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Full Length Research Paper

Science and technology parks: An overview of the ongoing initiatives in Africa

Raymond Tavares

Scuola Superiore di Studi Universitari e di Perfezionamento Sant'Anna Laboratorio Management e Innovazione. Piazza Martiri della Libertà, 33 – 56127 Pisa, Italy. E-mail: r.tavares@sssup.it. www.techbridge.sssup.it. Tel.: +39050883833.

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The aim of our study is to review the readiness of selected African countries to invest in Science and Technology Parks and manage them effectively. This is justified by the fact that the number of ongoing or foreseen projects aiming at the establishment of Science Parks is growing on one side. On another side, we observe simultaneously a persisting lack of critical scientific mass for knowledge production and the limited cases of success with regard to those which have been already established. Our study will also raise a provocative query or concern about possible alternative forms of infrastructure that can be most effective and appropriate to support the promotion of technologies and innovations in African countries.

Key words: Science park, technology park, Africa, knowledge society, high technology readiness.

INTRODUCTION

The concept of Science and Technology Park (STP) is diffused in industrialized countries as well as in Asian emerging states. In those countries, STPs are usually competing with universities for scientific invention and talent; and they still remain a "hot issue" for competitive-ness.
According to the International Association of Science Parks (IASP, 2002), a science park is an organization managed by specialized professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions. To enable these goals to be met, a science park stimu-lates and manages the flow of knowledge and technology amongst universities, R and D institutions, companies and markets; it facilitates the creation and growth of inno-vation-based companies through incubation and spin-off processes; and provides other value-added services to-gether with high quality space and facilities.

The first science and technology park was created on the campus of Stanford University more that 50 year ago. This is the base of the success of the Silicon Valley well know today for its technological, financial, educational and research based capacities (Pahlavan, 2007)

STPs remain attractive places for dynamic national and international companies. For instance, the Hsinchu Science Park in Taiwan is now home to several of Tai-wan's giant computer and semiconductor companies. Re-cent economic literature confirms the idea that STPs are the most challenging places to run innovative knowledge based activities.

As in other parts of the world, the STP concept has seized the imagination of African public policy makers. The STP concept is more and more a challenging target for African governments as well as nongovernmental organizations. According to Mr. Neville Comins, CEO of The Innovation Hub - Africa's first fully accredited. Science Park, "Building a culture of technology and entrepreneur-

ship appears to be one of the challenges facing many developing economies. Science Parks can make a meaningful contribution to addressing this". as well as non-governmental organizations. This is an attempt to integrate technology into the development process of African countries.

New technologies applications are promising in various fields of development in Africa. They are the proper responses to the various challenges the continent is facing nowadays. For instance the development and deployment of low-carbon technologies could be effective solutions to climate change problems of the continent. Information and Communication Technologies (ICT) have enabled appropriate solutions to health problems of selected rural areas in Africa. Biotechnologies solutions to the food shortage and poverty alleviation in certain African areas are in study.

There is an increasing consensus with regard to the key role of new technologies for a sustainable development and for the achievement of the Millennium Development Goals (MDG). There is also an urgent need for capturing the momentum for the inclusion of Africa in this technology race. On the one hand, with a few exceptions (Egypt, Kenya, Morocco, South Africa, Tunisia, etc) we observe the marginalization of the African continent with regards to Science and Technology production. On the other hand, we can list the series of declarations of interest, commitments or preliminary initiatives aiming at the establishment of STPs in order to increase the technological capabilities of the continent. Africa is experiencing a rising concern with regards to STPs. As a consequence to the above, our study intends to proceed as follows:

First of all, we will review the ongoing initiatives on STP in selected African countries. This would help us to clas-sify the countries and express the diversity on bases of development in the continent. In the second part, we will attempt to estimate the readiness for the selected African countries to establish STPs. The assessment will be based on the needed national conditions and countries key characteristics for effective Science and Technology activities.

As a starting point of our analysis or a basic hypothesis of our study, we consider that establishing an STP in Africa must be done in an appropriate way (less costly solution, with respect to the various cultural African contexts, and as a real answer to local ventures – enterprises). We will use the expression of readiness in order to appreciate where the African continent stands in this process of generalization of STPs throughout the world.

OVERVIEW OF THE STP DEVELOPMENT IN AFRICA

The African need for science and technology development is increasing as far as the digital divide between Africa and the rest of the world is worsening.

STPs seem to be the proper stop gap solution for most developing and emerging countries. Especially, Western STPs that have had notable success have influenced developing countries to adopt the "park model" as a vehicle for technology-based economic growth and development (Vaidyanathan, 2007). The on-going STP initiatives in Africa are attempting to attract foreign investments and to promote the growth of knowledge-based industries. Proper Research and Development (R and D) activities seem to be marginal and secondary as the cross-fertilization of ideas between domestic and foreign firms is still insignificant.

THE NEED FOR SCIENCE AND TECHNOLOGY IN AFRICA

World trade in higher value-added products and services and especially in high tech has been growing much faster than the trade in raw materials that still dominate African exports. The Asian tiger economies, with their high technological capability, have been able to participate in this development (Watson et al., 2003). By contrast Africa's share in global manufacturing, which was already very low with 1% in 1980, declined to 0.78% in 2002 (Wolf, 2007).

The African framework is characterized by a surprising lack of the critical or basic instrument for innovation. The low innovative capacity of most African countries had a negative impact on private sector development. Figure 1 highlights the above observation by underlying the diffused need for skills in Africa.

For the upper middle income countries. They represent those African states which are above the per capita income average of the continent which have a better structured and developed private sector and especially more financial resources to dedicate to innovation incentives, the most important constraints for business operations growth are skills for which STPs could apparently help to solve. STPs are increasingly being adopted as an important economic development tool and as an integrated part of the national or regional innovate- ion system.

The race for establishing STPs in Africa seems to be guided by a fundamental need to enhance the innovative capabilities and technological progress of countries; and in the long term to improve the standard of living of the African population.

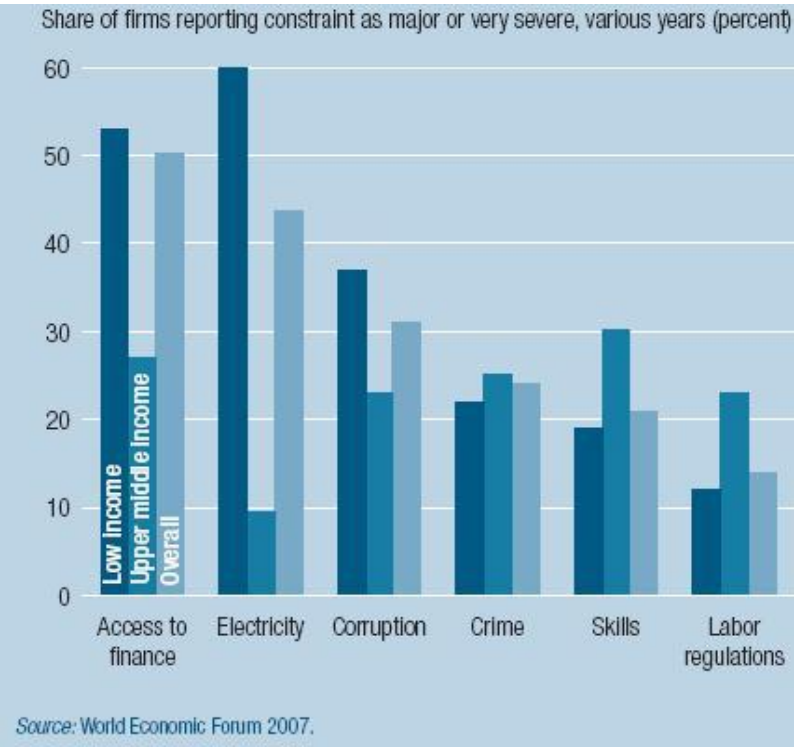

Figure 1. Top constraints to business operations growth in Africa.

From its original meaning, STPs are often associated with high-tech innovations for various reasons. They seem to be the most appropriate places for establishing growing high-tech companies and to promote innovations. These are the proper places for creating real synergies in such sensitive fields of high-tech and to "guide" and safeguard high-tech entrepreneurs whose previous experience is within purely technical spheres rather than areas of general management (Berry, 1998).

However, the only focus on high tech activities could appear inappropriate to most African countries considering the fact that there is still a chronic lack of S and T support infrastructure as well as the relevant skills. In fact, for the few ongoing experiences on STP in Africa, there is a variety of approaches and focus. In this part of the paper, we will attempt to group them in different categories.

OVERVIEW OF THE DEVELOPMENT PHASES OF AFRICAN STPS

Referring to the four traditional development phases of STPs (Weddle, 2008). Our study will show that African ongoing initiatives are in their majority, in a planning or operational phase, with the exception of selected South African experiences which are in a fully functional stage.

In fact, the first science parks on the continent were established relatively recently in South Africa (Stellenbosch and Pretoria). Nowadays, ideas of many African leaders on development projects are being progressively attracted by the establishment of science parks. Nevertheless, Africa has lagged behind. For those countries where the efforts of setting up STPs have reached a functional stage, it has been more than just a ministerial declaration, with the concept having different interpretations and achievements.

Furthermore, STP study in Africa recalls the notion of readiness. By readiness we mean a combination of at least three elements: willingness to develop scientific activities as a priority, affordability and ability to fulfill high tech activities, and appropriateness of national environment to develop STP quickly. We will further develop the question in the following part of our study.

The selected ongoing initiatives or plans for establish-

establishing future STPs in Africa is intended for the continent to be part of the world's science and technology trends and to avoid the continent being marginalized. These initiatives often undergo difficulties and lack of continuity because of the missing basis for their self effectiveness. STPs are real tools for innovation and knowledge development if they follow a certain method and are dynamic over the time. From our own recent inventtory. fulfilled through a web based analysis from October to December 2008 as well as the consideration of other information sources like the IASP list of members, United Nations Education, Science and Culture Organization (UNESCO), United Nations Industrial Development Organization (UNIDO) and New Partnership for African Development (NEPAD) reports or projects on Science and Technology development in Africa, we have divided the various African initiatives in STP development in four groups as follows: the high tech producers; the business facilitators; the ICT focus STPs; and the "in-study STPs". This classification attempt is new in the literature and should be the basis for further elaborations. Table 1 summarizes the ongoing initiatives in STP initiatives in Africa. Out of the twenty three ongoing initiatives in Africa, the majority is still in the development stage. Only eight are currently active as STPs on the continent. Half of them are not yet members of International Associations of Science Parks. Those which are fully active are various and they look for different objectives according to national priorities and strategies. The functioning eight STP are located in five countries which are more resourced and thus able to afford more investments in knowledge development infrastructures: Egypt, Mauritius, Morocco, South Africa and Tunisia.

Four initiatives are located in upper middle income. (Gross National Income: GNI between 3,706 - $11,455 according to World Bank classification) and the other four active STPs are based in lower middle income economies (GNI between 936 and $3,705).

The majority of these STP initiatives which are not yet functioning are in International Development Association in IDA countries according to the World Bank classification of the year 2007. Countries listed in the Table 1 are fourteen out of a total of fifty three African countries, and thus represent roughly a quarter of the continent.

While the focus is more accentuated towards research and innovation initiatives in South Africa and Tunisia, for Egypt and the Mauritius, the strategy places more emphasis on building the conditions for international business development. Morocco and Tunisia seek to support new ICT ventures through incubation initiatives and a tightening of the partnership between universities and local industries. The other selected national initiatives are at an embryonic phase of the STP development, characterized by an attempt to better integrate ongoing Science and Technology initiatives at the university level (feasibility studies (Kenya), declarations of interest (Mozambique)).

THE HIGH-TECH PRODUCERS

The selected cases are located in countries (such as South Africa and Tunisia) which have clear objectives to produce knowledge for their own markets and for export. Both countries have shown their capabilities to use new technologies and even to lead the production in selected technical fields (reference made to the number of international patents owned by the countries).

In this group of African STPs, we will consider the Innovation Hub and Stellenbosch Technology Parks of South Africa, and the Sidi Thabet technopark of Tunisia.

INNOVATION HUB SCIENCE PARK (IHSP), SOUTH AFRICA

South Africa's first internationally accredited Science Park is a high-tech cluster for knowledge intensive companies. This is the leading knowledge-intensive business cluster in South Africa. The Innovation Hub has created a unique space for high-tech entrepreneurs, world-class businesses, academics, researchers and venture capitalists to meet, network and make profit. Its value-adding business support services contribute to the growth and globalization of technology-rich enterprises in an environment that promotes innovation and enhances competitiveness for knowledge-based businesses.

As an STP, The Innovation Hub is fulfilling a key role in nurturing commercial and technological innovation to place the South African economy on a higher growth trajectory. The Know-How Network of knowledge and product partners and the Knowledge Centre, operated by the University of Pretoria, offer clients an extensive range of essential business information sources, skills and services.

In this STP, priority is given to ventures which are world leaders (actual or potential) in innovative technology and brand recognition; are inclined to develop synergies with other companies on the Innovation Hub; are engaged in the areas of electronics, information and communications technology, biotechnology and advanced materials.

Since 2005, the Innovation Hub Science Park has been at its new site in Pretoria. This new 60 ha site is at a dis-

Table 1. An overview of STP initiatives in Africa.

Name and country	IASP Members	1st group (high tech producers)	2nd group (business facilitators)	3rd group (ICT focus STP)	4th group ("in-study STP" and not yet fully operating as an STP)
Western University College of Science and Technology (Kenya)	affiliate				x
VITIB – SA - PARC TECHNOLOGIQUE MAHATMA GANDHI (Cote d'Ivoire)	affiliate				x
Casablanca Technopark (Morocco)	full			X	
Polytechnic of Namibia (Namibia)	associate				x
Akwa Ibom Science and Technology Park (Nigeria)	affiliate				x
The Innovation Hub (South Africa)	Full	X			
North-West University (South Africa)	Associate				x
Technopark Stellenbosch (South Africa)	No	x			
Elgazala Pole of Communication Technologies (Tunisia)	Full			X	
Sidi Thabet Biotechpole (Tunisia)	Affiliate	x			
Ebène CyberCity (Mauritius)	No		x		
Rose Belle Business Park (Mauritius)	No		x		
The Smart Village (Egypt)	No		x		
Technopole of Dakar (Senegal)	No				x
Technopole of Toamisina (Madagascar)	No				x
National University of Science and Technology Technopark - NUST, (Zimbabwe)	No				x
Kigali ICT Park (Rwanda)	No				x
Gaborone diamond technology park (Botswana)	No				x
Technopark Borj Cédria (Tunisia)	No				x
Technopark of Sousse (Tunisia)	No				x
Technopark of Sfax (Tunisia)	No				x
Monastir Science and Technology Park (Tunisia)	No				x
Technopark of Bizerta (Tunisia)	No				x

Source: Own elaboration

tance of about 30 km from Johannesburg International Airport. IHSP offers state-of-the-art ICT technology and the entire Park has been developed based on an Environmental Management Plan. The Park hosts about 60 high tech resident enterprises. This is a challenging space for high-tech entrepreneurs, world-class businesses, academics, researchers and venture capitalists to meet, network and generate revenue

TECHNOPARK STELLENBOSCH (TS), SOUTH AFRICA

The Stellenbosch Technopark was established in 1987. It is strategically placed close to the main sea route around Africa and provides exporters with easy access to the world's largest markets, including the huge demand of markets in Africa. The Stellenbosch Technopark offers an established and sophisticated business infrastructure. It is located 35 min away from Cape Town International Airport, 5 min from Stellenbosch Airfield and 40 min away from the city centre. The TS hosts the offices and laboratories of about 36 high tech companies. Office spaces are still available for potential newcomers. The focus sectors are the following: advanced engineering (mining technology and mineral processing), Agro-Food, Energy, Health Care and Medicine, ICT (software deve-lopment).

The partner University of Stellenbosch is amongst the leaders in many fields of R and D, notably engineering, biological sciences, medical sciences, etc. Many high-tech companies in Technopark are spin-offs from research and development undertaken by the Stellenbosch University.

SIDI THABET BIOTECHPOLE, TUNISIA

It was established in 2002, in the Sidi Thabet part of the governorate of Ariana. The Park is located about 30 min away from Tunis and its international airport in a strategic site in the heart of the Mediterranean crossroads of North Africa and the Middle East. Sidi Thabet Biotechpole is devoted to biotechnology applied to health and pharmaceutical Industries. It belongs to the network of Technoparks established in Tunisia. The purpose for its establishment is to offer a new concept of partnership between research, innovation, training and production with technological connotation. In fact, Sidi Thabet Biotechpole is strongly networked with the following prestigious partners: the Pharmaceutical Industries Company of Tunisia; the Tunisian Pasteur Institute; the Ecopark Borj-Cedria; the Foreign Investment Promotion Agency; the National Insti-tute for Standardization and Industrial Property; the Exportations Promotion Centre; the Industry Promotion Agency; and the Tunisian Union of Industry, Trade and Handicraft. For research activities, the Sidi Thabet Technopole is associated with two national centres of high-level scientific research that is endowed with highly qualified human resources (more than one hundred researchers, engineers and technicians) and state-of-the-art equipment: the National Centre for Nuclear Sciences and Technologies; and the National Institute of Research and Physical and Chemical Analysis.

The biopark in a geographic area ranging from 5000 to 10000 m² is available for Tunisian as well as foreign investors. The first parcels shall be exploited by the end of 2009. Furthermore an incubation programme is ready to be applied within the technopark. Potential incubator companies will be able to profit from a high flow data-processing network, a connection to internet network and a suscription to the national and international data banks available to the technological resources centre of the technopark.

Sidi Thabet Technopole has ambition to be a facilitator, an integrator of processes and a catalyst for innovative projects that would reinforce its attractiveness and contribute to the promotion of the Tunisian R and D initiatives.

THE BUSINESS FACILITATORS

THE EGYPTIAN SMART VILLAGE

The Smart Village model developed in Egypt and functional in Cairo since 2003 is mostly focused on establishing an attractive and effective business environment for local and foreign enterprises.

The ongoing STP model in Egypt is mostly focused in this phase of its development to make an attractive business environment with modern high tech facilities (that is fiber optic network, multi-source power supply, district cooling and Heating redundant network plant), effective coaching and management services for national and foreign ventures.

Smart Village Cairo has rapidly expanded and achieved successful contribution to position it among the world's most competent Business Parks. The Park accommodates multinational, Local Telecommunications and Information Technology Companies, Financial Institutions and Banks, together with Governmental Authorities on three Million square meters in the west of Cairo. Currently, 12,000 professionals run the operations of about 95 Companies located in the business park.

From the list of partners (reference made to the Smart Village Cairo Community) there is not yet a national or international University present in the business park.

Other Smart Villages are foreseen in Alexandria and Damietta in the near future. The ongoing STP model in Egypt is managed by The Smart Villages Company which was founded in 2001 to lead and foster a branded chain of Technology and Business Parks on the local and regional levels.

THE EBÈNE CYBERCITY IN MAURITIUS

Mauritius has initiated a similar model of business parks managed by a government-owned 'Infrastructure Development' company: Business Parks of Mauritius Ltd BPML. The creation of BPML was a key initiative of the Government's vision of transforming the Mauritian economy into an innovation-driven economy based on Knowledge. The experience has started with the Ebène CyberCity and will continue with Rose Belle Business Park.

The Ebène CyberCity is the role model for future ICT-connected communities in East Africa. Situated in the picturesque neighborhood of Ebène, close to the capital city and to the International Airport, the CyberCity provides a very high quality environment to live and work in ICT fields or with ICT tools. Spread over an extended area, the Ebène CyberCity is equipped with fiber optic cables and other real facilities for modern business development.

The CyberCity is divided in zones: business and commercial zones, residential zones, knowledge zones, etc. This Business Park in Mauritius was constituted in 2001 and is still in development with the mission to position Mauritius as a regional centre of excellence for ICT outsourcing.

THE ROSE BELLE BUSINESS PARK, MAURITIUS

This is a new Business Park, strategically located in the South of Mauritius. This is an initiative to expand ICT infrastructure to other areas of the island. The Park which is in a promotion phase is equipped with the necessary infrastructural facilities such as road network, water supply, drains, street lighting and telecom network.

Mauritius seems to be ready for STP with regards to our selected five criteria of readiness even if the national high tech market seems to be limited compared to the other countries of our study.

THE ICT FOCUS STP

In Tunisia and in Morocco, there is a consolidated focus on the ICT sector. In fact, the Elgazala Pole of Communication Technologies in Tunisia as well as the Casablanca Technopark are mainly ICT-oriented. They have been established with the intention of taking advantage of the ICT opportunities in Tunisia, Morocco and abroad.

In Tunisia and Morocco STP working in the ICT related fields show a continuous dynamism as well as a proven competitiveness in the African Mediterranean region.

ELGAZALA POLE OF COMMUNICATION TECHNOLOGIES, TUNISIA

This facility became operational in 2003. The pole of Communication Technologies is well placed in an environment of third level education like Ecole Superieure des Communications de Tunis, and the Institut Supérieur des Etudes Technologiques en Communication. The Elgazala Pole of Communication Technologies, which is very close to the international airport of Tunis Carthage, has the vocation to: Host innovating companies in the field of communication technologies, Develop the synergy between Industry, Re-search and Higher Education, Promote innovative ideas, Animate the Technological City of Communications, Establish an international cooperation network.

Currently, the incubation role of the park seems to be dominant with more than 30 companies hosted in the Elgazala pole. In the stated conditions for the establishment of a private venture in the premises of the Elgazala pole of Communication, there is a clear reference to the need for partnership with universities and the involvement of national skills (especially young engineers).

CASABLANCA TECHNOPARK, MOROCCO

This is a mixed capital business established in 2001 with the aim of promoting and supporting ICT-based activities in Morocco. The company, which is located in Casablanca, host about 160 incubated ventures in the ICT sector. Casablanca Technopark focuses mostly on incubation and consultancy services to the public and private sector. The Technopark has a much focused objective which is quite similar to that of the business Parks.

THE IN-STUDY STP

In this category we would group the declarations of interest or the ongoing preliminary feasibility studies for the establishment of an STP. We would also consider in this category all those African initiatives which are often called technopoles or technoparks at the national level but are just attempts to revitalize old training and acade-mic research activities. They are usually not exclusively focused on high tech activities and their capacities to enhance private businesses are still to be established. These could be considered as preliminary phases to establishing of STPs. Examples of this classification include: the technopoles of Toamisina and Dakar, the National University of Science and Technology Technopark

(NUST) in Zimbabwe, the Kigali ICT Park, the Western University College of Science and Technology in Kenya and the Polytechnic of Namibia.

Several African countries have expressed their intention to establish STPs and start participating in the global high tech enterprise or at least create conditions for better use of knowledge produced elsewhere.

Kenya has shown the capacity to produce and award patents at the international level but the country has yet to establish an STP. An existing plan for the establishment of an African Tech Park with the UN support is foreseen and under study.

In September 2008 the Mozambique Ministry of Science and Technology expressed its willingness to establish three Science parks in different provinces of Mozambique with the aim of building its national capabilities to support and maintain the technology and industry that the country needs to develop. There is a similar effort at the discussion/preliminary stage for the establishment of an STP in Ghana by an International Non- Government Organization (Life for Africa) and the United Nations Department of Economics and Social Affairs (UNDESA) in collaboration with the Ministry of Communications.

In Mozambique, the areas to be covered by future STPs include the development of agricultural technologies, agro-processing, energy and the environment, telecommunications, bio-technologies, bio-medicine and building materials. The national authorities have expressed their willingness to build the STP on three pillars, namely learning and research, technological incubation, and business and productive activities.

In some Sub -Saharan countries, new STPs have been established. In Botswana, Cote d'Ivoire and Nigeria, the Gaborone diamond technology park, the VITIB – SA – Parc Technologique Mahatma Gandhi and the Akwa Ibom Science and Technology Park are respectively still in the construction phase or in a so-called market positioning phase (When the mission of the Centre has still to be refined). In the case of the STP of the North-West University in South Africa, funds are being raised for its establishment.

In North Africa, especially in Tunisia, the establishing of STP is a component of the national science and technology policy and a strategy for economic and social development through encouraging knowledge- based Industries and innovations. Tunisia has at least five new science and technology parks to be completed: Technopark Borj Cédria, Technopark of Sousse, Technopark of Sfax, Monastir Science and Technology Park, and Technopark of Bizerte. Some of them are in an advanced phase in the project implementation process such as the Borj-Cedria Science and Technology Park and the Technopark of Sousse which has a SoftTech incubator, hosting currently seven Small and Medium-sized Enterprises (SME).

An overview of the developing situation of STPs in Africa shows basically two things: Countries do not apply a linear process of STP development at national level. The targeted countries do not apply a uniform development strategy of their national STP.

Furthermore, we have observed a limited research interest and thus little literature on STP development in Africa. Only international organizations like UNESCO, UNIDO and IASP have attempted to set up useful databases of existing initiatives as tools for policy making.

ASSESSING THE READINESS OF MOST COMMITTED AFRICAN COUNTRIES FOR STP DEVELOPMENT

Science and technology are crucial for development. They have had an enormous impact on reducing the burden of physical work and improving social welfare. Today's global challenges in areas such as economic productivity, healthcare, water sanitation, environment management, food security and participation in the global economy will require increased use of scientific and technical knowledge.

The World Bank (WB) Knowledge Assessment Methodology (KAM) has confirmed that knowledge and its application have played a major role in growth processes of countries, and knowledge related initiatives remain at the top of today's development agenda.

Many developing countries are recognising the importance of investing in science and technology infrastructures as well as in upgrading skills in order to take advantage of the knowledge economy. The majority of top gainers with regard to the positive changes in the WB Knowledge Economy Index (KEI) from 1995 to 2008 are developing countries. African countries represent a quarter of this list of developing countries.

The race for establishing STPs in various African countries is another indicator of the willingness of developing countries to participate in the knowledge development era. More importantly, the key challenge remains the ability to manage STPs and assess their performance.

Our focus in this part of the study is to assess the readiness of selected African countries to effectively engage and manage STP initiatives which remain ambitious projects of knowledge development. Our selected indicators of readiness in this study are focused on the capacity to sustain the performance of STPs and not just investments for their establishment.

As a first study, we will refer substantially to the four pil-

Table 2. Our selected countries of study.

Countries	Geographic	Level of development	STP stage of development
Botswana	SADC	Upper-middle-income	In completion
Cote d'Ivoire	West Sub-Saharan Africa	Low income	In completion
Egypt	North Africa	Lower-middle-income	1 functioning and at least 2 in completion
Kenya	East Sub-Saharan Africa	Low income	In study
Madagascar	Island Sub-Saharan Africa	Low income	In completion
Mauritius	Island Sub-Saharan Africa	Upper-middle-income	In completion
Morocco	North Africa	Lower-middle-income	Functioning
Mozambique	Southeastern Sub-Saharan Africa	Low income	In study
Namibia	South Sub-Saharan Africa	Lower-middle-income	In completion
Nigeria	West Sub-Saharan Africa	Low income	In completion
Rwanda	East Sub-Saharan Africa	Low income	In study
Senegal	West Sub-Saharan Africa	Low income	In completion
South Africa	South Sub-Saharan Africa	Upper-middle-income	Functioning
Tunisia	North Africa	Lower-middle-income	2 Functioning and at least 5 in completion
Zimbabwe	South Sub-Saharan Africa	Low income	In study

Source: Own elaboration

lars the knowledge economy framework, developed in the KAM of the WB: of Economic Incentive and Institutional Regime, Education, Innovation, and Information and Communications Technologies. Our study will focus on those African countries where STPs are already functioning or are close to completion or in the feasibility stage As referred in the Table 2, we consider fifteen countries: Botswana, Cote d'Ivoire, Egypt, Kenya, Madagascar, Mauritius, Morocco, Mozambique, Namibia, Nigeria, Rwanda, Senegal, South Africa, Tunisia and Zimbabwe. We have selected a representative list of African countries: from all various parts of the continent. The selected countries are at different stages of economic development process; and the respective local governments are fully committed to supporting innovative initiatives and the competitiveness of local companies through the establishment of STPs.

THE MISSING BASIS FOR HIGH TECH INVESTMENTS AND DEVELOPMENT IN AFRICA

The establishment of an STP requires some basic conditions for the effectiveness of the process in order to have a future knowledge ecosystem. The expression" knowledge eco system" has been taken from Weddle 2008.

The basic conditions are those we consider as criteria of readiness for the establishment of STPs in this paper. They are: the capacity to produce knowledge and technology, ICT availability and diffusion, a simplified business development framework, an influential and critical mass of scientists, and interactive learning basis, etc. These elements are more or less included in the World Bank four referring pillars of the knowledge economy.

The capacity to produce knowledge and technology is a basic condition that must be completed by a learning capacity for further development or adaptation of high tech knowledge. In fact, one of the original objectives of STPs is the strengthening of national technological capabilities. In other words, after proving its own capacity to produce knowledge and technology, the country could focus on building the framework to boost and strengthen this ability and thus attract foreign investments/ventures. The ability to produce technologies in an informal or "hostile" environment which characterizes a number of our targeted countries could be a proof of the existing basis for establishing STPs.

Furthermore, showing at an international level the capacity to produce inventions, the country would be very attractive for foreign scientists and MNC which foresee the delocalization of their R and D departments in order to better serve low income markets.

Not all of our selected countries have reached this stage of technological capability and thus would find difficulties in undertaking high tech programmes. Considering the level of KEI and its evolution from 1995 and 2008, we will attempt to assess the level of knowledge framework of our selected countries.

As a starting point, we presume that all countries would

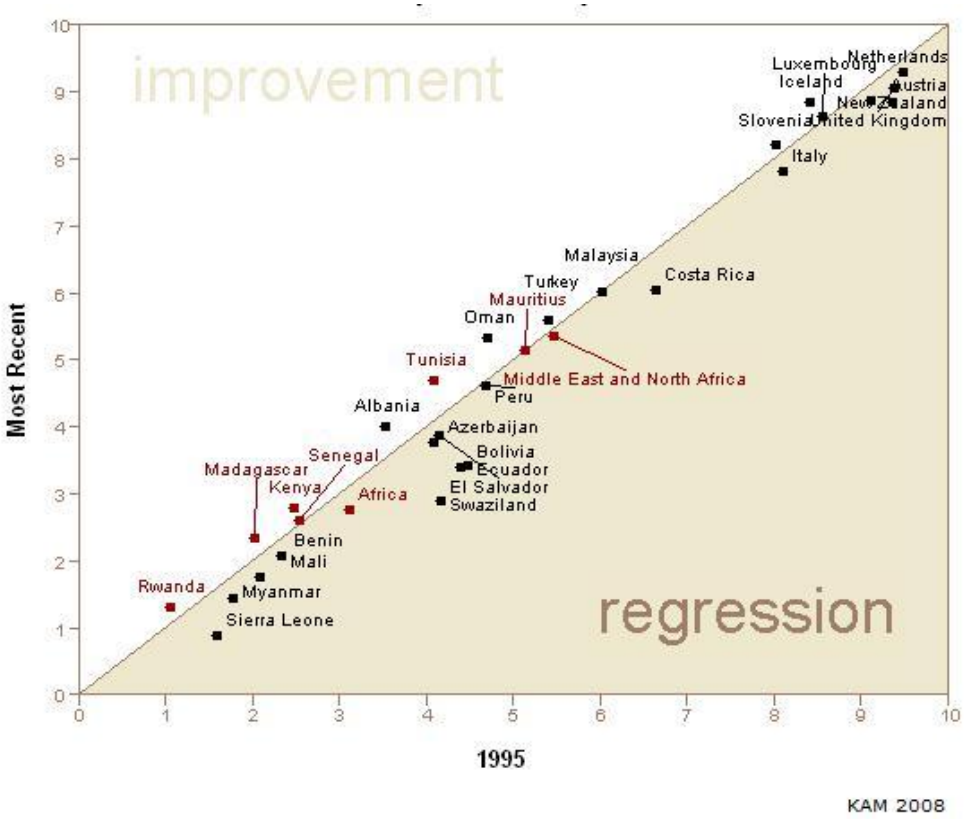

Figure 2. Knowledge economy index – Comparison group 1.

have experienced an improvement of their KEI during the selected period of assessment (1995-2008). This may have justified the willingness of countries to engage in the STP process. This is like an entry condition for establishing STP because we presume that the period considered for the analysis is sufficiently long to allow improvements in the knowledge development process of all countries, even in those areas that have experienced political instability. We have thus considered, in our study, any regression as an indication of not being ready for effective STP development. Figures 2 and 3 show the countries or regions that are plotted below the 45 degree line indicate a regression in their performance throughout time. The countries or regions that are marked above the line signify improvement.

The regression may be due to two reasons: the country either actually has lost ground in absolute terms over time, or improved slower than the comparative group.

The majority of the selected African countries like Botswana, Egypt, Morocco, Mozambique, Namibia, Nigeria, South Africa and Zimbabwe have experienced a slight regression of the KEI. The data interpretation is different according the level of knowledge development of the country.

For instance, South Africa has reached a knowledge development phase which has enabled the country to be familiar with modern technological developments and would justify an increasing demand of knowledge based products and services, and thus opportunities for high tech business opportunities in the short term.

In absolute terms, most African countries are far from being knowledge-based economies. Other political or material issues are at the fore -front of government agendas. National efforts deployed to build local conditions or frameworks for an active participation in the international knowledge economy are still insufficient and their results still limited.

For instance the next table Table 3 which considers the patent situation in Africa could help us have a relatively clear picture of the knowledge/technology production ca-

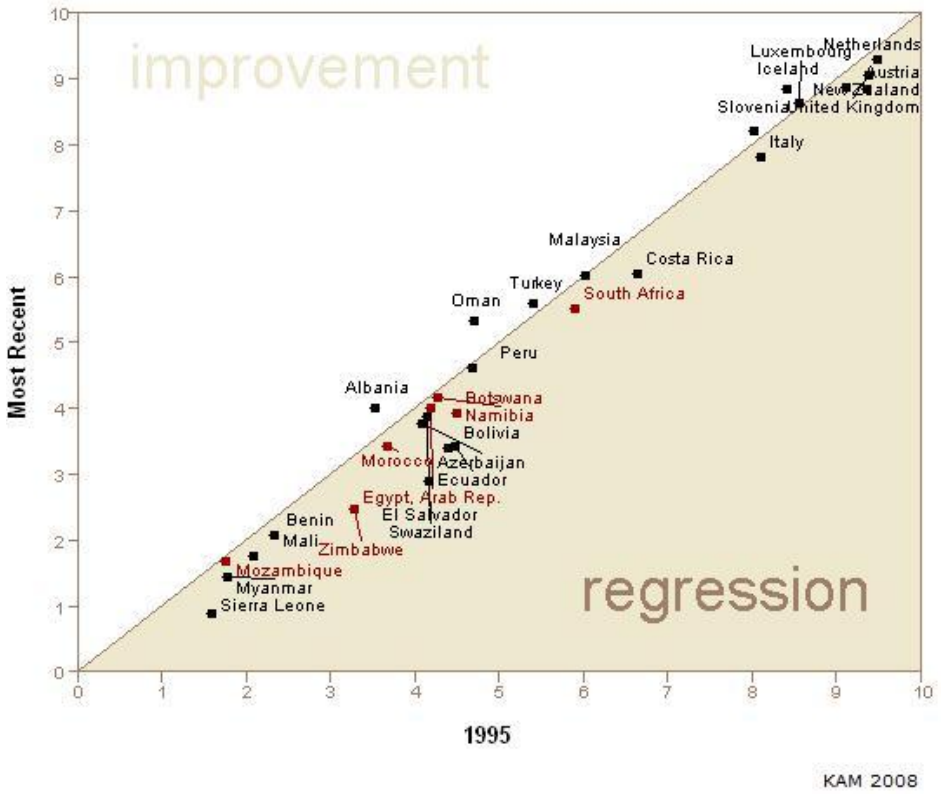

Figure 3. Knowledge economy index – Comparison group 2

Table 3. Patents awarded to African inventors by USPTO, 2000-2004.

Country	Utility patents	Design patent	Plant patents	Reissue patents
Algeria	2			
Angola		1		
Egypt	29			
Ivory Coast	1			
Jordan	1			
Kenya	17	12		
Morocco	4	1		
Namibia	1			
Nigeria	12			
South Africa	557	61	10	2
Tanzania	2	1		
Tunisia	1			
Zimbabwe	4			
Uganda	2			
Africa Total	633	76	10	2
Word Total	817,197	82,006	4,275	2,184

Source: UNECA, 2007.

pacity of our targeted countries. In a five year period, the number of patents awarded by our selected countries is still limited with the exception of South Africa which is leading by far this list of African knowledge producers, followed by Kenya, Egypt, Morocco and Tunisia. Countries within our study such as Madagascar, Mauritius, Mozambique and Senegal are even part of this list.

Generally, with the exception of marginalized cases, the African continent is characterized by a scarcity of high tech knowledge producers. This could explain why there are limited African STPs focusing specifically on high tech production or pioneering in a particular technology field or process. On the other hand, from evidence and governments' declarations of intent, STPs in Africa are mostly attractive as foreign business facilitators without sufficient enforcement measures for research or knowledge production activities.

THE LACK OF INSTITUTIONAL COMMITMENTS AND KNOWLEDGE INFRASTRUCTURES

The ICTs act as transversal tools and instruments for economic performance, social development and environmental sustainability. It comes thus clear this must be a challenge of Africa in the very short term. In fact, this is a target identified in almost all established or to be established STP in Africa. The lack or low level of ICT development in Africa is a barrier for STP functionality and effectiveness. In the meantime, this could be a motivation to establish an ICT focus structure. The Casablanca Technopark and the Elgazala pole of communication technologies are pertinent illustrations of the ICT challenge in Africa: a sector to be developed and adapted to local needs.

On the other side, ICT infrastructures and knowledge are strategic working instruments that could attract high tech activities mainly from abroad. These are the cases of The Egyptian Smart Village, the Ebène Cyber city and the Rose Belle Business Park. It is clear that without a minimum of ICT infrastructure and facilities, neither the research activities nor local or international partnerships are possible. This is one of the most tangible conditions to be fulfilled, like infrastructure building (laboratories, offices, etc) before the launch of a STP.

The current ICT situation is not well developed in Africa, but we could expect a better development of the sector in future because the investments per capita into the sector are increasing as well as the ongoing commit-ments of national governments, at least, with regards to the establishment of regulatory bodies towards their privatization. Other institutional commitments and knowledge infrastructures such as universities, R and D centres and technology observatories are needed. In fact, con- trary to the past when many economists downplayed the importance of African universities, currently the importance of tertiary education in Africa is more widely ack-nowledged. Moreover, African countries are increasing their expenditure on tertiary education in order to respond to the challenges of a learning economy with more know-ledge demanding activities. In recent economic reports, African countries are also deploying more efforts and budgets for R and D and other knowledge development activities. Countries like Tunisia and South Africa claim to have reached a targeted 1% of their respective GDP de-dicated to R and D. But, in an era of globalization, it could be also useful to provide further national reports and to investigate if African countries are performing equally in knowledge capacity building as other countries of the same level of development.

In other words, it is important to asses if African countries are sufficiently committed to the race of bridging the knowledge gap: establishing infrastructures and making appropriate policies.

We will do the analysis by comparing the KEI of selected African countries and their respective income groups. In Table 4, countries such as South Africa, Mauritius, Egypt, Botswana, Morocco, Nigeria and Rwanda are performing well in terms of KEI under their potential capacity with regard to their relative income category. Recommendations would obviously be to increase the efforts to fill the knowledge gap between them and countries within similar income category. Botswana and Rwanda seem to be the two countries which have made more efforts in the short term to increase their KEI. Ongoing commitments and expressions of interest for establishing STPs in these two countries could be justified by what we have outlined earlier.

Another interesting observation is related to the fact that no African country with an income lower than $3,706 (lower middle income or low income) has a KEI higher than 5. The problem in Africa is the high level of poverty and illiteracy among its population. A significant fraction of the population have no or limited access to modern opportunities (equipment and knowledge). The combination of a digital gap and knowledge gap is an evident and could increase the marginalization of the entire continent. STPs are instrumental for a catch up process with regard to the knowledge development process. For the majority African nations, the efforts should be made at the regional level because existing national scientific skills and infrastructure are not sufficient to sustain an effective STP development.

Table 4. The average KEI of the income group in which the African countries are included.

Country	KEI 2008	Upper Middle Income	Lower Middle Income	Low income	Observation
South Africa	5.55	6.21			< average category
Mauritius	5.18	6.21			< average
Tunisia	4.73		4.10		> average
Namibia	4.19		4.10		> average
Egypt	4.03		4.10		< average
Botswana	3.96	6.21			< average
Morocco	3.45		4.10		< average
Kenya	2.82			2.08	> average
Senegal	2.63			2.08	> average
Zimbabwe	2.51			2.08	> average
Madagascar	2.37			2.08	> average
Nigeria	2.04			2.08	< average
Mozambique	1.71			2.08	< average
Rwanda	1.34			2.08	< average
Cote d'Ivoire	-			2.08	-
Middle East & North Africa (MENA)	5.38				
Africa	2.80				

Source: own elaboration, World bank data of the year 2008.

THE ABSENCE OF PRIORITY PILLARS FOR COMPETITIVE STPS IN AFRICA

Scientific and technical interactions enable the rapid diffusion of information and could increase learning capacities. Obviously, this form of apprenticeship is more effective if people have similar background, technical skills or preparation: comparable basis. If we consider the level of education as the basis for high tech knowledge, we observe a low interactive learning basis in many African countries. In fact, third level education is very marginal and is not always focused on scientific or technical fields such as engineering, ICT, mathematics, biology, etc.

Living in a high tech era characterized by generalized knowledge-demanding activities, innovation is not by far the outcome of isolated entrepreneurial genius but the result of a continuous interaction between producers and users. In modern industrialized societies, innovation is the result of a systemic and complex and social process involving people playing different roles (Arocena and Sutz, 2000). The authors considered that learning is based on the idea of knowledge acquisition and "non transferable" conditions of the process of problem-solving that increasingly characterizes knowledge activities. In effect, jointly considering the percentage of higher education enrolment and the proportion of R and D expenses in the Gross Domestic Production (GDP) could inform us about the learning capacity of a country.

In the recent Human Development Report 2008 (UNDP, 2007), just Mauritius is among the high human development countries. Tunisia, Egypt, South Africa, Botswana, Namibia, Morocco, Madagascar, Kenya and Zimbabwe are respectively among the medium human development countries. Finally Senegal, Nigeria, Rwanda, Cote d'Ivoire and Mozambique are among the low human development group. The above three indicators show an urgent need for African countries to build scientific communities and infrastructures. Moreover, drastic efforts should be fulfilled to attract more young people in scientific fields of study as well as professions. Adding to the two above indicators, the proportion of tertiary students in scientific areas, we can estimate the ability of a nation to perform knowledge demanding activities in the high tech sectors. Considering, in Table 5, the above three indicators we can understand the urgent need for African countries to build scientific communities and infrastructures. Moreover, drastic efforts should be fulfilled to attract more young people in scientific fields of study as well as professions.

Another consideration with regard to the missing pillar for STP development in Africa comes from a close observation of the evolution of the KEI and mainly from a com-

Table 5. Overview of the need for tertiary education and R&D investments in Africa.

Selected countries	R&D expenses as a percentage of GDP in 2000-2005	Gross enrolment ratio in the Tertiary education in 2004 (% of relevant age group)	Tertiary students in science, engineering, manufacturing and construction from 1999 to 2005[b] (% of tertiary students)
Tunisia	1.02 (2005)	74.3[a]	31[c]
South Africa	0.92 (2005)	82.4[a]	20
Morocco	0.66 (2003)	11	21
Mozambique	0.59 (2002)	38.7°	24
Mauritius	0.37 (2005)	17	26
Madagascar	0.16 (2005)	3	20
Egypt	0.19 (2000)	71.4[a]	-
Kenya	-	73.6[a]	29
Senegal	0.09 (2005)	5	-
Botswana	0.44 (2005)	5	17[c]
Cote d'Ivoire	-		-
Namibia	-	-	12
Nigeria	-	-	-
Rwanda	-	3	-
Zimbabwe	-	-	-

a: adult literacy rate (% aged 15 and older), 1995-2005
b: Data refer to the most recent year available during the period specified
c: figure should be treated with caution because the reported number of enrolled students in the "Not known or specified" category represents more than 10% of total enrolment.

Source: Own elaboration - Data taken from various sources (Human Development Reports, UNDP -Science reports, UNESCO - Institut de la Statistique Quebec - government reports)

parison of the four knowledge pillars of our targeted countries. The Education index is the lowest or less strong pillar for 11 countries out of the selected 15 of our study.

The calculated Education pillars indices are lower than 3.00 for 11 countries and lower than 5 for all our targeted countries. These are indications of the absence of vital ingredients/basis for STP development. How can a minimal percentage of African population take charge of the ambitious high tech development programmes of the continent? This query could justify the ongoing challenging programmes of establishing regional STP in Africa. Furthermore, significant efforts could be focused on seeking alternative supporting infrastructure for high tech development in Africa.

The highest pillar index of the KEI for African countries (Figure 4) is more diversified and in many cases has been the Education index. The Economic and Innovation pillar indexes seem to be stronger than the ICT-based measures. The exceptions are Morocco and Tunisia that are investing considerably in ICT-focused STPs.

After consideration of the selected criteria, the result shows non-readiness on the part of a significant fraction of our target countries. There is, therefore, a need to look for alternative ways for the development of science and technology in these countries.

In future studies, we could identify some alternative forms of capacity building in science and technology for less developed African countries and assess their applicability and effectiveness.

CONCLUSION

In what may be considered an opportune moment for science and technology development in Africa, many governments are committing efforts and money to study which appropriate STP to establish. African leaders are thus joining regional or international initiatives (from NEPAD, UNESCO or the International Council for Science) aiming at building or strengthening S&T capabilities in Africa. The question remains whether

STPs are the most appropriate research and knowle-

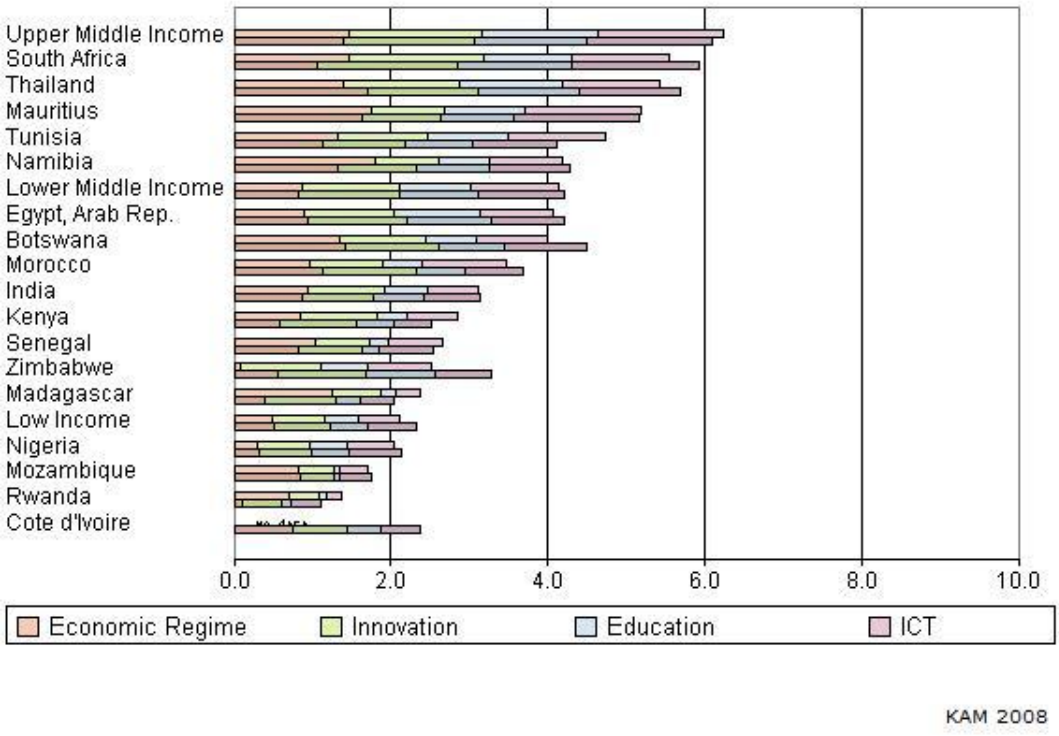

Figure 4. Cross country comparison of pillar indexes KAM 2008).
Each bar chart shows the aggregate Knowledge Economy Index (KEI) score and the contribution (relative weight) of different Knowledge Economy pillars to the overall country's knowledge readiness

dge systems for Africa? An overview of ongoing STP development initiatives in Africa has shown the lack of a strong basis for high tech knowledge production in many African countries. This could help to re-focus the perspectives of African policies on the development of science and technology.

STPs are usually focused on addressing challenges in the fields of high tech. In fact STPs have an objective of boosting the innovation capacities of a country which has the potential to do so. Considering the above, we can understand why it is urgent for many African nations to refocus their targets of establishing STP in those sectors where their countries already have competences (for instance South Africa and Tunisia). Alternatively, it could be affordable and most profitable to seek for alternative forms of high tech business facilities to STPs.

The only facilitation of MNC investments in Africa (Egypt and Mauritius) is not sufficient to enhance Africa's capacity to produce high tech knowledge and to place. Africa within the world scientific development process. Furthermore, the exclusive focus to the external market by African STPs does not ensure their stability and sustainable development.

Africa needs strong pan-continental research communities and networks of institutions of science and technology as well as centres of excellence. This could be done by facilitating the access to 3rd level education and thus help develop the research and learning capacities of African countries.

In fact, as an alternative to establishing national science parks, African governments could jointly build pan-African sectoral infrastructure for world class science and technology research.

The United Nations as well as other international organizations are promoting such a strategy in order to avoid the scientific marginalization of Africa and to reduce the knowledge divide.

For instance UNESCO launched in 2008 a pilot project

for the development of science parks in Africa. Nairobi, the capital of Kenya, is to host this science park, which will serve as a case study for establishing 'techno-poles' across Africa. This pilot science park will contribute to the programme for the Development of Science & Technology Parks identified for immediate cooperation between the African Union, NEPAD and the UN S&T Cluster in Support of the AU. UNIDO is the lead agency for this programme, which will involve close cooperation with UNECA, UNCTAD and UNESCO. The UNESCO pilot project for a science park in Africa is being implemented in cooperation with the World Technopolis Association and the Islamic Educational, Scientific and Cultural Organization. The project will develop a body of good practices and guidelines which will then be disseminated widely to national governments.

The regional infrastructure would promote effective partnership programmes (between local and international stakeholders) in order to support the diffusion of a relatively new technology transfer concept which would focus on promoting high tech for low income markets.

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