Technology and Knowledge Transfer for Development

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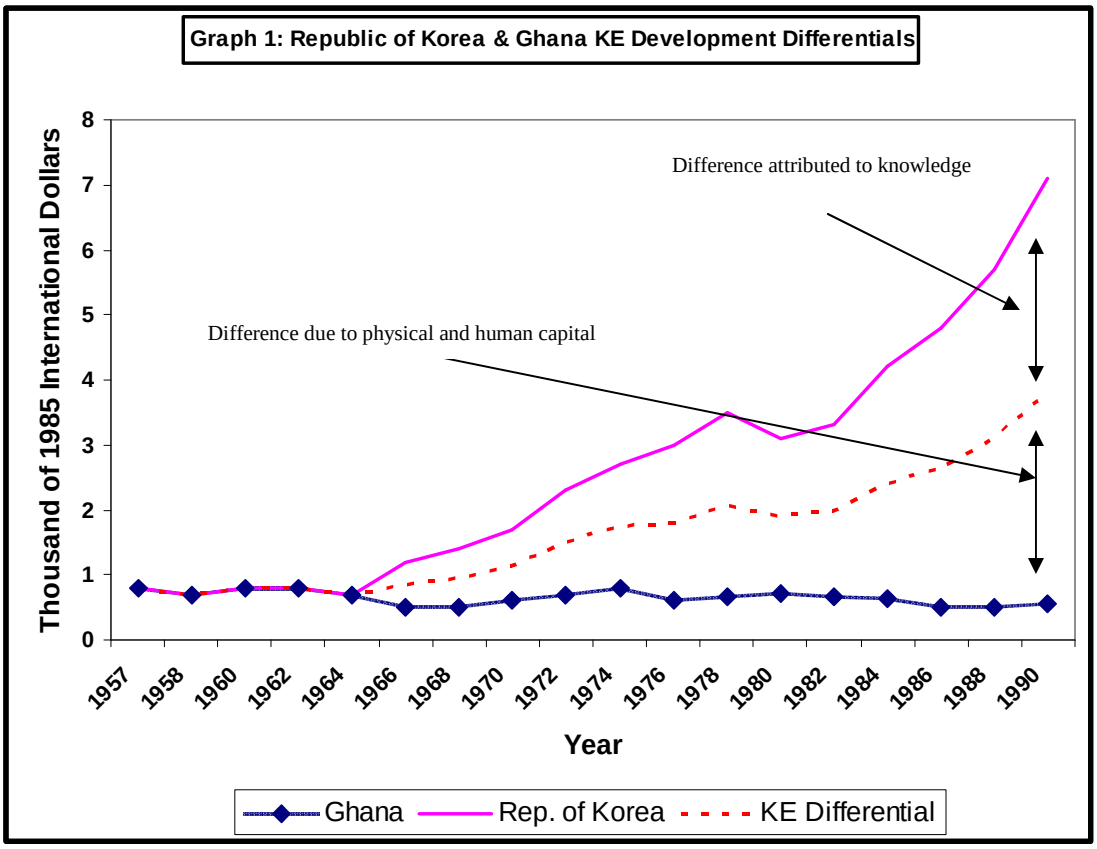
1.0 INTRODUCTION

This paper raises key questions about the philosophy of Knowledge Management in the context of technology and knowledge transfer. Fundamental issues related to the impact of technology on sustainable development in Africa are outlined. An overview of the technology and transfer challenges and issues in Africa is presented. An outline of international experiences that benchmark good knowledge and transfer examples from the Nordic countries is provided. Nordic Countries are used as barometer since they perform better in terms of human development index and knowledge economy index indicators (Freeman, 1995). The paradox impacting on Africa's technology and knowledge endeavours are discussed. These relate to the important socio-economic opportunities presented in the context of a wide range of shortages. In addition, the major challenges Africa is facing within the ambit of global development from a science and technology perspective are presented. The paper concludes by emphasizing that a real strategy to promote technology innovation and transfer in Africa, before tapping and adding value to the local input through international cooperation and partnerships is advanced. A rapid appraisal of the existing knowledge and technology initiatives in Africa is provided. The quick appraisal of experience and prospects for the African Regional Centre for Technology (ARCT) as well as [Council for Scientific & Industrial Research] CSIR caps the discussion. An indicative list of recommendations to turnaround the knowledge and technology transfer condition of Africa into a more resounding success than currently existing is indicated. A brief conclusion that includes critical percepts and thoughts on the future of science and technology within the context of knowledge management is provided.

1.1 BACKGROUND INFORMATION ON TECHNOLOGY & KNOWLEDGE TRANSFER

The new millennium is a platform and melting pot hosting different challenges for developing countries especially in Africa. A menu of development planning interventions and responses to the current development issues are being implemented with mixed results. Development is increasingly becoming knowledge based rather than raw material or natural resource based. The advent of new and emerging technologies, such as Information Communication Technologies (ICT), Biotechnologies, Nanotechnologies and, Genomics to name just a few is revolutionizing economic, social, administrative and cultural activities. This is impacting on the kind of relationships, transactions and production systems of goods and services in society. The development success story of the Republic of Korea aptly demonstrates that knowledge is most probably the single most important foundation factor of development. Graph 1, reflects the role that knowledge can play in development differentials.

Graph 1: Republic of Korea and Ghana KE Development Differentials



(Source: Knowledge for Development, WBI, 1995)

At the same time, there is a global knowledge revolution, leading into a post-industrial society. This current wave of knowledge revolution is an opportunity for Africa which missed the industrial era, to narrow the development gap between developed and developing countries (Bell & Pavitt, 1993). Africa needs to strategically position itself to derive optimum benefits from the mega trends in knowledge such as the telecommunication explosion, intensified global competition, scientific advances , increased exchanges of technology [international licensing flows], automation and the resultant shift in qualifications (brain power).

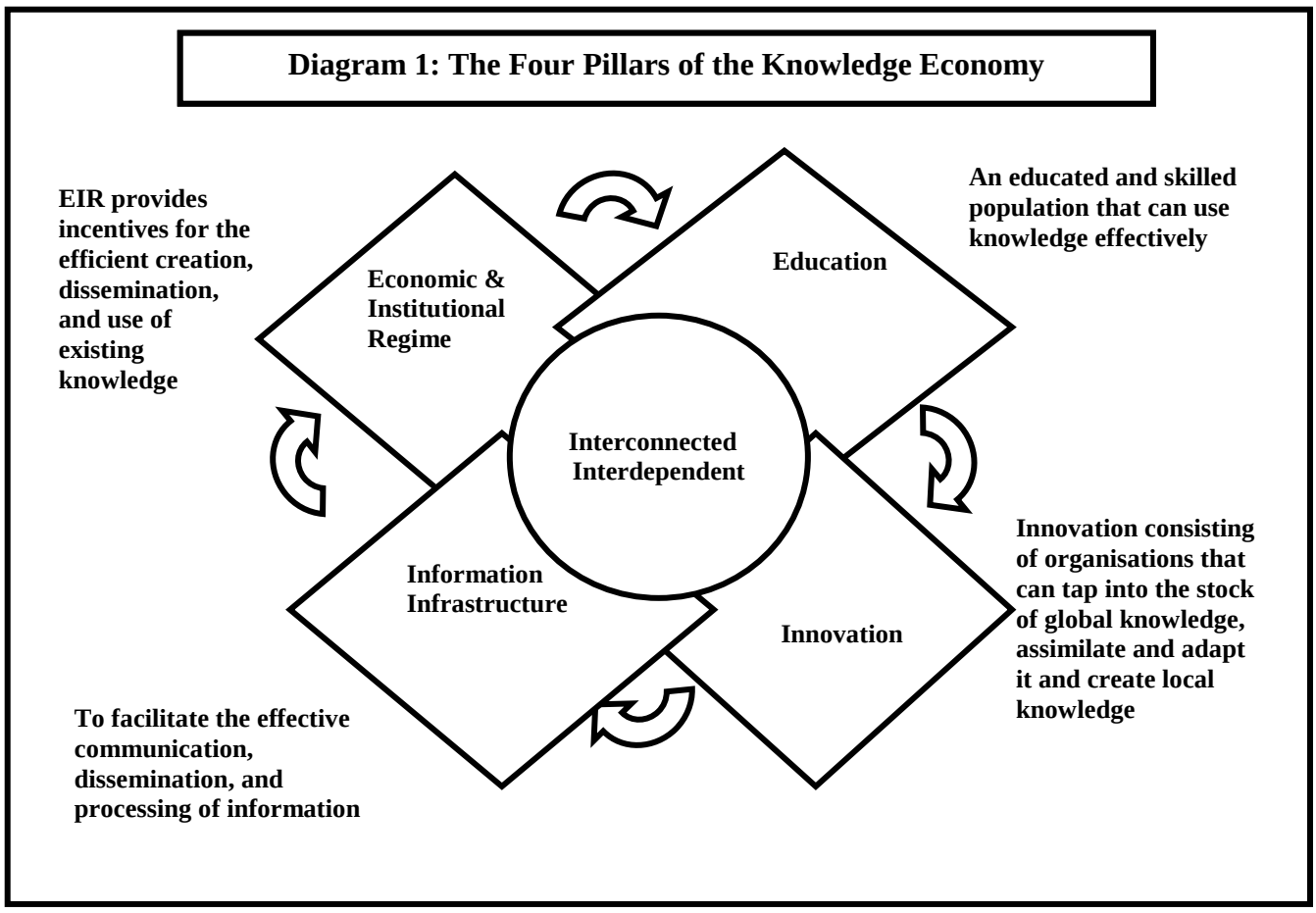
1.2 Definition of Key Concepts

This section defines Knowledge Management and knowledge transfer, two key concepts that underpin knowledge generation, application, replication, duplication and transfer along different intervention platforms and drivers of socio-economic and political growth and development.

"Knowledge Management caters to the critical issues of organizational adaption, survival and competence in face of increasingly discontinuous environmental change. Essentially, it embodies organizational processes that seek synergistic combination of data and information processing capacity of information technologies, and the creative and innovative capacity of human beings" (Malhotra 1997).

Diagram 1 presents the four pillars of the knowledge economy. Productive exploitation and engagement of the four pillars can yield positive technology and knowledge transfer outcomes. Therefore any attempt to transform and change an economy and society has to start with an analysis and on the basis of an informed understanding and knowledge of the given state at hand.

Diagram 1: The Four Pillars of the Knowledge Economy



(Source: Kim L, 1997)

Knowledge Management involves key concepts such as *'doing the right thing'* instead of *'doing things right.'* The concept embodies a transition from the recently popular concept of 'information value chain' to a 'knowledge value chain.' This also entails knowledge **rethinking and reengineering and a life cycle system of continuous learning, unlearning and relearning** (Lundall, 1992, Boisot, 1998, Buckman, 2004).The creation of a knowledge society, an information society, knowledge workers, knowledge communities, knowledge systems, appropriate knowledge technologies, knowledge transfer platforms, knowledge and data warehousing is important. Knowledge Management has strong connections and linkages with several well-known management strategies, practices, and business issues, including;

- Change management
- Best practices
- Risk management
- Benchmarking

Consequently, Knowledge Management may be viewed from each of the following perspectives:

- Techno-centric: A focus on technology, ideally those that enhance knowledge sharing/growth.
- Organisational: How does the organisation need to be designed to facilitate knowledge processes? Which organizations work best with what processes?
- Ecological: Seeing the interaction of people, identity, knowledge and environmental factors as a complex adaptive system.

1.3 Key Issues in Technology and Knowledge Transfer

Technology transfer is embodied in the actions taken by individuals and organisations. The investment and trade decisions made by firms, acquisition of knowledge and skills by individuals through formal education and on-the-job experience, purchase of patent rights and licenses, assimilating the published results of public or private research, research development and demonstration (RD&D) activity, and migration of skilled personnel with knowledge of particular technologies, all represent different forms of technology transfer. Technology transfer can also be influenced by government aid and financing programs, and by multilateral bank lending. Governments can implement policies that promote R&D programmes that address for example global climate change concerns in sectors such as energy, forestry, and transportation (Cohen & Levinthal, 1989, Malhotra & Galleta, 1999, Uhlir, 2005). The role of governments is especially important for those climate-related technologies, which are not immediately viable and profitable.

The rate of technology transfer is affected both by motivations that induce more rapid adoption of new techniques and by barriers that impede such transfers. Both types of factors can be influenced by policy. Motivations of the various stakeholders can differ markedly:

- Transnational or multinational corporations are major sources of technology. They seek international sales, market share, and cheaper production costs through equipment transfers and foreign direct investment. Corporations are primarily concerned about profits, acceptable risks and ensuring protection of intellectual property.
- Recipient-country firms are also motivated to transfer technology to minimise costs, just as with transnational corporations. But other motivations may be quite different from those of supplier firms, such as: (a) technical capabilities, quality, or cost reductions that they cannot achieve on their own; (b) the higher perceived status of "international level" technologies; (c) access to managerial and marketing expertise and sources of capital; (d) access to export markets; and (e) access to new distribution networks.
- Recipient governments may seek to increase capabilities for domestic technology-development and promote foreign investment in their country. At the local level, communities and community organisations need to be reached by information networks, get organised and participate in decision-making processes to improve local living

standards and the quality of the environment via appropriate technologies.

- Provider or donor governments may set up policies to encourage technology transfer and fund transfers of research and expertise via Official Development Assistance (ODA) to support development and political goals, but more often are interested in policies that expand foreign markets for their national firms and increase exports.
- Multilateral agencies with development goals, such as the World Bank, the United Nations Development Programme (UNDP), Regional Development Banks and Regional Organisations, pursue technology transfer to support development and as an instrument for achieving desired economic and policy reforms. Multilateral agencies with environmental goals, such as the Global Environment Facility (GEF), have the transfer of ESTs as an explicit objective, and explore new and effective means to accomplish these objectives, by catalysing sustainable markets and enabling private sector involvement in the transfer of these technologies (Freeman, 1995, Grossman & Helpman, 1995, Juma & Yee-Cheong, 2005).

Non-governmental organisations have been at the forefront of concerns about technology choice and the "appropriateness" of technologies transferred through development assistance and commercial channels, the social and cultural impacts of such transfers, and the needs for technology adaptation to suit local conditions and minimise unwanted impacts. The decisions and policies shown in Table 1 represent another point of departure for thinking about barriers to technology transfer and interventions for overcoming such barriers. Each of these decisions and policies will encounter a range of obstacles that have to be overcome if a sound platform for technology transfer and intervention is to be realised. It should be emphasised that Table 1 and examples used throughout this presentation highlight how interventions affect decision and policy making and vice versa.

Table 1: Policy Institutions & capabilities Matrix for Analyzing the Innovation System

Indicators	Policies/Instruments	Institutions	Capabilities
Creating & Commercializing Knowledge	▪ Public Spending on R & D ▪ National mission Programmes ▪Competitive R & D Grants ▪Peer Review ▪ Public Policies for R & D ▪ Matching R & D Grants ▪ Tax subsidies for R & D ▪ IPR Regime ▪ Public Policies for the Commercialisation of Publicly financed Knowledge such as new innovation law ▪ National Research education Networks	▪ Public R & D Labs and Universities ▪ Private R & D Labs, Firms and Private Universities ▪ Informal Innovation Taking Place in Firms ▪ Specialized Government Agencies Supporting Creation and Commercialisation of Knowledge ▪ Specialized NGO innovation institutions ▪ Intellectual Property Right Institutions ▪ Technology Transfer Officers in Public R & D, Labs and universities ▪ Science Industrial Parks ▪ Business Incubators ▪ Early Stage Finance & Venture Capital	▪ High Level Human Capital for R & D ▪ Scientists ▪Engineers ▪Technicians ▪ Techno Entrepreneurship
Acquiring Global knowledge	▪ Openness to outside ▪ Trade; ▪ Foreign direct investment & Technology import policy ▪ Foreign ▪ Education ▪ Business Travel & Trade Shows ▪ Publications &n databases ▪ Internet Access ▪ Attracting Diaspora back home ▪ Setting up R & D antenna abroad	▪ Firms ▪ Universities ▪ Government departments ▪ Individuals ▪ NGOs	▪ Global Scanning ▪ Technology Assessment ▪ Technology Negotiation ▪ Adaptation to domestic conditions

Indicators	Policies/Instruments	Institutions	Capabilities
Diffusing & Using Knowledge	▪ Public policies towards the dissemination and use of knowledge such as for setting up technological information & technology extension services ▪ Policies towards standards ▪ Policy towards intellectual property rights	▪ Technical information services ▪ Extension services in ▪ Agriculture ▪ Industry & Services ▪ Productivity Organisations ▪ Technology Support Institutions & Programmes ▪ Metrology, Standards & Quality Control System ▪ Industrial Clusters	▪ Literacy ▪ Numeracy ▪ Communication Skills ▪ Job & technology specific skills ▪ Management skills
Broader Enabling Environment	▪ Competition & Trade Policy ▪ Effective Regulatory Policy ▪ Support for Entrepreneurship ▪ Good Rule of Law ▪ Good Macro Stability	▪ Efficient Financial System ▪ Flexible labour markets ▪ Fair Courts & justice System ▪ Effective Governance ▪ Effective Formal Education, Institutions & life long Learning System	▪ Capabilities to ensure ▪ Macro stability ▪ Rule of law ▪ Security ▪ Efficient capital and labour markets ▪ Basic citizenship skills ▪ Education & Skills required to compete in an increasingly demanding global economy

Table 1. (Source: OECD,1998)

Table 2, is a tabular representation of the relationship and connection between scientific research, technology transfer and product development. Table 2 presents the linkages of structured R & D with knowledge value chain addition. In addition, intelligent partnership and mechanisms for dialogue and feedback are crucial elements in unleashing the sum potential of the three sectors.

Table 2: Scientific research, product development, and the bridges created between them by technology transfer

Scientific Research	Technology Transfer	Product Development
Research creates new knowledge	Appropriate Technology Identification Knowledge Transfer	New Product Development
Knowledge application beyond research	Knowledge Identification gaps Overcoming prejudices	Knowledge Acceptance, Acquisition & Application
New knowledge horizon	New and creative for doing previously impossible tasks or activities	Breaking new ground/frontiers
Philosophy science paradigm focusing on free exchange , critical analysis of knowledge generation and application	Reconciliation of published results and knowledge promotion vis a vis the need of companies to recoup research investments costs	Patents Proprietary Rights Licenses & Royalties Copyrights
Research Replication & applicability	Research limitations Identification Experimentation & testing	User Friendly Products based on new discoveries or technologies.

Table 2. (Source: Adapted UNECA et al 1998)

In summary, Table 3, maps out the theoretical migration and solidification of key technology and knowledge transfer principles metamorphosis. What is critical is to realize that the development trajectory has moved from being exclusive of society to being inclusive as democracies have progressed from one stage of development to a more advanced form of development.

Table 3: Chronology of Technology & Knowledge Paradigm Shift

Indicators	Liberalisation Mindset	Modernization Mindset	Knowledge Based Economy Mindset
Is About	Undoing	Building	Building Winning Opportunities
Creates	Freedom Fluidity Even Playing Field	Modern Institutions Rule of law Professionalism & Ethics	Vision Winning Mentality Vibrant industrial base
Main Focus	Stability Incentives	Productivity catch-up	Global Competitiveness
Domain	Economy	Economic Social	Society
Government Role	Deregulate	Appropriate regulation	Facilitation Intergration
Anxiety	Did you liberalise too fast?	Did you modernize too slowly?	Did others leave you in the dust?

Table 3. (Source: Vinnova et al, 2006)

2.0 TECHNOLOGY & KNOWLEDGE TRANSFER: PERSPECTIVES

One major result of the advent of ICT is higher networks and connectivity. Globilisation has increased competition leading to significant shifts in world trade patterns and economic relations. Now, even corporate research and development is internationalised. Countries and companies/organisations competitiveness depends, more than ever, on their ability to access, adapt, utilize and master scientific and technological knowledge, for a continuous innovation process geared towards enhanced development. The ability and capacity of an entity to reduce science and technology through knowledge transfer of products and services in tandem with market demand becomes of paramount importance.

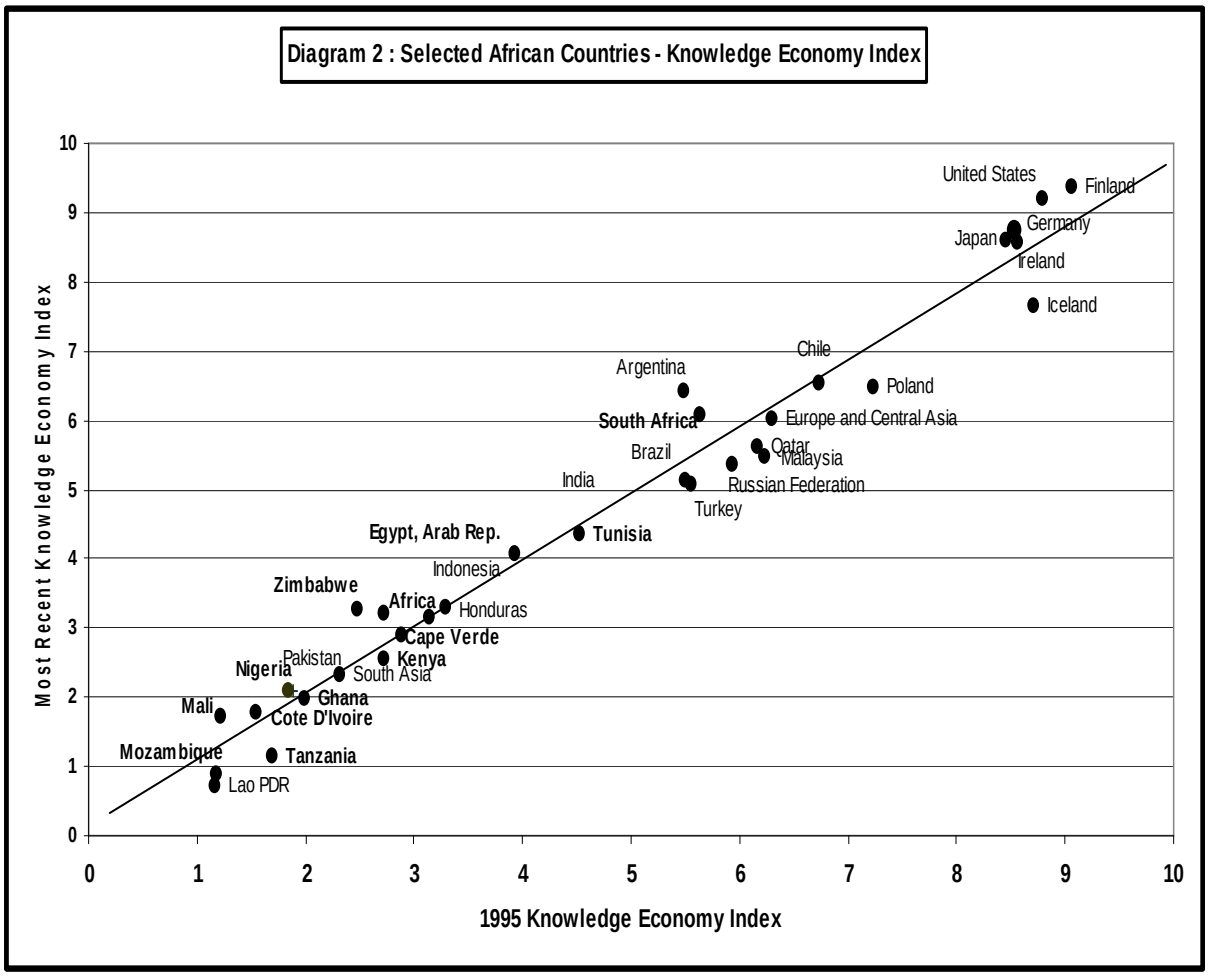
In this worldwide context, to promote sustainable development, Africa should adopt and implement a breaking-down approach from its current position of passive "Technology Spectator" and urgently embark on a vigorous technology innovation strategy, both at national and regional levels. To that effect, it has to be noted that Africa's overall and longstanding development, like in any region of the world, should be based on the triptych **E**conomy-**E**nergy-**E**nvironment, named as the **E3 dimension** of sustainable development. However, in Africa two other dimensions of the environment namely cultural and social play a very important role and have to be taken into account for any development policy and process to be meaningful and successful (Mlosy, 2005, NEPAD, 2005, Kane, 2007).

Today, what is termed the "Knowledge Economy "(KE) arises, above all, from the application of the twin forces of globalization and technological advances, resulting from a closer linkage, between science, technology and innovation. Therefore, KE requires proper Knowledge Management (KM) which is a multidimensional process involving context, culture, content, mechanisms, infrastructure, policy, *et cetera.* The knowledge economy is creating a constant state of restructuring at the global, continental, national, regional, sectorial and firm levels. This provides leverages and opportunities for enhancing growth and competitiveness by increasing productivity in all sectors of the economy and adding massive value to local raw materials and natural resources. Diagram 2 depicts a snapshot of KEI for a few selected Africa countries in contrast with a few selected developed countries.

Diagram 2, presents a diagram that shows the Nordic Countries such as Finland in the leading pack while the bottom is predominantly made up of sub-Saharan African countries. African countries as they embark on their technology and knowledge transfer path need to benchmark efforts with their developed counterparts but at the same time develop context specific technology transfer and knowledge model best customized and formatted for their own conditions.

In this regard, KE has brought revolutionary change to virtually all markets and sectors but at the same time, also carries risks of relegation and marginalization for countries, firms or organizations which fail to keep pace, and track with those knowledge and technology trends to transform them into deliverables that make them continuously relevant.

Diagram 2: Selected African Countries – Knowledge Economy Index 2005



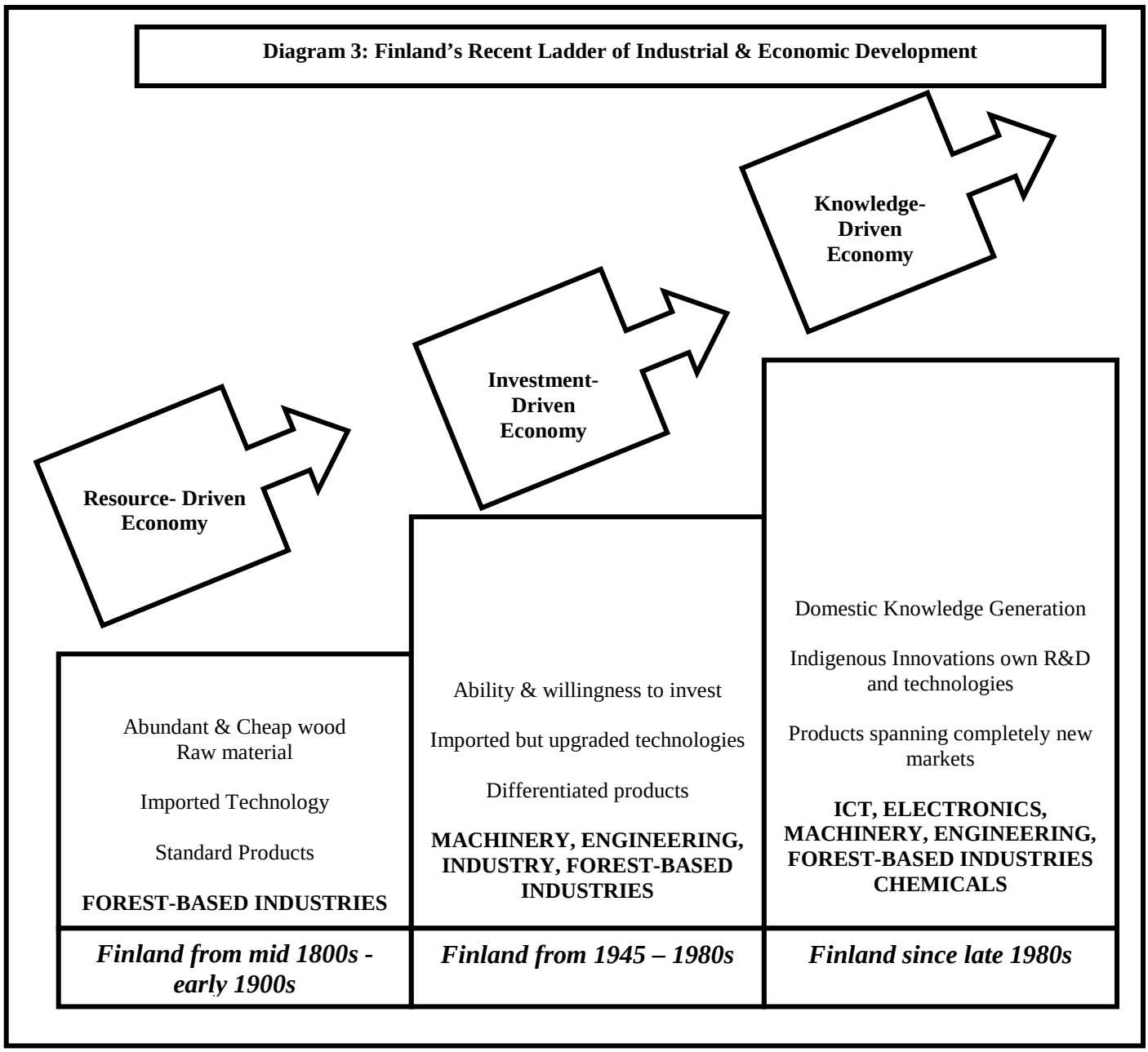
(Source : www.worldbank.org (K4D)

A successful and sustainable KE requires a strong economic and institutional regime, a well educated and skilled population, an efficient innovation system and a dynamic information and communication infrastructure. Finland's success story clearly highlights that engaging in a successful development planning exercise requires a clear vision, support systems and an enabling infrastructure as presented by Diagram 3. Diagram 3 presents a fact suggesting that African countries need to benchmark and compare technology and knowledge development experiences with caution. Defining an appropriate technology and knowledge transfer approach is important. It is important to stress that Finland's industrialization was anchored on forest based industries. African countries can take anchor their own industrialization on the basis of resources indigenous to each country be it in the mining sector, agriculture sector *et cetera.* This should be informed and underpinned by the initial development and growth of available natural resources (OECD, 1998).

Diagram 3 portrays how over the past 50 years Finland' production in key industrial sectors has grown from strength to strength. The key was to engage in R & D and technology innovation and transfer. Reviewing Finland's industrial development over the last 50 years underscores a number of points.

Firstly, return on investment from the R & D and S & T focus has a long gestation and incubation time.

Diagram 3: Finland's Industrial & Economic Development Path

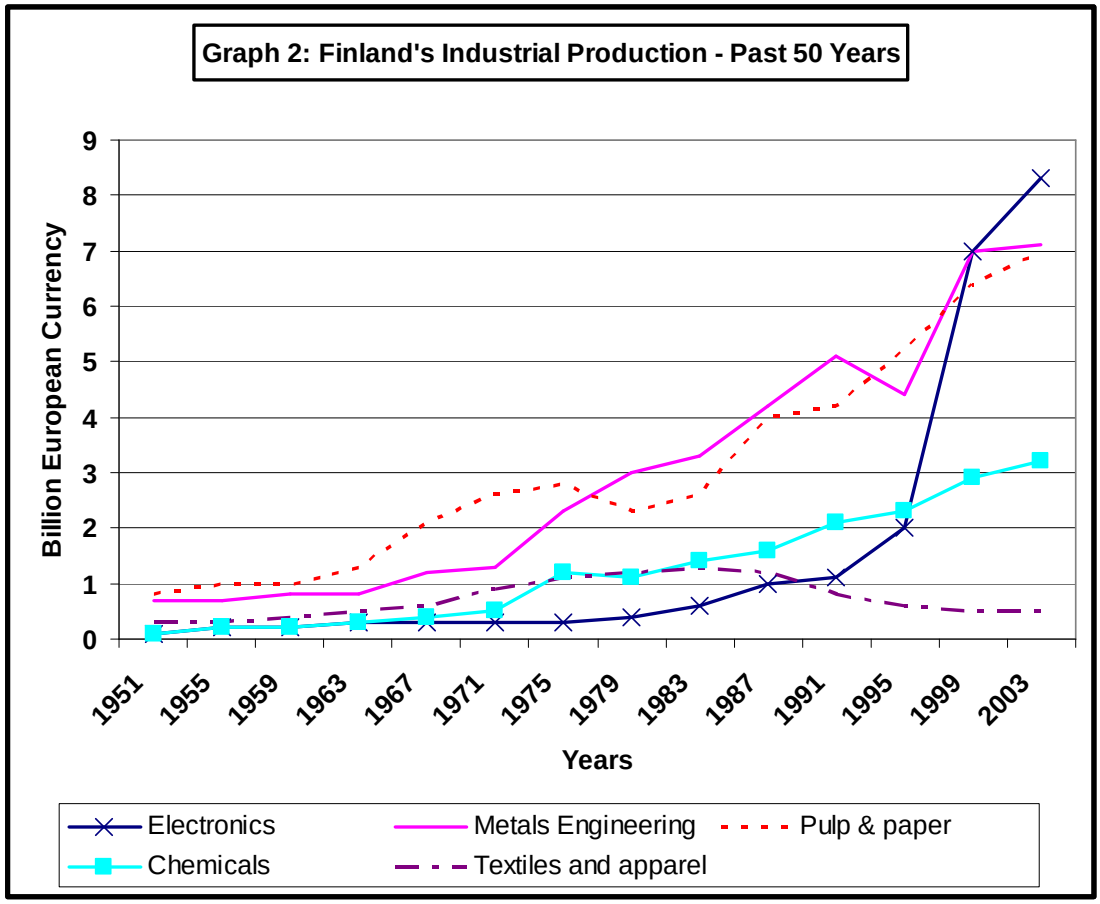


(Source: Vinnova, 2006)

A close analysis of Graph 2 indicates that the take off after initial investment in science and technology is slow as establishment costs of infrastructure and systems installation and configuration and human capital development take the bulk of national resources (i.e. 1950-1960). The initial development and growth phase is depicted by the years 1961-1975. 1975 -2000 represents the

rapid growth and development phase of science and technology. The years' extending beyond 2000 is the maturity and stability phase of technology and knowledge transfer. It therefore goes without saying that strong and visionary leadership and finding champions in the technology and innovation revolution are key ingredients for success. Graph 2's success story depicted by the rising levels in various technology areas, could not have happened without a strong S & T infrastructure, mechanism and system.

Graph 2: Finland's Industrial Production – past 50 years



(Source, www.worldbank.org (K4D)

Diagram 4 presents the Centres of Expertise concept that anchored and propelled the successes in technology and knowledge transfer for Finland. However, diagram 4, does not indicate the importance of providing incentives and creating intelligent viable linkages, networks and connections between knowledge generators points, incubation points, value addition factories and marketing and retail sector. A sound platform that enhances synergies produces knowledge creation, innovation, patents, royalties, copyrights *et cetera.* Such an appropriate environmental infrastructure leads into various products, projects, programmes and services that impact positively on the economic performance and human development index (HDI) of a people. This implies that African Governments should maybe clearly lay the ground for Africa readiness to seriously increase its scientific and technological potentials, resolutely embark on KE, promote its sustainable development and

become a key partner of the world economy and trade (Kuchena & Chakwizira, 2004a,c).

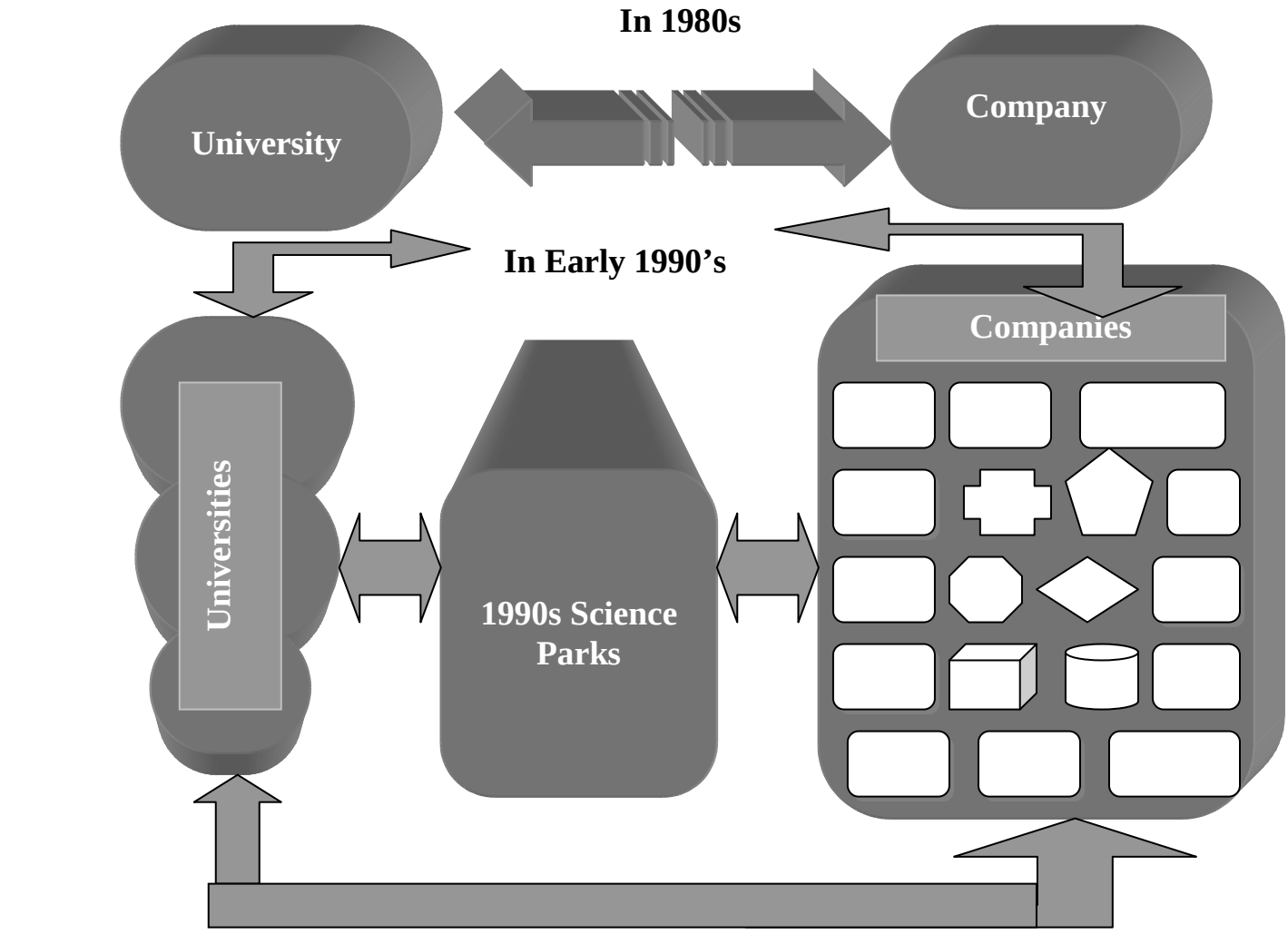
It has been argued that the real wealth of any country is its people. The centerpiece of any country's development process can be argued has always revolved around knowledge. In this regard, a fundamental enabler of KE is education especially of the scientific and technical skills which are generally associated with higher levels of teaching and research. Science and technology generation, application, duplication and transfer are key factors for creating, sharing, disseminating and effectively using knowledge for problem solving and innovation. Technological knowledge and its proper use has always been a critical ingredient for economic success. Indeed, the western and eastern world development and compositeness is build and anchored on a strong science and technology base. However, the paradox and challenge for Africa is to entrench and foster a strong culture and infrastructure for science and technology education and discipline growth, development, management and sustainability. The ultimate aim being to develop a critical mass of African scientists and researchers to tackle head on the development challenges and issues swiftly. Currently, Faculties of Science and Engineering of African Universities are registering low intake and annual growth rates in students enrolment. The capacity to replenish, replace and increase the stock of scientists and researchers is therefore being eroded and threatened posing a threat and dent at efforts towards addressing the capacity skills gaps in the science and technology industry and field. A science and technology policy framework and strategy both at the continental level cascading to country and regional level needs to be strongly pursued to its logical conclusion (Karisson, 2006, Naim, 2005, Kane, 2007].

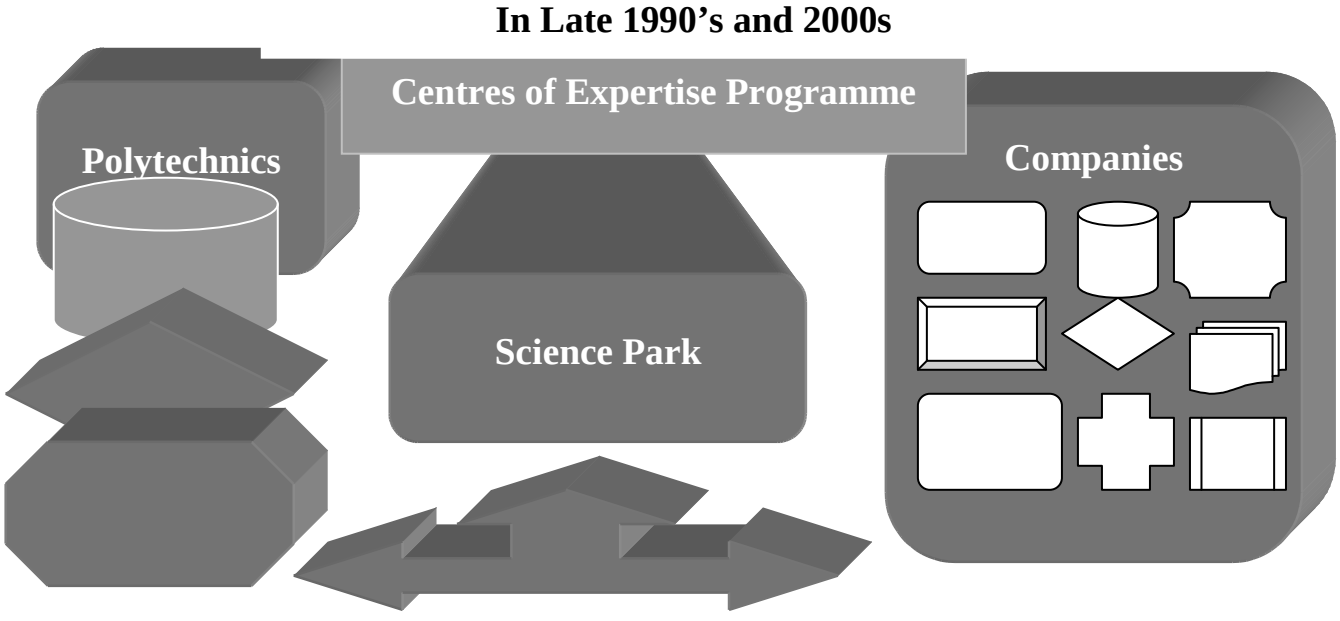
Therefore, investing in human capital resources, research-development, promotion of innovation and entrepreneurship through establishment of trust and strong partnership among all key stakeholders such as government policy makers, higher education and research (HER) communities, production entrepreneurs, funding agencies and consumers associations should be given priority. More emphasis on technological education and training as well as on the ability to acquire new scientific and technical basic skills, allowing comprehensiveness, performance in a competitive world, autonomous action, interactivity and functioning in socially heterogeneous groups, should be top priorities and basic elements of new Africa's lifelong learning systems, for which specific strategies should be implemented both at national, sub-regional and regional levels (UNECA, 1997).

These strategies need to be conducive to long term sustainability. The approach should both adapt the education and research systems to the new and evolving world development paradigms and challenges. In addition the role and scope that the involvement of the private sector, with a more market oriented approach, as well as with a large utilization of environmentally sound technologies (ESTs) should not be under-estimated. The use of ESTs, in the context of Africa's sustainable development, should first require a comprehensive technological needs assessment, through complete surveys (TNAS), to clearly identify the real needs to be satisfied. In this regard, it has

to be taken into consideration including a number of key parameters related to the global economy, technological opportunities, energy supply but also to socio-cultural dimensions so that the goal of a clean environment is harvested.

Diagram 4: Centres of expertise role in regional and local innovation (Source: Vinnova et al, 2006)





Consequently, African Universities, Higher Education and Research & Development Institutions, Ministries of Education, Science & Technology in collaboration and partnership with other Ministries such as Ministry of Health, Ministry of Environment & Tourism, Ministry of Mining & Energy Resources, Ministry of Trade and Commerce have important and crucial roles to play in actively contributing to Africa's sustainable development, by judiciously performing their mandate, standing mainly on the following three pillars:

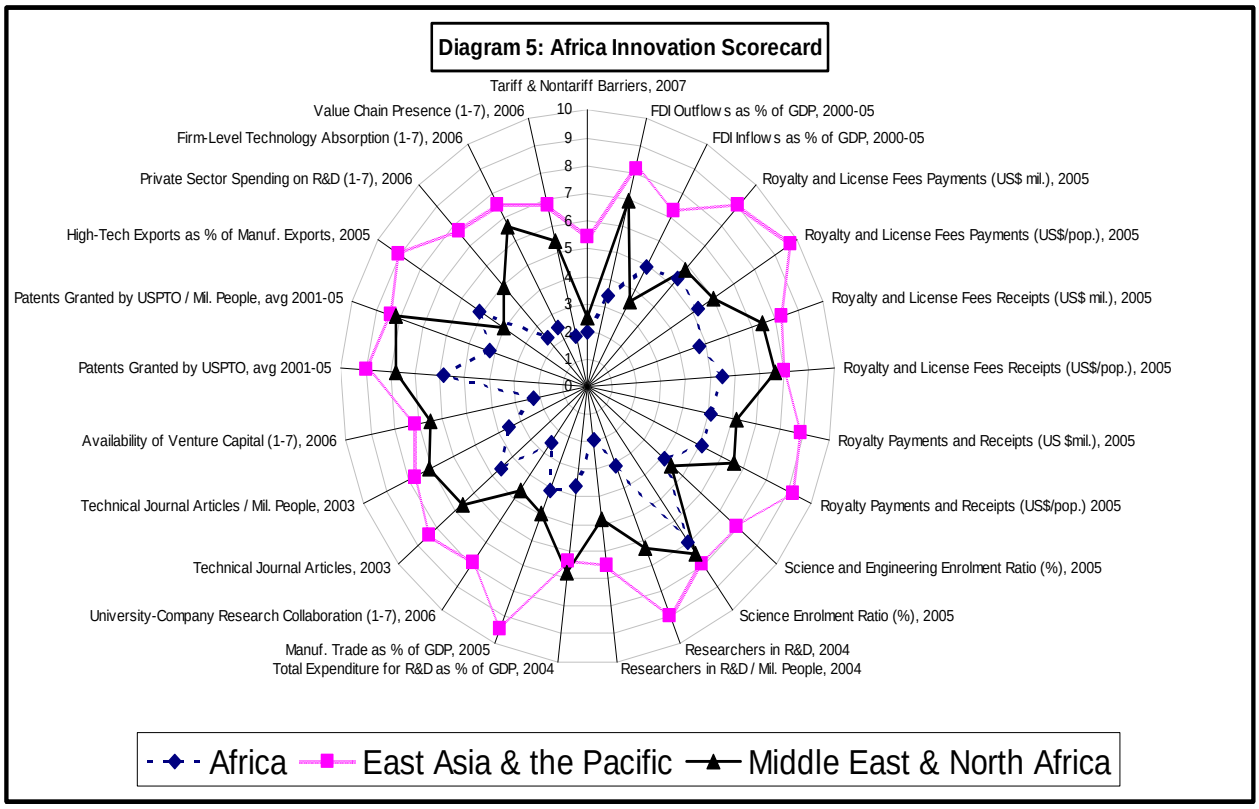
- Knowledge generation, with relevant research programmes;
- Knowledge sharing, dissemination and diffusion, through training; and
- Knowledge utilization and application for development purposes, through innovation and delivery extension services, properly geared to the needs of national communities, whether at governmental, entrepreneurial and societal levels (Allee, 2003, Kim, 1997, Kuchena & Chakwizira, 2004, Kane 2007).

This needs to be combined with innovative skills and knowledge transfer management programmes, projects and systems that can outreach migrant internationally attractive and competent African labour (Kane, 2007). At the same time, a fast-track second-generation succession plan and strong policies to reverse brain drain need to be instituted with clear vision, milestones, incentives and infrastructure support for indigenous science and technology policy and strategy. It is also important to entrench and sustain mobility of Scientists and Engineers and promote public-private partnerships, to develop technological capabilities of African Universities, R &D Centres, firms and businesses with national, regional and global partners.

2.1 TECHNOLOGY & KNOWLEDGE TRANSFER THEORETICAL DISCOURSES

Proponents of endogenous growth theory and evolutionary economics emphasize the importance of spillovers in technology and innovation both of which are important elements of long run economic growth (Abramovitz, 1986; Benhabib and Jovanovic, 1991; Romer, 1990; Grossman and Helpman, 1991). Developing countries are typically poor, technically backward and often characterised by low levels of physical investment, technical change and innovation (Lall, 1992; Rasiah, 2005). In comparison to developed countries, Paul Romer claims that developing countries suffer from 'idea gaps' and 'object gaps' (Romer, 1993). They suffer from idea gaps since they generally lack economic value adding ideas such as knowledge and technology. Similarly, they suffer from object gaps due to scarcity, or all together lack of physical capital such as factories equipped with state-of-the-art machinery as well as existence of efficient communication networks such as roads, railway, ports and airport facilities. Diagram 5 consequently, aptly highlights the low output and throughput in terms of patents, royalties, journal publications *et cetera* by Africa. This has implications in terms of the science and technology agenda that African governments can consider adopting.

Diagram 5: Africa Innovation Score Sheet

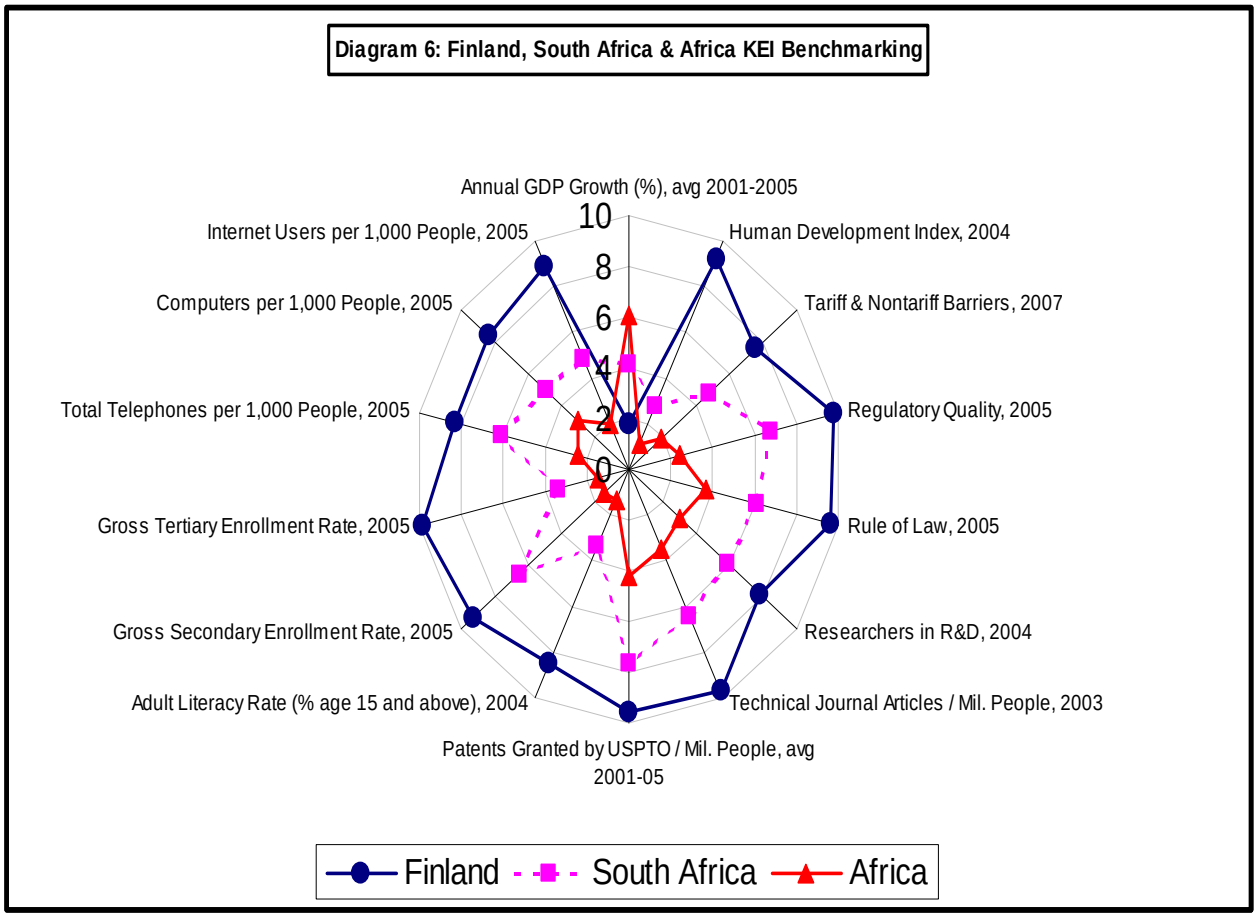


(Source www.worldbank.com)

Diagram 5 shows Africa's innovation scorecard. On average Africa lags behind all the other continents on the parameters that measure innovation in technology and knowledge transfer. The obtaining situation points to a malfunctioning and dysfunctional knowledge system requiring attention (Kuchena & Chakwizira, 2004). Revamping the educational and knowledge reproduction system maybe be crucial if the trend has to be reversed. Diagram 6 takes the analysis deeper by considering a leading economy in Africa (i.e. South Africa) and juxtapositioning it with one of the leading economies in the World (i.e. Finland). The idea is to see whether the patterns change or not. Suffice to point out that the gulf in the KEI still remains sharp pointing to the need for more work in this direction by African countries.

Diagram 6 highlights that despite South Africa being one of the strong and advanced economies in Africa; it still has a long way before it can compete effectively with the developed countries in terms of the KEI. Although South Africa performs significantly different from the average African performance, it however performs at half the leading countries performance. Perhaps a lot of groundwork has therefore to be done by both leading and lagging African countries if they are to come to levels of development that are close with their counterparts in the developed countries.

Diagram 6: Finland, South Africa & Africa KEI Benchmarking



(Source: www.worldbank.org)

In light of this debate, spillover occurrence is presumed to be one of the ways through which idea and object gaps can be filled. This is based on the premise that MNCs are characterised by firm specific assets1 – ownership characteristics – which enable them to invest abroad (Hymer, 1960; Kindleberger, 1969; Dunning, 1993). Such investments are likely to be accompanied by spillovers often perceived to include techniques and advanced know-how in production technology, organization, management, marketing, commercialization of R&D innovations etc. Architects of endogenous growth theory however, reiterate that for technology and innovation development to take place, positive spillovers must be accompanied by tremendous accumulation of capital and knowledge through concerted learning effort, R&D and human capital development (Nelson and Phelps, 1966; Lucas, 1988; Romer, 1990). This is supported by evidence based on East Asian economies such as Malaysia and Singapore which relied heavily on FDI – sometimes referred to as FDI led growth process (Westphal, 1990; Rasiah 2005).

[1] Firm specific assets in the context of developed countries imply things like sophisticated state-of-the-art technology, process in production technology, high R&D and innovation capacity etc.

2.2 MAJOR CHALLENGES FOR AFRICA

2.2.1 Global Development Challenges

Africa faces a number of paradoxes. On one hand, Africa is endowed with significant manpower and a wealth of natural resources such as water, minerals, petrol, biodiversity et cetera. At the same time poverty is rife in Africa.. Consequently unemployment, hunger, malnutrition, serious diseases, lack of access to social facilities such as health and education are key development challenges.

Table 4: Selected Socio-Economic Indicators on Africa

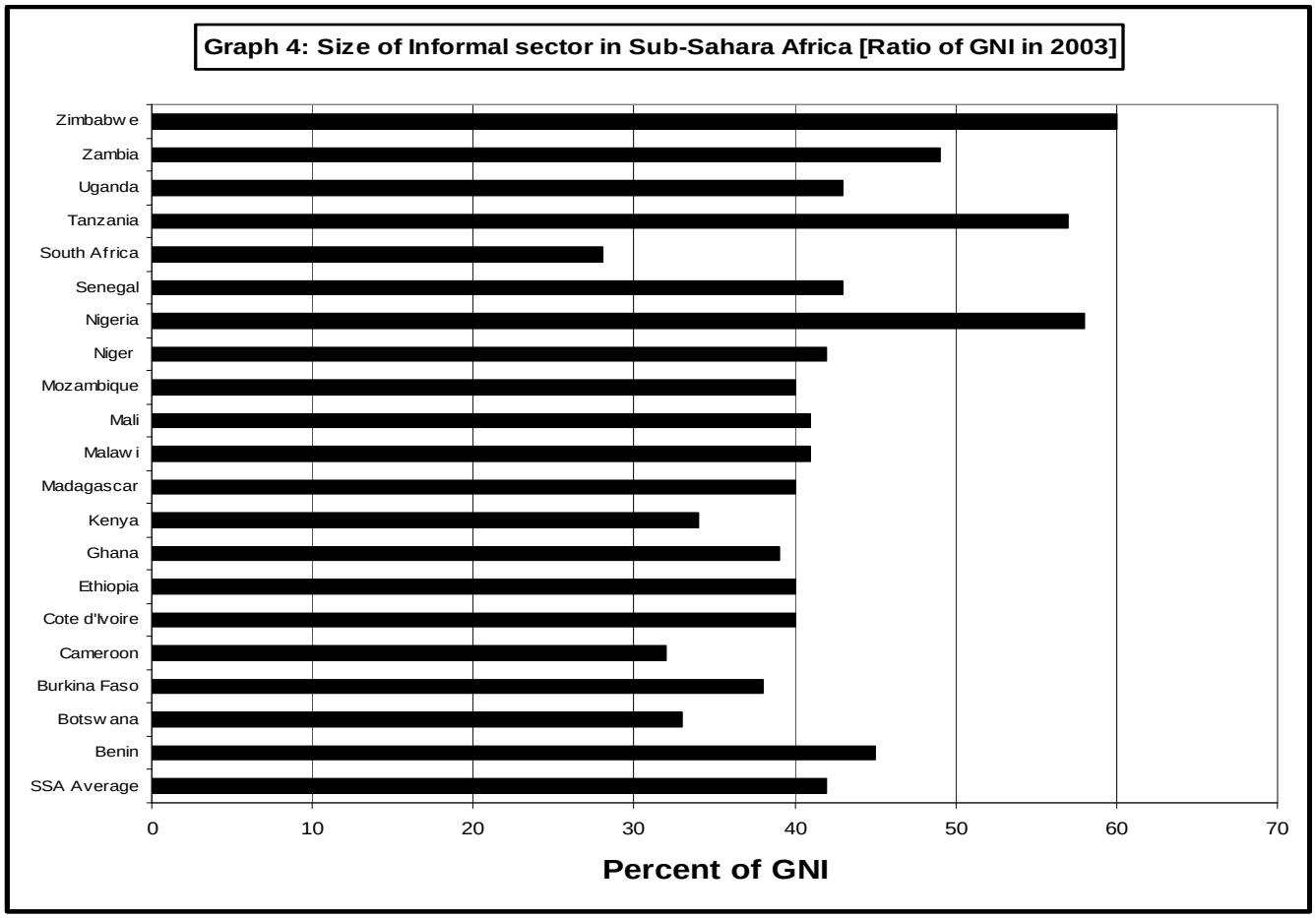
Year	2000	2002	2003
Life Expectancy at Birth	50.9	50.7	50.8
Infant Mortality Rates (per 1000)	88.7	86.9	85.8
Crude Death Rate (per 1000)	15.2	15.3	15.2
Gross Primary School Enrolment Ratio	87.3	90.3	92.0
Gross Secondary School Enrolment Ratio	37.5	41.2	42.1
Adult Illiteracy rates	39.8	37.9	36.9

Source: AfDB 2007

Table 4 reinforces the observation that faces problems of numeracy, water and sanitation as well as proper health facilities and services. Technology development and knowledge transfer directly in the health, water sector, engineering, agricultural processing et cetera may possibly play a significant role in tackling these challenges.

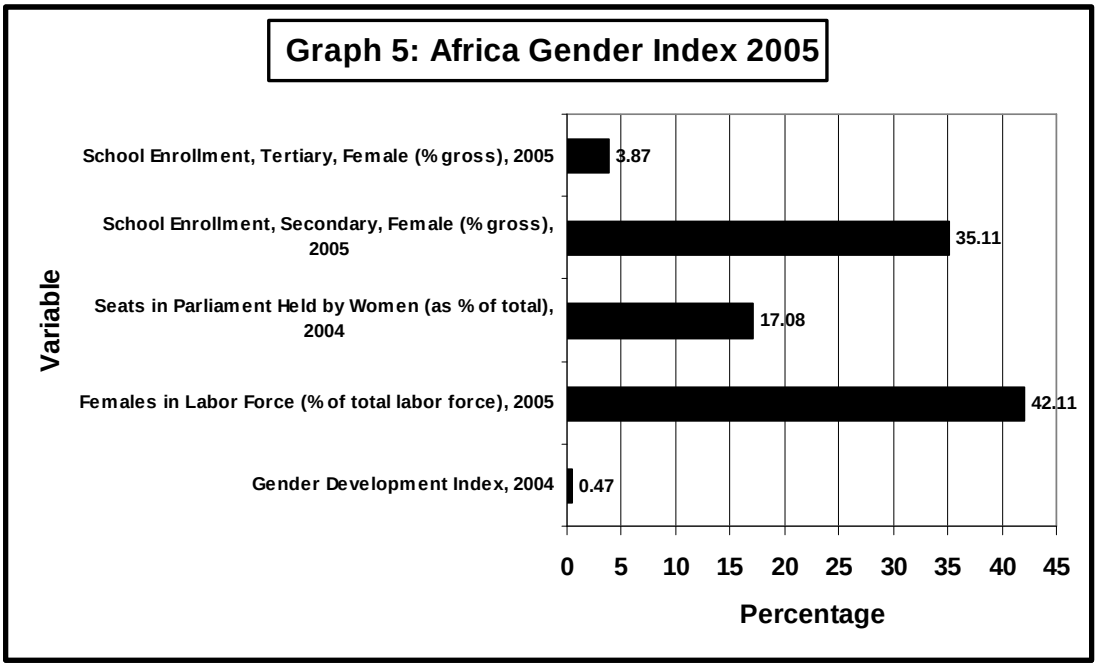
Another challenge that Africa faces besides the education challenge is an unemployment problem (Kane, 2007). Consequent to the high unemployment, the informal sector has increased over the years in various African countries. Graph 4, shows a pictorial survey of the informal sector component in sub-Sahara Africa.

Xaba et al (2002) summarises the experiences of a number of African countries, which shows that there is a decline or stagnation in employment growth in the formal sector, while the informal sector on the continent has been growing in terms of both its share of output and employment. For example, informal employment in Kenya and Uganda exceeds employment in the formal sector. In terms of southern Africa, In Zambia, 43% of urban employment is in the informal economy, while in Mozambique evidence suggests that 30-40% of urban households were dependent on the informal economy in the 1990s. Developing appropriate technology to incubate and support SME/Is therefore is important.



(Source: World Bank Doing Business database. This indicator measures output in the informal economy as a share of gross national product (%GNP, 1999/2000) sourced from a study by Schneider (2002).

Besides, education and the informal sector, Africa also faces the challenges of responding to gender and development as it embarks on various endeavours meant to revolutionize the science and technology landscape. Graph 5, presents the skewed nature of access to education and gender imbalances within Africa. While it is recognized that science and technology development should be at the forefront of development endeavours by various African governments, this should be pursued with gender equity and management not being forgotten (AfDB, 2007). The Gender development index is very low yet at the same time female students who proceed to enrol for tertiary education are few. The challenge for Africa is that they are few females in the science and engineering sectors including research and technology fields. Policies, measures and strategies to integrate the girl-child and women in the science and technology areas need serious consideration,



Source: (www.worldbank.org)

Observers have commented that these problems are compounded by the lack of a clear vision by national governments, lack of strong political will and leadership, inadequate infrastructure, energy challenges, lack of basic water and sanitation infrastructure and provision. This situation, among other shortcomings, is largely due to lack of strong innovative science and technology strategy. These strategies should be endowed with required resources, whether human, physical or financial and fully articulated at the national level. In short, the socio-economic development plans should reflect such strategic goals and thrust (Inter Academy Council, 2006 in Kane 2007).

An analysis of the map of Africa yields interesting issues. Whereas Africa's size can absorb China, Europe, Argentina, India and the Lower USA for example, the paradox is that in terms of KEI Africa plays second fiddle to all these continents and nations. For example one Nordic country such as Sweden has a KEI which is double of Africa. However, at the same time this highlights that scope for developing Africa into a Science & Technology giant is huge, given its resource base. Technologies and innovations developed in Europe for example has to take into account the short distances and limited size of their continents. This may by proxy suggest that technologies for Africa may not need to be necessarily the same as those since the distance involved in Africa are long and the resources are vast. This may be a point of departure in terms of appropriate knowledge generation and innovation in Africa.

In order to break the vicious circle of poverty and underdevelopment, Africa needs to define and footpath its development trajectory in a way different from how its has tackled the issue previously. Africa needs to transform itself into a world economic region that is resolutely engaged in overall sustainable development and is a respected global partner in the world economy. Africa has to establish an enabling environment underpinned by fundamental parameters. Among those parameters are peace, democratic and stable political systems, Good governance, social justice, security of both people and goods, together with an appropriate application of scientific and technological knowledge and transfer in the development process (Nawaz, 1986).

It should be pointed out that, in Africa, many resolutions have been adopted aimed at addressing the science and technology landscape and challenges. Firstly, the African Union (AU) (formerly Organisation of African Union) on the importance of science and technology as prime movers of the Continent's socio-economic development (Kane, 2007). Carrying this spirit and purpose further, the major continental initiatives, such as the Lagos Plan of Action (LPA, 1980) and the New Partnership for Africa's Development (NEPAD, 2001) have both made wide provisions on science and technology. However, fine-tuning the implementation modalities and mechanisms to deliver concrete programmes that significantly impact on the continent's socio-economic development still requires sharpening.

A situational analysis of the science and technology terrain in Africa yields the following challenges requiring overcoming. The major issues are:

- Weak strategies for technology innovation and transfer. These are an outcome of an inadequate and inappropriate higher education and research systems. Consequently, few innovative and inventive potential are the output. This may be explained partly by the large trends of brain drain which have now to be converted into brain gain. There is also a lack of a National technological high education, research and innovation systems. In addition Africa is home to a lack of reliable data on Scientific and Technical Potential (human resources, institutions, programmes, *et cetera*.);
- Prevalence of micro-nationalism vivacity, resulting in rivalries, instead of cooperation and integration, based on comparative advantages;
- Communication barriers (Infrastructures, telecommunications, languages, visas, cost of travels, *et cetera*.);
- Harmonization of initiatives aiming at the promotion of Science and Technology throughout the continent (ASADI, NEPAD, MSI, KMA, *et cetera*.) (Posner, 1961, , Nelson & Phelps, 1966, Romer, 1990, Sjoholm, 1997, Kane, 2007]

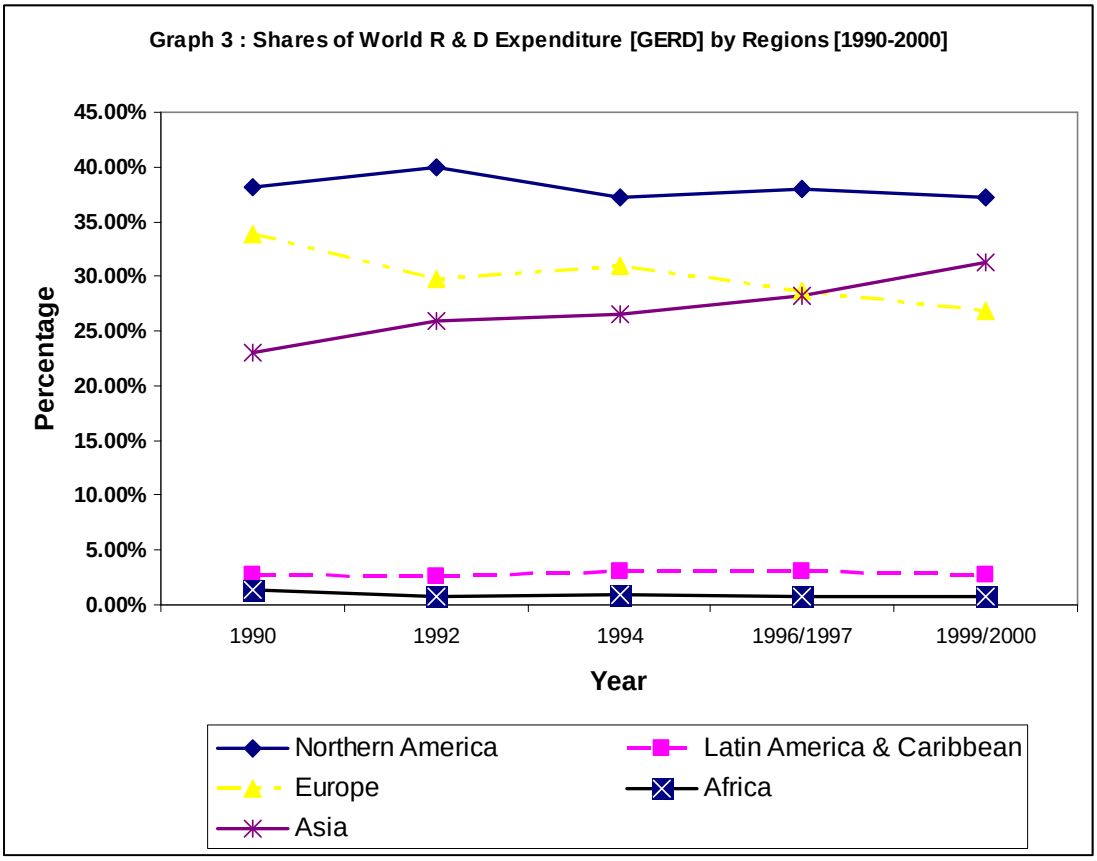
2. 3 Specific Challenges for Higher Education and Research

As Stated by the African Union in its Plan of Action for the Second Decade of Education for Africa (2006-2015), Africa entered the Millennium with severe education challenges at every level. To cope with these challenges, Conferences of Ministers of Education have continued to reiterate the need to

increase access to education, improve quality and relevance, and ensure equity. Among specific challenges the African higher education and research systems have to face are:

- Lack of structural and organizational framework (institutions, infrastructures, extension and innovation mechanisms, feasibility studies, *et cetera*…);
- Lack of capacities and adequate resources (human, physical, financial, communication, information, etc...l). Africa being the world region with the lowest expenditures devoted to Higher Education and Research and, consequently, the lowest number of scientists and engineers, with poorly equipped laboratories and packed lecture rooms ;
- Adaptation to new world integrated Higher Education Systems, such as the "License-Master-Doctorate", named as LMD;
- Inadequate and fragmentation of curricula and research programmes;
- Partitioning and disarticulation towards National Socio-Economic development plans and enterprises, particularly of the private sector;
- Lack of motivation, leading to brain drain;
- Lack of assessment of teachers, researchers, programmes, *et cetera*…;
- Lack of cooperation and partnerships with other institutions, both at national, regional and international levels;
    - Management procedures and bureaucracy, together with the frequency of strikes, either from students, teachers/researchers or administrative staff, *et cetera*…

Diagram 7: Shares of World R & D Expenditure (GERD) by Regions (1990-2000)



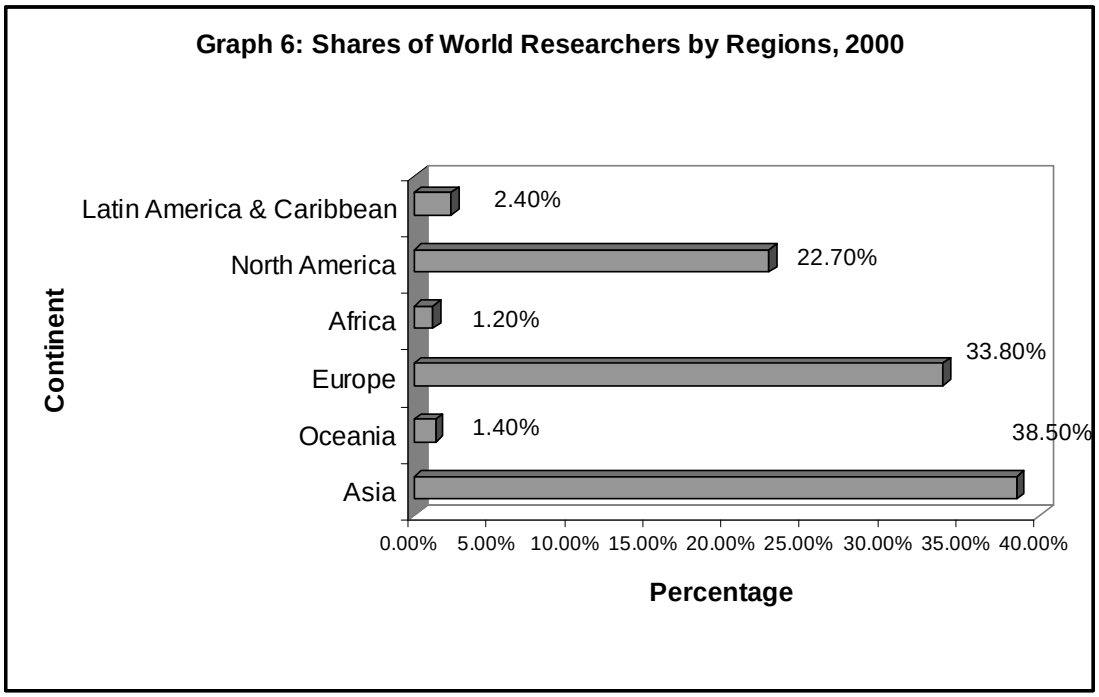
Source: www.worldbank.org

Graph 4 shows that Africa has the lowest share of researchers (i.e. 1.2%) as compared to almost 39 % (Asia) working on innovation, R & D , science and technology , Africa therefore needs to increase its stock of scientists and researchers so that it can compete globally and is able to deploy its own resources to tackle its own challenges.

Accordingly, the African Union (AU, Sept. 2006) considers that following priority areas should be addressed for the Second Decade of Education:

- Improved supply and utilization of teachers;
- Enhancing teacher competence;
- Institutionalizing systematic career-long development of teachers;
- Professionalizing and enhancing capacity for school leadership;
- Improving teacher moral , working conditions and welfare;
- Intensifying pedagogical research for continued improvement of teaching and learning.

Graph 6: Shares of World Researchers by Regions, 2000



(Source: UIS estimates 2004)

2.4 Existing Situational Analysis in Africa (Case Studies & Experiences in Technology & Knowledge Transfer)

The following section highlights examples of technology and knowledge transfer from different parts of the World. This serves as barometer and yardsticks for lessons and good practices that can act as benchmarks for Africa and various African governments as they address the technology and knowledge transfer issues confronting and impacting on them. What Box 1 presents is that Africa has already made significant strides in adoption and implementing ICTs as a change and development agents and catalyst. Its application has been extended to the rural areas so that it's also plays a role in the development and growth of rural areas. It is important to realize that concrete training of target population precedes e-governance. The unlimited potential frontiers of application make ICTs a useful catalyst and tool in accelerating development in Africa, both in the urban and rural areas.

Box 1: ICTS in Africa

ICT – e-leadership is a major factor in process [dynamics] of ICT for development and implementation.

Rapid catching up is taking place, thanks to increased uptake of mobile phones [Tanzania & South Africa for example]. Also improved Internet and PC penetration across Africa explain these trends.

- Tanzania has developed National ICT Policy & stakeholders discussions held through e-think tank
- In Mozambique ICT is a cross –cutting platform for socio-economic development areas e.g. health, education, agriculture, government, businesses et cetera
    - In 2002, the Mozambican government adopted the strategy for the implementation of the 2000 national ICT Policy
    - ICT is better seen as a tool for improving the efficiency and effectiveness in the performance of all development sectors
    - Mozambique is systematically increasing use of ICTs in the government, schools and rural communities
- Support ICT business incubators as a way to empower ICT innovators and entrepreneurs
- Mainstreaming full participation of women in all aspects of ICTs especially in innovation and entrepreneurship

(Source www.csir.co.za, AfDB et al, 2007)

Existing KE initiatives from the grassroots already exist in Africa. This is just one of the examples to the effect that Africa is ready and has already made tremendous progress in mainstreaming itself for the KE and such efforts have to be galvanized.

On the other hand Box 2 gives some tips on how to implement KE strategies. It is critical to start small, phase the KE strategy implementation and be as practical as possible. The local context and context under which technological development takes place is important. Technological innovation should not be at the traverse of a given society and culture.

Box 2: How to Implement KE Strategies

The starting point would be to think of China, some 25 years ago

- Pragmatism & begin with Small IER improvement to leverage entrepreneurship.
- Attract foreign technology and knowledge'.
- Local dynamic spots, scale up [competition].
- Gain confidence and move to higher level of reforms.
- Combine to down reforms with bottom up initiatives.

(Source Mlosy et al, 2005)

It should also be taken into account that a variety of innovations spanning various natural and social science disciplines have occurred in Africa. The disciplines were active R & D and S & T research and products have and are being developed include but are not restricted to ecosystems research, manufacturing, engineering and infrastructure, geomatics, biosciences, mining and processing, energy research, infectious research, indigenous knowledge systems, information communication technology, human science and policy research, agriculture research, water research, health research *et cetera.* Box 3, gives a glimpse of some innovation in Africa.

Box 3: Innovation in Africa: A Snapshot

- Floriculture in Kenya & related Products
- The wine cluster in South Africa and related exports
- Pineapple Exports in Ghana
- Uganda's fish processing and exporting Industry
- Zimbabwe's Micro –Concrete Roofing Tiles, Rammed Earth Technology, bio-diesel local production

(Source UNECA et al, 1998, Kuchena J & Chakwizira J, 2004a)

It is also important to realize that at the strategic continental level, significant progress has been made in creating an atmosphere for research collaboration and partnership within Africa and beyond Africa. Box 4, presents an example of Africa's regional intelligent partnership mapping and collaboration systems. What is critical is to ensure that these linkages and networks leads to tangible innovations.

Box 4: Africa Regional Schemes Global Partnership NEPAD (peer review mechanism).

- Think tank networks.
- Management Schools – Global Business School Network (IFC).
- Science & Technology: ANSTI.
- Role of diaspora to be cultivated.
- Make use of African bases and roots; IK, governance traditions, local languages.
- Africa has good prospects in the 21st century to integrate in the global economy.

(Source: AU, 2006, NEPAD et al, 2005)

In short, Box 4 presents that Africa has the resources and basic knowledge to start and further strengthen existing programmes and activities in place for knowledge generation and management. The role that local champions such as NEPAD, AU et cetera can play in policy guidance and management is important. Finding viable and practical ways of exploiting the Africans in the Diaspora is also a novel area requiring resolution. The role and direction that KMA through DBSA has taken is a step in the right direction. There is need to follow and support such initiatives by a broader and wider African stakeholder base.

Section three to follow reviews the technology and knowledge transfer terrain. In the process key strategic thoughts on the subject are discussed.

3.0 LOOKING AHEAD & CONSIDERING THE OPTIONS: NEED FOR A TECHNOLOGY INNOVATION AND TRANSFER STRATEGY

The Global development of any nation or region is based in its technological advancement and, as observed by Savarain (1993), cannot occur automatically or by chance. It should rather derive from a cautious planning and management, integrating education, research, transfer of technology, intellectual property, the promotion of local enterprises, etc. In this regard and as stated by Uhlir (2005), "perhaps the most important, and frequently the most difficult, requirement for capacity building and development in this area is a political commitment at the top of the government as well as at key Institutions. The commitment needs to be both to the strong support of public investments in education and research…"

Therefore, research and the whole process of technological innovation play a vital role, as they are key elements to increase economic performance which, in turn, promotes employment, food security, access to energy and well-being. They play a fundamental role in the improvement of the standard of living of a nation (OECD, 1984). Consequently research and development should be closely linked to a strong policy, if research results are to be transformed into genuine and sustainable development instruments.

Africa has a solid base to build a prosperous science and technology future. It possesses a rich endowment of human and natural resources. If this can be combined with a real commitment by Governments, it is possible for Africa to reach higher levels of growth and development. This can be achieved through more effective use and sharing of scientific and technological achievements (Kane, 2007). Many African countries are well placed to tap the vast and growing stock of global knowledge in order to overcome the inertia of underdevelopment. To that effect it can be argued that the African continent could make the transition to Knowledge Economy by building on their strength, through strong and appropriate investment in human capital and institutional capacity building on science and technology, as well as through promotion of innovative and competitive enterprises.

In this regard, sectors like agriculture and exploitation of natural resources which moreover constitute the mainstay of the economy of the majority of countries in Africa, fully justify the adoption and implementation of a strong strategy for technology innovation. This approach would perhaps address problems such as poverty, endemic diseases, hunger and malnutrition, which are hindering Africa's quest for sustainable development (Kuchena & Chakwizira, 2004).

This strategy perhaps should be given the highest priority, to allow the creation of a greater range of sustainable wealth, through long lasting income and employment generation, resulting, for example, in more export opportunities for locally processed products (Kane, 2007). A relevant innovation system should be put in place, with appropriate manpower, institutional framework, rules and procedures, aiming at efficient and useful acquisition, mastering, appropriation, dissemination and proper utilization of technological knowledge and packages.

Accordingly, although African countries are generally heavily dependent on foreign direct Investment and donor assistance, our continent should learn from the experiences of other regions. Benchmarking and international best/good practice are important in informing Africa's appropriate, sustainable and accelerated economic growth systems adoption and implementation. Therefore, investment in the science, technology and innovation, through preferential funding, should be linked to achieving specific industrial goals and focus on developing research networks, within the country as well as the region and with the best centres abroad, to lead to an effective and sustainable agriculture and industrialization process.

This strategy should take into account the possible contribution of Africans in the diaspora. This is part of key element for Africa in entering the Knowledge Economy. In this regard, regional organizations such as the African Regional Centre for Technology (ARCT), especially created to promote Africa's technological innovation and transfer capabilities, should be strengthened and given more support, to increase their performance in assisting African countries technological higher education and research Institutions and contributing efficiently to The Continent's technological integration.

The Commission for Africa observed that in terms of technology and knowledge transfer, a number of challenges beset Africa. Scientifically and technically proficient staff is needed to identify opportunities arising from innovation and scientific discoveries and to develop effective policy in areas such as science, trade and resource management. Especially in the private sector, these particular skills are key to performance and innovation.

Africa has been lacking skilled men and women in all these spheres and fundamental to this shortage is the loss of much of Africa's pool of skills to they developed world. Around 70% of Ghanaian medical officers trained in the 1990s have left and it has been estimated that there are more African scientists and engineers working in the USA than in the whole of Africa (African Union, 2006, Kane, 2007).

This shortage starts with higher education, which ought to be the breeding ground for the skilled individuals whom the continent needs. Higher education and research institutes can also improve the accountability of governments and build participation and citizenship. As well as providing skilled staff, they also generate independent research and analysis that supports the vibrant debate that can greatly improve the effectiveness of government policy and other services.

The international mobility of skilled people is one of the key mechanisms for the transition of technological capability across countries. To use this mechanism effectively, countries need to design institutions that enable them to use the skills of their nationals wherever they live. Such institutional arrangements need rely on commitments to international cooperation and partnerships.

Marganinalised in the development process, these universities seek only to churn out graduates. Universities need to be re-envisioned as potentially powerful partners in the development process.

The science, technology and innovation curricula in many developing country universities are outdated or lack a cross disciplinary approach. In certain departments, the research emphasis needs to be shifted towards issues of local and national relevance.

Creating links between knowledge generation and enterprise development is one of the most important challenges developing countries face. A range of structures can be used to create and sustain enterprises, from taxation regimes and market based instruments to consumption policies and changes within the national system of innovation (African Union, 2006, Kane, 2007).

The AU Commission 2004-7 Plan of Action aims to “promote human resource development, capacity building and science and technology as tools and youth as partners for socio-economic development”. Vision of 2005 S & T Consolidated Plan of Action is to;

- To enable Africa to harness and apply science, technology, and related innovations to achieve sustainable development
- To ensure that Africa contributes to the global pool of scientific knowledge and technological innovations

It is also important to note where is further SETI (Science Engineering Technology and Innovation) capacity most needed to advance the MDGs? Are they any critical gaps? This could be in specific areas of research or knowledge in particular skills and professions or in countries and regions. How can developing countries use SETI to best contribute to their development, and to respond to opportunities and threats such as climate change and natural disasters? What can African governments and international organisations and partners such as DFID do to enhance the role that research plays in informing policy and practice, both in developing countries and in DFID.

It is critical for African governments to focus on innovation; especially at local level including organisational change. Research and development can lead to innovation which ultimately will impact on societies positively (AU, 2006, NEPAD, 2005).

The future of S & T lies in investing in higher skills and innovation. There is also need to identify some priorities for African S&T statistical development.

South – South Cooperation and forming intelligent linkages, connection and partnership is crucial.

3.1 NEED FOR COOPERATION AND PARTNERSHIPS

3.1.1. GLOBAL CONTEXT

Maintaining information or experience exchange is a must, to stimulate S & T research activity or industrial production. As result of efficient and vibrant Higher Education and Research Systems, establishing Technology Innovation Strategy in our countries, like in any other region of the World, could tap into global knowledge, through trade, foreign investment, collaborative programs and technology transfer with relevant channels and should be based on the four following steps:

- Clear assessment and identification of technological needs, both for productive, educative, administrative and cultural systems;
- Adoption and improvement of locally available technologies; including those based on indigenous knowledge.
- Adaptation and mastering of imported technologies to develop competitive industries, with due consideration of intellectual property rights issues;
- Development of brand new innovations of significance to the country, the region as well as to the global economy.

Now, very often, African researchers or industrialists do not have the appropriate scientific environment, due to the non existence of a well organized scientific and technological community, for instance, in federations or associations by subject matter (e.g. physics, chemistry, biology, etc) or by corporation (e.g. agronomists, nutritionists, electrical Engineers etc) and which participate activity in solving development problems. These researchers are generally isolated and affected by the absence, in their own country, of valid interlocutors in their areas of specialization. In the same way, the rule is the inadequacy of Scientific and Technological information media (updated libraries and documentation centres, specialized periodicals or publications, etc.) or of quick communication on new scientific and technological achievements (access to databases and data banks). Furthermore, it should be noted that the participation of African researchers in international scientific events, like seminars, symposia, congresses, etc.) Is most often hindered by the lack of financial means to cover registration, travel and/or subsistence fees – which, of course results in their almost chronic under representation in fora where scientific and technological world events are being discussed. All this has also a negative impact on the inventive and innovative capacities of African Teachers and Researchers (Kuchena & Chakwizira, 2004a, African Union, 2006 , Bhagat, 2005, , Kane, 2007].

Moreover, the scarcity of Scientists, Technologists and Engineers, as well as of physical and financial resources, makes it necessary to avoid duplications and to promote a sub-regional, regional and international cooperation.

This cooperation and partnership strongly advocated by the Lagos Plan of Action (OAU, 1980) as well as the New Partnership for Africa's Development (NEPAD, 2001), could materialize through the establishment of consortia, joint programs or thematic networks, aiming at promoting HER to pave the way for a strong Technology Innovation and Transfer strategy.

It could thus be convenient, through an international approach, to harmonize national scientific and technological development, as well as technological innovation strategies, including within the context of sub-regional politico-economic organisations, such as ECCA, ECOWAS, SADC, *et cetera (*African Union, 2006).

With regard to the need to support African Technological Higher Education and research systems, through dynamic inter-institutional partnerships, following elements could be taken into consideration:

- Needs Assessments of Faculties of Science, Techniques and Engineering;
- STI National Strategy through interactive seminars involving Higher Education Teachers and Researchers as well as top Policy Makers ;
- Capacity Building of Technological Higher Education and Research (HER) institutions, including:
- Exchange of Teachers and Researchers, through visiting programs in Nordic Countries Universities and Research Centres;
- Infrastructure and Equipment of Laboratories;
- Development of curricula on STI policy;
- Establishment of a Framework for National integrated system of Higher Education and Research;
- Establishment of an Extension and innovation Unit, with services to national or regional Communities (private Enterprises, Public bodies, NGO, etc..); and
- Networking, Connectivity and sharing success experiences.

It is understood that partnerships which could be driven by the KMA initiative should mostly focus on the development and utilization of relevant Scientific and Technological achievements, to address specific development priority areas, among which are:

- Agriculture and Food security ;
- Public Health ;
- Water and sanitation ;
- New and Renewable Energy sources;
- Valorization of Natural Resources ; and
- New Materials development.

Therefore, the promotion of emerging technologies, such as Biotechnology, Nanotechnology, Information and Communication Technologies, Renewable Energy Technologies, etc…, should be taken into due consideration.

3.2 ARCT'S EXPERIENCE AND PROSPECTS

The African Regional Centre for Technology (ARCT), an Intergovernmental Organization established in 1977, in Kaduna, Nigeria, under the aegis of the United Nations Economic Commission for Africa (UNECA) and the former Organization of African Unity (OAU), Now African Union, became operational in 1980 with its Headquarters located in Dakar, Senegal. With a membership of 31 African countries (Algeria, Benin, Burkina Faso, Burundi, Cameroon, Cape-Verde, Democratic Republic of Congo, Egypt, Equatorial Guinea, Ethiopia, Ghana, Guinea, Guinea Bissau, Kenya, Liberia, Malawi, Mauritania, Mauritius, Morocco, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Somalia, Sudan, Tanzania, Togo, Uganda and Zambia), the ARCT is made up of 3 Organs: the Governing Council of Ministers, the Executive Board and the Secretariat (Kane, 2007).

According to its objectives, the ARCT aims at becoming an efficient tool in triggering, strengthening, coordinating and integrating national, sub-regional and regional technological capacities and strategies of African States.

In this regard, the operational programmes of the Centre, mainly centered in the generation and application of Environmentally Sound Technologies on the priority areas of Food, Energy and Capital Goods, have covered Technological Needs Assessment Surveys; Technological Information and Documentation; Research-Development; Technological Demonstration and Extension; Consultancy and Advisory Services; Training and Human Resources Development.

Through its natural resources development programme applied to the Food and Energy Sectors, the Centre is currently embarking on the use of techno-enterprise incubators to ensure an effective link between Research and Development and a better adaptation of training to employment. In this regard, and according to the orientation set by the Centre's Policy-making Organs, special emphasis will be laid on Human Resources Development, Technology Transfer services and technology information system for the strengthening and development of endogenous technological capacities and on the enhancement of the local value added, particularly within the framework of private rural SME/SMIs.

Recently, based on the experience of previous projects, the ARCT focused its efforts more pointedly on programme elements whose outputs show great promise for visible impact in the region, particularly for food security and poverty alleviation. To that effect, the Centre strategic programmes have been reoriented on the following elements:

- Technology Policies : Their reviews and integration with economic development planning;
- Technical Training and Human Resources development ;
- R&D Community and Enterprise Linkages : Establishment of demand-supply-driven Technology Services ;

- Assistance to Small and Medium Enterprises, through Provision of Integrated Package of Technology
- Transfer Services ;
- Technology Information Systems and Networks, Particularly as a tool for technological awareness and
- Regional integration.

Now, with the prospects and hope of the AFRICAN UNION, the ARCT aims to become either it's statutory or subsidiary body, and fully committed for the implementation of the "AFRICA'S SCIENCE AND TECHNOLOGY CONSOLIDATED PLAN OF ACTION" launched by the AU/NEW PARTNERSHIP FOR AFRICA'S DEVELOPMENT (NEPAD). Therefore, the Centre which is about to initiate a program on "Managing Science, Technology and Innovation for Africa's sustainable development," in cooperation with the STRC/AU and various partners ,is fully prepared to play a significant role in the KMA process, particularly with regard to issues related to Technology Innovation and Transfer (African Union, 2006, Kane, 2007).

It should be pointed that it is debatable whether ARCT has made a positive impact to the African science and technology landscape. One school of though argues that the centre has not made any meaningful impact on the continent except in French speaking countries. It should be pointed out that for example in Southern Africa; the CSIR has made a big impact not only regionally but also internationally. Currently a regional research alliance involving, CSIR (South Africa), SIRDC (Zimbabwe) and BOTEC (Botswana) was instituted with the mandate to carry out joint projects, research and exchange experience in the science and technology fields. It is important that centres such as ARCT be also established, or existing science and technology centres in East and Southern African be upgraded and developed to levels comparable or even better than those at ARCT. In cross pollination and fertilization of ideas between and across science and technology centres will bear fruits.

3.3 MAIN RECOMMENDATIONS

This paper highlights a number of key recommendations for technology and transfer in Africa, some of which are under listed here as;

1. Knowledge Economy Benchmarking is important for African countries and governments. This should be developed around the tried KE standard unit of measurements namely economic incentives, institutional regime, education, innovation and information and communication technologies.
2. Innovation in Developing Countries and in Africa in particular is not just new at the global frontier but can be new to the local context. It is therefore important for Africa not to just focus on R & D however important it is, but innovation can and may come from knowledge existing elsewhere. It is not very beneficial to reinvent the wheel. It may be more profitable and relevant to scan the World for knowledge relevant to a specific country's need. It is therefore useful to distinguish five innovation related concepts, namely creation, acquisition,

adaptation, dissemination and use. Each of these knowledge and technology transfer concepts requires different policies, mechanisms and capabilities. Therefore establishing the appropriate infrastructure and enabling environment is paramount. By the same token, focus should not only be limited to creating knowledge but also to getting the knowledge into use.

3. African governments should put in place incentives and mechanisms to make knowledge creation relevant to the needs of the economy inclusion provision for its transfer.
4. Granted that Africa has a strong agriculture and mining component, it is important that R & D and technology interventions should not overemphasized attention to agriculture and industry. The services sector is the largest sector and deserves special attention in the whole knowledge technology and transfer innovation chain.
5. There is need to create and promote more interaction among research centres, enterprises and universities locally, nationally, regionally, sub-regionally and internationally. Intelligent mapping and partnerships are important in technology and knowledge transfer management and sustainability
6. It is also important that measures to support and improve the collection and improvement of indigenous knowledge be strengthened and further developed. The importance of local innovation by communities with clear empowerment implications should be clearly and explicitly defined and provided for. The resources and opportunities to use traditional or indigenous knowledge should be up scaled.
7. It is also important to take note of the fact that Africa is home to a large size of the informal sector and opportunities for innovation embedded in small companies need be galvanized.
8. The technology and knowledge transfer agenda in Africa needs to respond to the concerns and realities of the youth. More than 50% of the African population is young. The gender mainstreaming in this vein is also crucial.
9. In terms of the educational system, on average it needs major improvements. The instructional pedagogy employed means that problem solving, social and life skills (KE) are lacking. It should be re-emphasised that African research institutions are (and have been) generally involved in technology transfer rather than real innovation. Consequently the scientific divide is more acute compared to the digital divide. Invariably, specialized centres of education are needed where absent and should be strengthened where already in place but must work differently from traditional research or learning centres. There is need to exploit fully the opportunity of the “decade for African education 2006-2015” launched by the African Union.
10. It is important to develop explicit strategies and policies to leverage knowledge from the country’s Diaspora.
11. In the whole technology and knowledge transfer debate and movement, it is important to avoid neglecting metrology and quality control. They may not be exciting but they are very important to disseminate technology and to help firms and countries compete in global markets.

12. Innovation in technology and knowledge transfer is not just about hardware. It is important to intergrate the cultural and social aspects. They need to be taken into account to succeed in innovation.
13. Africa needs to think big around the four knowledge and technology pillars namely the economic and institutional regime, education, information infrastructure and innovation. This entails thinking outside the box and developing new mindsets around approaching the technology and knowledge transfer challenge.

Having discussed, reviewed, and made suggestions concerning the technology and knowledge transfer terrain in Africa, it becomes important to advance concluding remarks. A mammoth and complex task such as resolving the technology challenge for Africa cannot have one answer. One cannot also therefore be conclusive.

4.0 CONCLUDING REMARKS

The inadequate global teaching and research capacities of the African Technological Higher Education and Research Systems, as a consequence of poor technological Innovation Strategies, are all negative factors affecting Agriculture, Environment, Industry and the Manufacturing sector.

Therefore, it becomes urgent to promote, within African states, a strong technological innovation policy, supported by efficient Higher Education and Research Systems and based mainly on the valorization of local resources.

To that effect, it would be necessary to significantly increase the global resources allocated to Technological Higher Education and R&D institutions, to enable them to fully contribute to Africa's sustainable development, define promptly for potential promoters all the technical and financial specifications as well as the practical modalities for the commercial exploitation of technological results at industrial or craft level, with due consideration to national socio-economic and cultural specificities.

While the phenomenon of universalization is more and more subject to Scientific and Technological innovation, intensified among other things, by the spectacular progress in information and communication technology, Africa continues to be concerned by its mere survival, by the needs of its populations to guarantee their daily subsistence, to combat severe diseases and a number of poverty clusters (African Union, 2006).

The capacity to generate, disseminate and utilize knowledge determines more and more the success of the participation of the countries to the world economy. Being at the rear in all areas of activity, the African population, in spite of the continent's richness in human and natural resources, obviously runs the risks to be abandoned and forgotten in an economic backwardness ghetto, with restricted opportunities.

However, taking into consideration the inception of new initiatives, such as the KMA, led by the Development Bank of Southern Africa (DBSA), together

with sub-regional, regional and international solidarity and cooperation, partnerships, Africa has many assets to ward off pessimism and play its role, as a respected partner, in the world globalized economy. To that effect, the price to pay will be a determined option to increase and develop scientific and technological capacities led by a strong technological innovation policy, fully standing on Technological Higher Education and Research Systems.

In this regard, the original role played by the DBSA, under the KMA process, through concrete inter-institutional partnerships and collaborative programs are of crucial importance. This bank, in conjunction with other Regional Development Banks such as the ADB, the IDB and World Bank could play a leading role to boost African Technological Higher Education, Research and Innovation Systems, to efficiently link them to the continent's sustainable development. In this regard, the ARCT, in accordance with its mandate and experience, is ready to contribute and play significant role, as far as the technology component of KMA is concerned.

It can be argued that Africa runs the risk of falling behind even though there are many opportunities. For Africa to keep pace and track with the rest of the World, in the context of technology and knowledge transfer, it may be necessary to start on many fronts. A top down reform approach where actions to address binding constraints are a necessary but not sufficient condition to resolving the science and technology challenges in Africa. This should be complemented by a bottom up actions reform approach to take advantage of concrete opportunities (African Union, 2006, Dahlman, 20007).

Poor infrastructure emerged to be one of the biggest problems facing firm operations in the Africa. This makes operation and transaction costs extremely high. The consequence is that it lowers interactions among firms and reduces willingness to invest or. Thus poor infrastructure hinders technological spillovers from occurring. As an example, bad roads and high cost of telephone reduces interactions and thus sharing of information, knowledge etc. The government should therefore provide basic infrastructure in earnest. Much has been said on this in the Kenyan context; hence the government should do something once and for all. The success story of East Asian countries shows us that a government that does not offer continuous support and effective industrial facilitation often fails its own entrepreneurs.

Formal and informal interactions with institutions and business associations were important factors in the spillover occurrence process. For instance, interactions created an atmosphere where local entrepreneurs share manufacturing experiences, market information, skills and technological knowledge with foreign firms. The government should therefore encourage more of such interactions. It should encourage and facilitate more and routine manufacturing exhibitions, trade fairs and agricultural shows. This should include international exhibitors who in this case could be technology, machinery and equipment suppliers or just ordinary manufacturing firms. It should encourage product, process and marketing promotions by foreign and local manufacturers. It should encourage firm and institutional visits. Joint activities such as learning and training should be encouraged. Encourage

informal collaborations in activities which reach SMEs and the local communities, through community responsibility programmes, such would widen scope of spillover occurrence. These are just a few examples as cases of useful interactions are endless.

In conclusion, the Zimbabwean experience shows that mainstreaming ICTs into education sector is critical in knowledge transfer to poor, particularly in reaching remote population (Moyo, 2007). A key strategy in developing comprehensive strategies on knowledge transfer in the education sector is to create a supportive policy framework for related sectors. This includes a policy framework to incentive development of mobile market, allow freedom of flow of information and communication, develop rural electrification and a stable human resource based skilled in provision of ICTs. In addition this synopsis proposes exploration of successful replicable distance education models which use internet based solutions to bring about effective educational outcomes .This is exemplified by the successful University of South Africa distance education model in provision of university education. The study argues that an already literate population in countries such as Zimbabwe, Kenya, Tanzania et cetera provides an excellent platform for knowledge transfer to poor through integrated education and ICT strategies that serve poor and remote populations. On the other hand, the Royal Bafokeng ICT and Knowledge Management for community development process in South Africa clearly presents the potential of IT in community structuring, development and transformation. Various ICT office automation tools were employed to enhance Knowledge Management in the context of community development. These include the following:

- Web environment (Internet sites, extranet, and intranet);
- Enterprise Resource Planning (ERP);
- Document/Records and Contract Management Systems.
- Major capital ICT projects within the RBN villages include the following:
- Extension of Wireless Network Infrastructure;
- Voice Over Internet Protocol (VoIP); and
- Multipurpose Community Centres (MPCCs).

The project continues to be refined and improved with time, the ultimate goal being to create an empowered and knowledge community and society that engage meaningfully in development processes and activities [Gachino, 2007, Kane, 2007].

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ACRONYMS AND ABBREVIATIONS

ADB	:	African Development Bank
ANSTI	:	African Network of Scientific & Technical Institutions
ARCT	:	African Regional Centre for Technology
ASADI	:	African Science Academies Development Initiative
CSIR	:	Council for Scientific & Industrial Research
DBSA	:	Development Bank of Southern Africa
DFID	:	Department for International Development
ECA	:	United Nations Economic Commission for Africa
ECCA	:	Economic Community of Central Africa
ECOWAS	:	Economic Community for West African States
ESTs	:	Environmental Sustainable Technologies
HER	:	Higher Education and Research
ICT	:	Information and Communication Technology
IDB	:	Islamic Development Bank
KE	:	Knowledge Economy
KEI	:	Knowledge Economy Index
KMA	:	Knowledge Management Africa
LMD	:	Licence - Master - Doctorate
MSI	:	Millennium Science Initiative
NEPAD	:	New Partnership for Africa's Development
NGO	:	Non Governmental Organisation
R&D	:	Research and Development
OECD	:	Organization of Economic Cooperation for Development
SADC	:	Southern African Development Community
SETI	:	Science Engineering Technology & Innovation
SIRDC	:	Scientific & Industrial Research & Development Centre
SMEs	:	Small-Medium Enterprises
SMIs	:	Small – Medium Industries
STRC	:	Scientific, Technical and Research Commission of the African Union