** (Riddell, 2003) and Ghana is adopting a similar policy

just as Botswana is **providing free uniform**, **food every month and transport to and from school for orphans** (Moko, et al, 2009). In countries such as Botswana, Burkina Faso and the Gambia, provision of **free textbooks** to pupils is part of the programme.

Moreover, the **NEPAD** e-Schools project is revolutionizing the school system in many countries. African governments in **collaboration with the private sector** have been working on overcoming structural barriers to the use of computers in African schools since 2006. The project provides a computer lab with computers, software, internet connectivity, maintenance, and a digital Smart Board connected to a projector which allows users to input directly on the screen. In Rwanda, as at 2009, this project had trained teachers and school administrators to use the equipment for teaching and learning purposes. This project, with **Microsoft's support**, has already been implemented in over 25 schools in Cameroon, Kenya, Lesotho, Mauritius, Mozambique, Rwanda and Senegal and has reached out to over 1,000 teachers and 20,000 students. Its ultimate aim is to connect 600,000 primary and secondary schools in Africa.

Yet another targeted area within the education sector is early childcare, which enhances enrolment and performance in primary schools. Although **Early Childcare and Education (ECCE)** is not part of the MDGs, it accelerates entrance into primary schools and improves the quality of the latter. One of the reasons for excellent results in primary school enrolment rate and in the quality of education services in Mauritius and the Seychelles is the adequate attention given to ECCE. As of 2007, Mauritius provided early childhood education to 94 per cent of children aged between 3 and 5 years and by 2004, Seychelles was able to provide this level of education to 85 per cent of children aged 3.5 to 5 years. As stated by Moko et al (2009), this performance was made possible by utilizing classroom space in some primary schools for ECCE; providing financial assistance to private providers through soft loans; and constructing pre- school classrooms in primary school facilities.

Utilizing innovations for rapid progress on the MDGs

The knowledge of how innovations take place and how policies and institutions facilitate enhanced innovations are central to unlocking the potential of reaching the MDGs in Africa. Evidence abounds that

Africa is very rich in innovations, yet they remain at the micro level and have yet to generate the macro-level effects. We have provided some excellent examples above of local innovations and discoveries in the agricultural sector including crop breeding, grafting against pests, water harvesting, soil management, conservation and processing. Indigenous agricultural innovations have continued to be important as most of the locally-grown food is for local consumption. While these series of innovations have produced some incremental values to their inventors, their applications are still confined to those who invented them and are yet to add to the frontier of knowledge. These innovations have not been linked to the national innovation system that could generate economy-wide effects at the national and regional levels. The question is, how to maximize the benefits of these innovations? The following is an account that gives hope of providing the answer to that question.

First and foremost, harnessing knowledge for development is better achieved when there is **space for policy experimentation and learning**. This allows development to be expressed as local initiatives and champions additional international partnership. The role of IFAD in participatory learning in transforming the land tenure system in the Gambia and the irrigation programme in Tanzania are good examples for experimentation.

Second, in order for innovations emanating from the public sector to generate maximum results they should be supported by **extended interactions**, collective action and broader public-private partnership programmes. **Multiple knowledge sources** are always more reinforcing and have higher multiplier effects. Innovation collectively derived by multiple actors often creates ownership, elicits support and commitment and is more sustainable. The KMET project in Kenya and the Tassa drought resistance programme in Niger and Burkina Faso provide illuminating examples.

Third, determinants of innovation are not viewed individually but within the complex sectoral innovation system. The **sector of interest should be integrated with relevant innovation systems**. Rapid progress on development issues have been attained where emphasis is on knowledge generation and adoption. This is specifically important for progress made in such countries as Ghana, Kenya, Rwanda and Uganda on agricultural innovation, productivity enhancement and poverty reduction (Larsen et al 2009).

Fourth, most policies and institutional innovation that have achieved rapid progress depend on **simplicity and adaptation to suit the**

local context (the Tassa drought initiative in Niger is a good example). In addition to significant adaptation, stronger coordination and collaboration are also required for the benefits of innovation to be maximized.

Fifth, countries where continuous adherence to standards is promoted by relevant **public quality assurance and standards organizations** create opportunities for innovation to take place. Besides, the context of specific public sector programmes and the prospect for higher profits often spur the private sector on to innovations . In this regard, creating a conducive environment for the private sector to make normal profits allows for inventiveness and creativity that makes a difference in product and service deliveries.

Sixth, Africa's indigenous knowledge and ideas remain perpetually individualized or localized and sometimes disappears at the demise of the innovator. As expressed by the World Bank (2006), "… this occurs when an economy is caught in the indifference-trap with isolated agents innovating on the same knowledge system over and over again". An important way of harnessing this idea is to make indigenous or local innovations continuous and additive so that lessons can be learnt from past experiences. Due to lack of patent in local setting, people should be rewarded and acknowledged accordingly. It is also advisable to **integrate indigenous knowledge into the innovation systems at the local and national levels**.

Seventh, bridging the gap between research/knowledge institutions and practitioners across sectors is vital for harnessing knowledge. This underscores the need to strengthen **decentralized research structures with the aim of bringing these structures closer to their beneficiaries.** For instance, the establishment of a liaison mechanism to bridge the gap between the research community and beneficiaries such as the Research-Extension Liaison Committee (RELCs) in Ghana and the Regional Committees for Agricultural Research and Extension (CRRVA) in Mali (SWAC, 2005) has succeeded in establishing more cordial relationship between the two parties.

Eighth, the MDGs have behavioural and cultural dimensions which require **proactive social marketing and domestic policy and practices to reflect local context**. Using innovations based on social marketing, products or services may achieve behavioural changes. For instance, on HIV/AIDS, Africa is endowed with rich humours to address taboo subjects such as contraception. Implementing innovative ideas such as "Condom Nights" and "Miss Anti-AIDS Beauty Pageants" in the red light areas in African towns and communities

may produce remarkable results. The establishment of waiting houses in Mozambique meets the needs of people in poverty living at a distance from nearby clinics. **The waiting houses** represent a place for pregnant women to be admitted a few days prior to delivery date with free feeding, medication and treatment. The waiting houses have provided substantial results.

Ninth, many innovative pilot projects have been adjudged successful in Africa, but governments have failed in many situations to **expand the successful projects to benefit the larger population**. There is a need to develop frameworks for scaling up successful projects. This could take the form of a resource team, an organization, or a strategy.

7

Conclusions and recommendations

Knowledge represents the basis of implementing technology, science, innovation and invention to real-life needs and improvements in the quality of our lives.

Harnessing knowledge will help achieve the MDGs in Africa. Indeed, progress has been recorded in the achievement of the MDGs, but it is not enough to achieve all the goals by the target date. It is necessary to utilize all available means to step up progress on MDGs. Knowledge harnessing is, as shown by the numerous real-life examples, crucial in this regard.

Knowledge can be explicit, implicit or tacit. For instance, education as a proxy of knowledge is found to be positively related to growth, but the quality of education is crucial. Knowledgeable labour is more creative, and therefore more able to promote economic activity and thus, development in general.

Furthermore, in order to harness and develop knowledge

systems, the role of the state and institutions is, of course, of utmost importance. Knowledge harnessing needs policy interventions and integration into the national development agenda. It is obvious that there should be a national and public hub that is able to channel new and old knowledge and related innovations into the development needs of the country.

Moreover, such a hub should make sure the private sector functions over an environment that is more conducive to creative innovations. In order for the private sector to prioritize and invest in R&D, and other knowledge enhancing activities, they need the backing and support of the state, through the provision of incentives in terms of regulations, economic, political and overall conducive environments. The same should be done in terms of indigenous knowledge, a sector that needs special reward systems as an incentive for sharing with national development at heart.

As a matter of fact, this logic can be extended in keeping human resources inside Africa and in individual countries, thus minimizing the deteriorating effect of brain drain. Labour, especially skilled labour, is more likely to remain and pursue employment in the country when the working and living environment is appreciated.

We may also conclude that the knowledge related structures and mechanisms have thus far been driven by the high-income countries (for instance patent rules), which have often been an obstacle for domestic and indigenous knowledge development. However, Africa has prospered recently through an overall global shift, in terms of GDP levels and technology-driven development. There is a momentum to explore and exploit these changes in order to step up the knowledge-driven development of the continent. Africa has vast resources, both in terms of natural and human endowments. The question is how to utilize them. It is obvious that there is a great deal of traditional and new knowledge to stand on the shoulders on in Africa. We have presented some examples in this regard, but in the face of poverty and underdevelopment, there is a great need to expand their implementation and fruition over nations and the continent.

Considering the account provided above, it is worthwhile to provide central recommendations.

1. African governments should establish a link between research centers and universities (where knowledge is produced) and industries (where knowledge is applied).
2.
3. Science, Technology and Innovation (STI) should be integrated into national poverty reduction strategies.
4.
5. While acknowledging that the different ministries deal with different issues, it is important to develop an effective coordination mechanism (hub) at national level to ensure coherence and minimize duplication of effort.
6.
7. There is also a need to catalogue knowledge, especially knowledge that could be scaled-up at low-cost and which would be beneficial for the national development agenda.
8.
9. The role of the state should be to provide a conducive environment for research and its application, without being too intrusive.

Finally, it should be borne in mind that knowledge has an instrumental value for development. A knowledge-driven development framework aims at transforming structures and human beings. It should therefore take into account these five features:

- A non-linear and non sequential complex process;
- Recognition of the importance of the uniqueness of the continent since different countries are at different levels of the process;
- Knowledge acquisition in a country is shaped by culture and historical background;
- Knowledge-driven development supposes a new role for the state, which should be more efficient and competent in order to address market failures;
- Conceptualization of knowledge is complex, since it is embodied in people, technology and bureaucracy.

Finally, there is a great moral and practical need to advance the continent and its citiizens in terms of knowledge-driven development, including progressing on MDGs.

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