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HIGHLIGHTS:

"Civilization advances by extending the number of important operations which we can perform without thinking of them."

(Alfred North Whitehead)

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Africa in the global flows of technology: An overview.

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Abstract

This overview seeks to highlight Africa's place in the global flows of technology. As the least producer of technologies, its ability to access, adapt, use and modify foreign technologies has to be one of the key element of development strategies. While many papers have focused on research and development (R&D) expenditures, this overview compares Africa's use of intellectual property, trade in industrial machinery, attracting R&D projects and stimulating spending by businesses in comparison to other developing regions. The aim is to help policy makers and analysts realize that the gap in technology is much wider than that in incomes and that Africa may not develop without deliberate efforts to help firms and institutions acquire technologies to enable them compete in the global market place.

Introduction

The transfer of technology assets from one country to the other has been a subject of great debate especially after the 1970s. Much of the debate focussed on conditions associated with transfer of technology and, the costs and the lack of a fair market for technology . Much of this debate was and is driven by the recognition that technology is required for development of all countries. Since a handful of countries own most of the technology used, most countries will need technology transfer under fair conditions to meet their development aspirations.

For example, most telephone calls between African countries are still routed through Europe, attracting transit fees estimated to cost Africa between $400 million and $1 billion annually. [1]This may make a call from Chad to neighbouring Cameroon more expensive than to France as Chad's 16 international circuits are all with France. If such sums of money were invested in telephone infrastructure, it could lower the cost of calls within the continents and make the service affordable and accessible to more people in Africa, and promote development.

The term technology seems synonymous with biotechnology, nanotechnology or other sophisticated knowledge fields. In this case, it may sound like fiction and possibly irrelevant to the poor or a preserve for the rich. Technology has to be seen as a tool that enables farmers, industrialists, governments and society get the most out of their investment and thus important to all countries irrespective of their level of development.

Transfer of technology has been defined as the "transfer of systematic knowledge for the manufacture of a product, for the application of a process or for the rendering of a service and does not extend to the transactions involving the mere sale or mere lease of goods." [2] Transfer of technology transactions include:

1. The assignment, sale and licensing of all forms of intellectual property, except for trade marks, service marks and trade names when they are not part of the agreement;
2. The provision of know-how and technical expertise in the form of feasibility studies, plans, diagrams, models, instructions, guides, formulae, basic or detailed engineering designs, specifications and equipment for training, services involving technical advisory and managerial personnel, and personnel training;
3. The provision of technological knowledge necessary for the installation, operation and functioning of plant and equipment, and turnkey projects;
4. The provision of technological knowledge necessary to acquire, install and use machinery, equipment, intermediate goods and/or raw materials which have been acquired by purchase, lease or other means; and
5. The provision of technological contents of industrial and technical cooperation arrangements.

This definition attempts to differentiate transfer of technology from diffusion of technology. Technology diffusion is best seen as the non-commercial, often involuntary or deliberate, dissemination of technology and skills or the ability of the technology importing country to learn from the acquired technology to develop its domestic capabilities. Government policies that encourage strategic alliances, joint ventures, training of employees and demonstrations, as well as international cooperation in research and education, among others, are deliberately designed to promote diffusions of knowledge, skills and techniques. Technology diffusion is important in deriving maximum benefits from any technology that has been transferred or accessed.

Technologies may diffuse across national borders when industrial and research clusters defy or spread across national boundaries [3] or through increased trade and research contacts, exhibitions, fairs, conferences etc. Similarly, education and exchange of expertise, even when they are targeted, are largely tools for technology diffusion rather than transfer. More importantly, technology diffusion may pass on skills and knowledge as well as organizational arrangements that may be difficult to buy or transfer.

Although there is a thin line between technology transfer and technology diffusion, such differentiation is important as measures that promote technology transfer are not necessarily the same as those that facilitate technology diffusion, and in determining actions or measures that constitute technology transfer in negotiating or assessing the implementation of technology transfer agreements.

For instance, countries are failing to agree whether the measures developed countries have undertaken and reported to the Council for TRIPS of the World Trade Organization (WTO) constitute technology transfer. [4] For developed countries, enabling their firms to invest in developing countries, funding workshops and training, among others, is technology transfer while developing countries would like to see the transfer of core technologies needed to manufacture a vaccine or produce energy, etc. In this case, developed countries are referring to technology diffusion while developing countries are referring to technology transfer. However, for developed countries, this is proprietary knowledge owned by the private sector, sometimes not even published.

It would be wrong to assume that technology is only transferred across countries. Few firms produce and own most of the technologies used in their industries. Other firms have to acquire the technology they need from those that own it, at home or abroad. For instance, International Business Machines (IBM) holds about 26,000 active patents in the United States and over 40,000 world-wide. [5] Other firms in the IT sector may need to use the knowledge developed by IBM to develop software, storage systems and displays, be they American or not. Similarly, many universities and research centres have developed technology transfer offices charged with the management and licensing of technologies largely to domestic industries and institutions. [6]

1 International technology flows

Most technologies are transferred internationally through trade and foreign direct investment (FDI). In trade, technologies are transferred through import of capital goods and of intermediates products needed to assemble high-technology exports, purchase of or access to intellectual assets and by exporting into a developed country market.

In terms of FDI, technology may be transferred through greenfield investments, acquisition and mergers, joint ventures and investment in R&D projects abroad. In addition to many other reasons, acquisitions and mergers may partly be driven by the need to gain access to key technologies, especially in knowledge intensive industries such as pharmaceuticals, information technologies (IT), automobiles and biotechnology.

1.1 Internationalization of R&D projects and expenditure

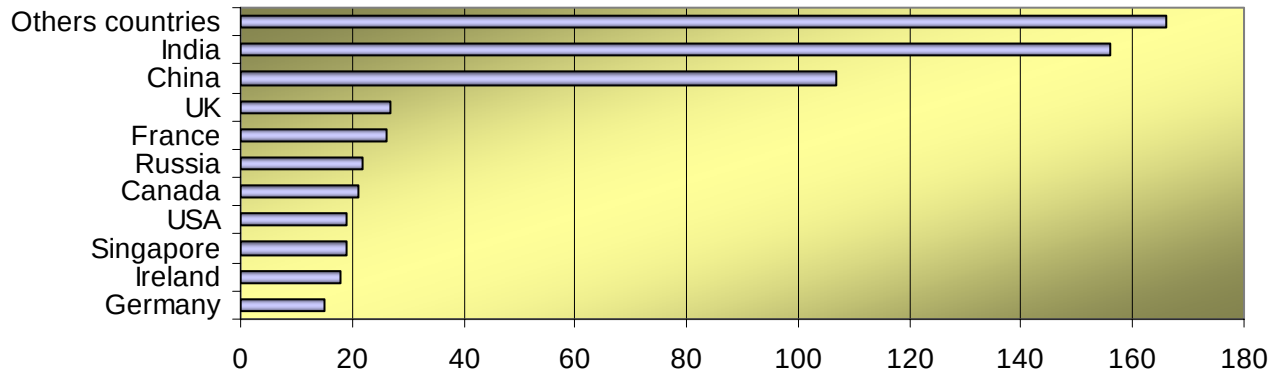
Firms or institutions may wish to locate a R&D unit in a country with a more advanced technological base than its home country in order to gain access to knowledge or skills of interest. Such investment is used to source technologies useful to the investing parent firm. A survey of United Kingdom firms with R&D units in the United States observed that they had higher productivity than comparable firms without such R&D units abroad. [7]

At national level, the Republic of Korea uses similar approach to source technology. For example, the Korean Institute of Science and Technology (KIST) has established international research centres. In addition to KIST-Europe (German) it has cooperative research centres with China and Russia. Specifically, the Korea-Russia Scientific and Technological Cooperation Centre seeks to evaluate and transfer Russian technologies that Korea cannot acquire from other advanced countries.

Another alternative is the location of R&D units of technologically advanced firms in emerging knowledge hubs. In this case, firms at the frontiers of knowledge generation may locate some of their R&D units in countries with the basic technological foundation to cut costs and develop or adapt their products to meet the needs of emerging markets. Such investment is likely to transfer skills and technologies to the host country, at least to perform R&D activities.

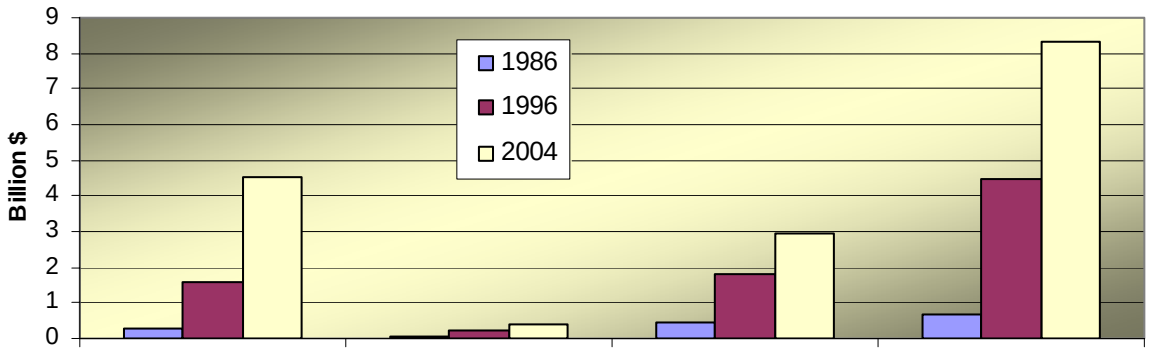
Figure 1. Top destinations for R&D projects

Number of projects (October 2004 to September 2005)



Source: LOCOmonitor

Figure 2. Royaty and licensing fees paid to US by developing regions



Source: US BEA

One of the most celebrated examples is the location of one of Intel's manufacturing and testing factory in Costa Rica, and its positive impact on exports, emergence of IT firms and growth of the economy. After years of decline, exports and gross domestic product (GDP) of the country grew rapidly after Intel's plant in Costa Rica commenced production in 1998. Although Intel has not transferred the technology to make microprocessors to Costa Rican firms, its presence has undoubted stimulated the growth of the IT sector - with over 100 firms.

Attracting such huge R&D-intensive investment is desirable but is not easy and does not seem to flow to all countries. For example, about 596 R&D projects were made abroad between September 2004 and October 2005. [8] About 75% of these projects were made by firms from United States, Germany, Japan, United Kingdom and France. As shown in figure 1, about 44% of these R&D projects were located in China and India. Among developing countries, China, India and Singapore were among the top 10 locations of foreign R&D centres. [9]

Therefore, technology flows through R&D projects is concentrated to a few countries and Africa's share is negligible. This is not surprising as most of the firms making such investment, such as IBM (19 projects), Microsoft (14 projects), Intel (12 projects) and Alcatel (10 projects), among others, are seeking to benefits from skills in countries such as India, China and Russia, to develop technologies at a lower cost than their home countries, in addition to adapting their products to meet the needs of markets. African countries with limited human capital and firms in IT sector is unlikely to be considered a destination for such investment.

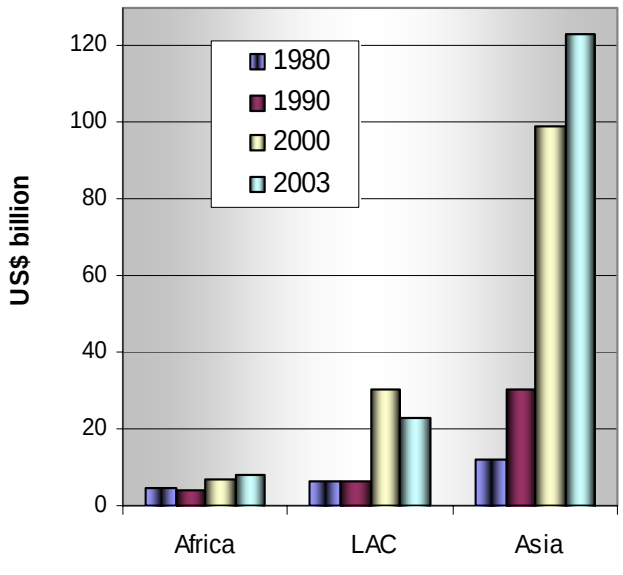
There is also an increase in R&D expenditure by foreign affiliates of technology-intensive firms. For example, R&D expenditure by majority owned foreign affiliates of United States parent firms in developing countries increased from $902 million in 1994 to $2.855 billion in 2001. [9] Affiliates of United States firms spent $29 million in Sub-Saharan Africa, $562 million in Latin America and the Caribbean and $2.39 billion in developing Asia on R&D activities in 2001. Out of the $29 million spent in Africa, $24 million was spent in South Africa. Globally, expenditure on R&D by foreign affiliates abroad increased from about $29 billion to $67 billion between 1993 and 2002. [9]

Increased expenditure on R&D by foreign affiliates may results in more technology being developed from which a country could earn fees, improve productivity and competitiveness through continuous innovation. This could play a role in modernization of production processes.

1.2 Trade in ideas: royalty and licensing fees payments.

The United States is the main exporter of technology to developed and developing countries. It is also a major importer of technologies but has a healthy trade balance in its favour as far as trade in intellectual property is con-

Figure 3. Imports of capital goods by developing regions



Source: UNCTAD

cerned. It is for this reason the United States will be used as a proxy of general trends in trade in intellectual property rights (IPR).

Royalty and licensing fees receipts by the United States increased from $8.1 billion in 1987 to about $52.6 billion in 2004. [10] Similarly, royalty and licensing fees paid by the United States to other countries increased from $1.4 billion to $23.4 billion over the same period. In general, developed countries account for a larger share of trade in intellectual assets.

Among developing regions, royalty and licensing fees paid to the United States increased 16-fold for Latin America and the Caribbean and 13-fold for Asia (excluding Japan) and 5-fold for Africa between 1986 and 2004 (see figure 2). South Africa accounted for over 50% of the payments made by Africa.

More importantly, Africa paid 58 times more in royalty and licensing fees than it received from the United States in 2004 – one of the worst trade balance deficit! All other regions paid between 1.9 and 2.7 times more than they received for trade in IP. In other words, Africa is developing very little knowledge of global interest.

1.3 Trade in capital goods

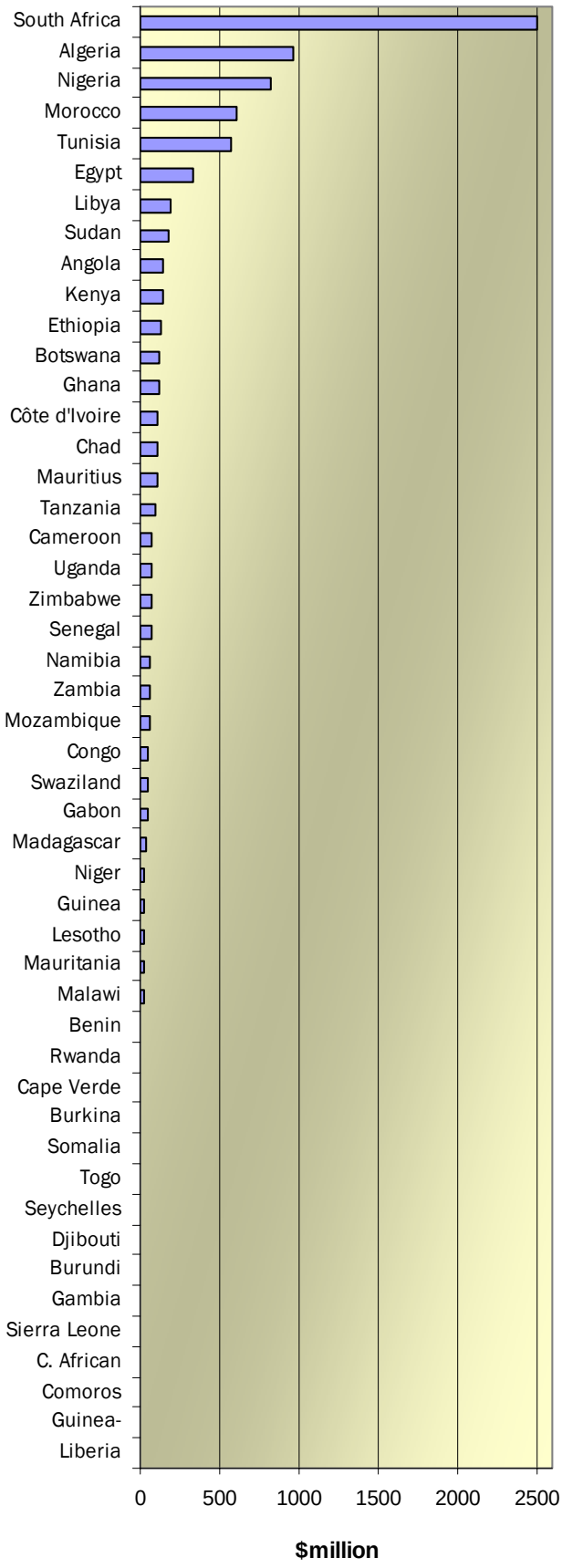
Technology may be embedded in machinery and equipment used in production of goods and delivery of services. Although the import of a piece of equipment does not constitute technology transfer by itself, such imports play a vital role in skills formation, development of innovative capabilities and establishment of a sound industrial base.

In this paper, the proxy of capital goods is the sum of handling, electrical and non-electrical machinery, telecommunication equipment and metal work machinery or tools (SITC [11] groups 736, 744, 745, 764 and 778) traded. Countries investing in manufacturing are likely to rely on this class of goods. Furthermore, workers learn and develop skills to operate, maintain, install and, in some case, modify imported sophisticated machinery. Such capabilities are the initial steps towards laying a sound technology and industrial foundation.

Among developing regions, the growth in the import of capital goods increased by 10-folds for Asia, 4-folds for Latin America and the Caribbean and 1.8-folds for Africa between 1980 and 2003. As shown in figure 3, the import value of capital goods by Africa has remained low- increasing from $4.5 billion in 1980 to $8.2 billion in 2003. [12]

About 21 African countries spent less than $50 million on imports of capital goods while another 11 countries spent between $50 million and $100 million in 2003. With $2.5 billion in imports of capital goods in 2003, South Africa accounted for about 30% of Africa's capital goods imports. The impact of capital goods import on technology transfer in a country may be difficult to assess as many factors are often at play, although research suggests it plays a key role. [13]

Figure 4. Imports of capital goods by African countries



Source: UNCTAD

Tunisia's imports of capital goods have increased from $106 million to $570 million between 1980 and 2003 while its exports of electrical and engineering machinery and transport equipment have increased from about $170 million to about $790 million between 1990 and 2001. [12]

One cannot conclude that such fast growth in Tunisia's manufacturing sector is due to the increase in imports of capital goods. However, it is equally difficult to assume that such growth in the manufacture of products requiring investment in sophisticated machinery could have been achieved within a decade by Tunisia without the import of capital goods. Similarly, it is difficult to imagine that such inflows of capital goods have not transferred or facilitated the transfer of technologies needed to produce the export goods and induced development of skills to maintain or adapt the imported machinery to local production environment.

2. Africa in the future technology market: A player or observer?

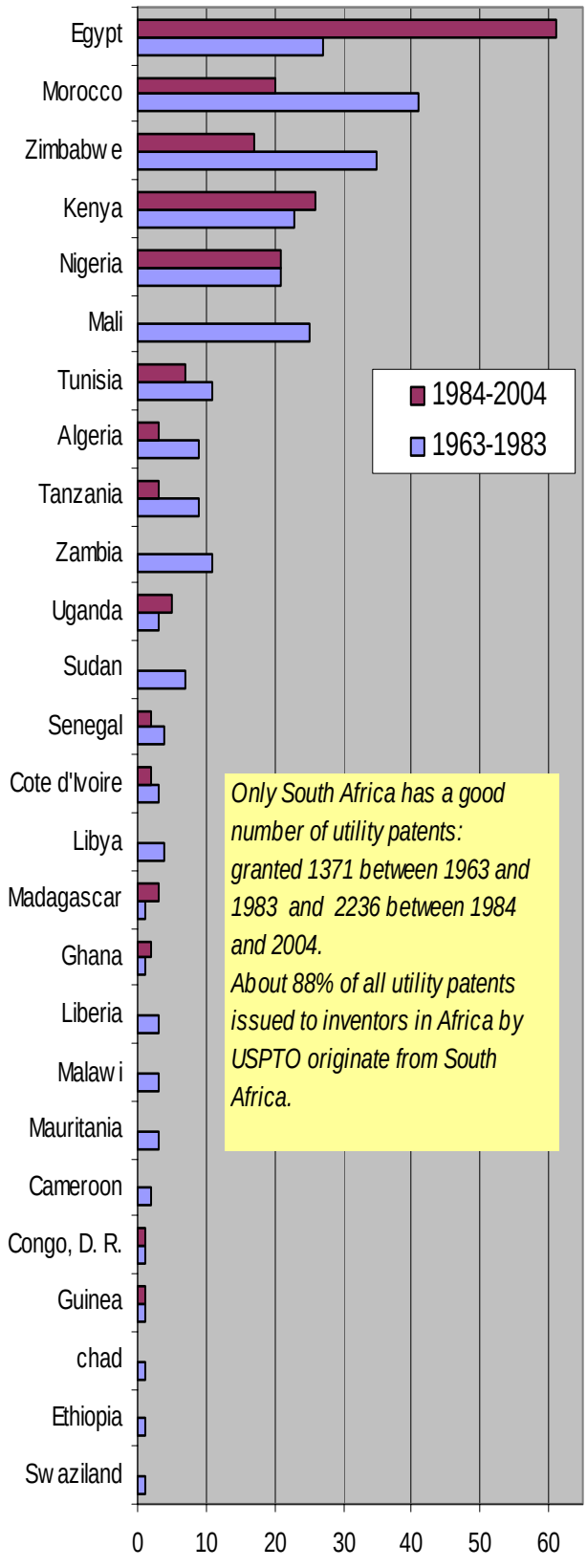
The increasing location of R&D projects and increased expenditure by foreign affiliates on R&D performed in developing countries is likely to fuel innovation. Similarly, the increase in outsourcing of assembly and manufacturing activities to developing country partners is also promoting the transfer of technologies and skills needed to develop new products and services. More contractors are passing on the cost of R&D to contract manufacturers in developing countries. Such changes in the global production may be shifting the traditional model of R&D and technology management as a preserve of headquarters to a more flexible and efficient technology development strategy that enables affiliates to compete in emerging and differentiating markets. Such shifts may help some developing countries become major owners and future players in the technology market.

For instance, the number of utility patents issued to inventors in China, India and Singapore has more than tripled in less than a decade. More than half of all the utility patents issued to inventors in China and India by the United States Patent Office (USPTO) between 1963 and 2004 were issued between 1999 and 2004 [14].

More importantly, Texas Instruments, IBM and General electric Company are the top three firms in India granted more utility patents by USPTO between 2000 and 2004 in India. In the case of IBM, they have risen from 8 patents granted in 2001 to 28 patents granted in 2004. It is important to also underscore that most USPTO utility patents issued to Indian inventors are from the Council of Scientific and Industrial Research (India)- over 100 patents a year. If this trend continues, India may see its knowledge base expand rapidly and the concentration of such top technology firms is likely to induce development and transfer of technology .

Africa is not benefiting from these trends and this is also reflected in the number of inventions seeking interna-

Figure 5. Utility patents granted to inventors in Africa over the last four decades by USPTO



Source: Based on USPTO

tional protection. For example, the total number of utility patents issued to inventors in Africa, excluding South Africa, by the USPTO has declined from 251 for the period 1963-1983 to 174 for the period 1984-2004. About 11 of the 27 African countries granted one or more utility patents by the USPTO did not get any in the last 20 years, as of 2004 (see figure 5). This is contrary to global trends.

The general decline in economic development, deterioration in terms of trade, political upheavals and limited investment in higher education and industries that affected parts of SSA in the 1980s and 1990s may explain why even the limited R&D activities by firms and institutions seized or was scaled down. Given patents reflect R&D activities of at least a few years ago, its not strange that Africa is behind in generation of knowledge of global interest.

Although South Africa has a good track of technology leadership in Africa and is issued about 100 to 123 utility patents per year by the USPTO over the last decade, the country seems to be registering a small decline in the number of patents issued to South African inventors.

It is also possible that African inventors think their inventions are of little interest to firms and inventors in developed countries or they simply do not know where or how to get a patent. It is also possible that they are not interested in patenting. But it may also be an indication of their lagging behind in technology use, development and trade. The latter seems the most plausible of the three reasons given the importance and time that has been devoted to developing and encouraging intellectual property protection, especially under the WTO.

Concluding remarks:

The need to stimulate technologies flows to Africa for development

Technology is not a panacea and should be pursued as part of the national industrial and development strategies. As East European countries soon found out, it may be easier to send a man to the moon than to use technology assets to promote industrial competitiveness.

Technology is not cheap to buy, use or produce. Therefore, before a call is made for more spending on technology assets, there must be clear goals such investment is meant to achieve, and all options to acquire, use and develop technologies have to be considered.

Different countries have used different strategies to acquire and develop technology. The Republic of Korea often formulates clear strategies on technologies, skills, numbers of professional and firms within the field of interest it wishes to develop in a given period of time and budget. It often focuses on acquisition of production and processing technologies to develop its products. For this reason, the country has a high technology import bill. In 2004, It paid $1.6 billion to the United States in royalties and licensing fees– almost twice that of China and four times that of Africa.

Chile uses a different strategy from that of Republic Korea. Chile employs its national R&D institutions to identify technologies that could be used to turn its vast natural resources into exports, to develop value-added products or improve production processes. Among others, Chile has acquired technologies that enabled it become a major exporter of salmons, wines and fruits. Since raw and processed agricultural and mining products account for a large share of its exports (~60%), technology payments are smaller than those of Korea.

Therefore, most African countries could promote technology transfer for development of industrial clusters or improving production processes. To achieve such targets, long-term plans to acquire, adapt and develop technologies, and mechanisms to deliver the technologies to market have to be put in place. Incentives, such as tax, soft loans etc may have to be provided to help emerging and existing firms access and use technologies.

African countries may have to revisit their higher education policies. Countries such as Chile, China, India and Tunisia, that invested in higher education are becoming part of the global production chains, and in the process accessing technologies. It is not surprising that these countries are attracting R&D projects or are using and producing more technologies.

With few exceptions, Africa has neglected higher education, a gamble that may be costing the continent dearly. The lack of skilled manpower is one of the most cited reasons why Africa is failing to close the digital, genetic and poverty divides. Many African countries now need technology to use technology. For example, some countries do not have the capacity to reproduce drugs already developed by others, and thus cannot take advantage of international agreements to do so, making some of the flexibilities in the WTO TRIPS Agreement meaningless.

Africa's low technology consumption and development is partly an indication of lack of a large number of firms and institutions with the capacity to exploit existing global knowledge base to upgrade or develop new production processes.

Developed countries too have a role to play (and should have interest) in facilitating technology transfer to Africa. The green revolution that helped Asia meet most of its food security concerns was driven by developed countries. In Africa, the European Union backed the eradication of rinderpest, an animal pest, with funding ($200 million over a decade) and technical support. Such investments saw some African centres develop capacity to produce and/or store the vaccine, and, for the majority of countries involved, national and cross-border surveillance and monitoring capacity. Above all, there is nothing wrong in including technology in official development assistance.

African countries could also develop innovative mechanism for funding R&D activities. For example, Mexico last year raised $44 million for science through fine for violation of campaign regulations by political parties [15]. Such measures advance science and democracy and Africa has major headaches with both. Indeed, similar measures already exist in some African countries on rural electrification taxes in electricity bill or road taxes in fuel pump pricing. However, these taxes tend to lack a technology development dimension—i.e. using part of it to fund alternative electrification or development of cheaper but effective road tarring materials.

Finally, encouraging the emergence of technology entrepreneurs and firms is part of prompting technology transfer and development. The birth of the biotechnology industry is often traced to Genentech, a firm founded by a University professor and a venture capitalist. Today, a vibrant biotechnology industry has emerged that is investing more in R&D than the public sector. Therefore, public investment is important in stimulating private sector growth if targeted, especially in emerging and new technologies or areas with limited industrial development.

For Africa, the question is not whether or not industry is investing in R&D or acquiring technologies but how we could acquire and/or use technologies to build industries. India and China are still relying on public sector investment for knowledge generation despite their economic and technological development.

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The Transfer and Dissemination of Agricultural Technologies: Issues, Lessons and Opportunities

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Abstract

The rapid and widespread abandonment of the World Bank's Training and Visit system in the mid-1990s created an operational vacuum within the national extension programs of West Africa. At the same time, non-governmental organizations gained much recognition for their use of participatory and processed-based approaches, which national programs subsequently attempted to emulate. Key issues related to this period of transformation, as well as the current status of technology transfer activities within the sub-region, include: the increased plurality of extension service provision; significant changes in the methodological orientation of extension practice; continued struggles with the weak level of human resources in extension programs; the limited base of relevant technological innovations; and exploration of alternative approaches to extension financing. While use of a loose collection of participatory tools has become widespread, no dominant approaches experiencing widespread adoption have emerged, nor have any particular types of organizations (governmental, non-governmental, or private) distinguished themselves as operationally superior. Factors associated with positive impacts include programmatic size and strength, attention to supportive capacity-building, and lateral networking efforts linked with strong vertical integration into field programs. Future successes in the sub-region will be linked to greater attention being given to strengthening the human dimensions of development practice.

Key Words: extension, agricultural development, technology transfer, technology dissemination, West Africa, capacity-building.

1 General background

Just over a decade ago, a survey conducted within the West Africa sub-region on the basic structure and orientation of extension practice would have found the majority of national extension programs using some variant of the Training and Visit (T&V) system promoted by the World Bank. These systems featured a highly centralized, top-down 'cascade' administrative structure, designed to maximize efficiency in moving new technological recommendations from research out to farmers through bi-weekly meetings with field agents (using demonstrations and contact groups), who in turn were supported by a small cadre of subject matter specialists and regular in-service training.[2] Ultimately, the high costs of operating these elaborate structures, combined with the lack of new technologies to extend, led to the eventual abandonment of the model. Although increasingly relegated to the realm of historical footnotes, the T&V experience has continued to exert itself through the attitudinal and operational footprint it left upon individuals and programs indoctrinated in its use.

Today few, if any, of the classic T&V programs still operate within the sub-region. The extent of the fall from grace of the T&V model is remarkable for both its breadth and rapidity, and is based upon the combined effect of (i) the mutual recognition by the Bank and implementing countries of the operational shortcomings (or outright failures) of the T&V approach in West Africa, (ii) the shifting of the Bank and other donors to channelling increasingly large shares of operational funds through so-called non-governmental organizations (NGOs),[3][4] and (iii) based on both the weak performance of the T&V model and the withdrawal of financial support, governments have had to face 'a day of reckoning' over what type and size of programs they can support through their own resources, and in response, national programs have begun to gravitate towards alternative methodologies of extension practice and models financing.

Although few entirely new forms of extension service provision have emerged in recent years, there has been an important shifting and re-partitioning of activities among the existing actors. One of the most important trends across the sub-region has been the transfer of basic service provision, such as rural credit, input supply and produce marketing, out of national extension programs and into the private sector. This process began in the mid-1980s with the introduction of structural adjustment policies, and accelerated through the 1990s. Interestingly, and contrary to the trend among national programs, a surprising number of donor-supported NGOs, large and small, are promoting their own credit schemes and arranging for input delivery. Seed multiplication and dissemination is perhaps the single major agricultural service area that has remained primarily under public sector control, due largely to the nature of the product and the weak potential for private sector enterprise to profitably provide the service. In terms of their overall content, it is fair to characterize public sector extension programs, as well as most NGOs, as providing public goods (largely in the form of technical advice and recommendations) to farmers across the majority of, but not all, environmental and socio-economic conditions found within each country's borders. In contrast, private sector service providers, and quasi-governmental parastatal organizations, tend to be oriented towards the provision of private goods and services within much more limited geographic and economic domains.

Although the perfunctory characterization of governmental extension program performance as slow, ineffective and grossly inefficient in comparison to NGOs has become standard, the on-the-ground reality is not so clear-cut. Freed from the operational bondage imposed by the T&V system, and armed with cutting-edge approaches and more responsive management styles, national programs are proving to be equally capable of delivering the same types of benefits as NGOs (at the same, or even lower, costs). In addition, due to their large size, national programs are able to generate impact at a speed and scale that are orders of magnitude beyond that possible for most NGOs. Poor infrastructure and policy constraints continue to limit the impact of market forces and the ability of the private sector in many countries to offer clearly superior alternatives. In general, African farmers face some of the highest transaction costs in integrating themselves in the marketplace, paying 3 to 5 times the world market prices for inputs, while receiving only a fraction of market value for their produce. While the provision of certain goods and services (e.g., veterinary services) is finding a ready home in market-based transactions, others have not (e.g., seed supply), and may never be fully absorbed by private enterprise. In general, the low educational levels of extension field staff and supervisors, and limited sources of new, viable, technological innovations, affect all technology diffusion efforts alike, regardless of the type – public, private, or NGO.

2 Major issues

A number of important issues warrant identification and further comment regarding their immediate and mid-term future impact on technology transfer and dissemination efforts in West Africa.[5] The first concerns the general increased plurality of extension service provision that has occurred over the past decade. For recipient countries, one of the major fallouts from the waning support among donors for public sector institutions is the structural transformation of how, and by whom, extension services are provided. This is most clearly seen in the emergence of a truly pluralistic organizational landscape, where state extension agencies have had to learn to share the field with an increasingly large number of NGOs. To illustrate the point, in the case of Mali, over 1,800 NGOs were reportedly listed at the national registry office in 2002,[6] compared to the estimated 800 a decade earlier.[7] While not all of these organizations carry out direct extension activities, many do. These range from one-person 'briefcase NGO' consultants, to large, principally northern-based, and often times well-funded, organizations that rival and may even exceed the national programs in terms of budget and operational prowess. Despite this trend towards diversification, the fact remains that in most countries within the sub-region, state extension services remain the largest, and single-most important, organization engaged in technology dissemination. The reason Guinea, for example, has been able to successfully launch and sustain a massive effort to rapidly multiply and disseminate NERICA rice varieties (NEw RICe for Africa), developed by the West Africa Rice Development Association,[8] is because they have over 2,000 agents in the field. Similar figures can be cited from neighboring Cote d'Ivoire and Ghana. Compared to the one or two hundred field personnel of the very largest NGOs, and the more typical number of 6 to 7[9] field technicians, the potential and real power of public extension services must not be under-valued.

As would be expected, under conditions of appropriate public policies, adequate infrastructure and sufficient effective consumer demand, the private sector has been successful in providing a wide range of production inputs (including, in some contexts, the emergence of private seed companies), certain discrete technical services (such as veterinary), as well as various production credit opportunities, particularly in situations where farmers have achieved higher levels of market integration through cash crop production. The provision of 'public good'-type services, however, such as technical advice on crop production techniques, natural resource management, small enterprise development and others, has not been an area of growth, although Mali is currently experimenting with a limited program.[10] Nor has the private sector done particularly well in situations where the farm population is dispersed and generally poor. In response, one observer has wondered where the rich body of experience is found showing that farmers living on 1-2 dollars a day "have bought their way out of poverty."[11] Others have raised questions over the willingness of the private sector to invest in staff training, who will provide this training, and how effective for-profit enterprises will be linking with governmental research institutions, among other issues.

The examples of voluntary technology dissemination emanating from certain group-based development efforts, and the increased political advocacy of established farmer unions, fed hopes through the 1990s for the potential involvement of producer associations in technology dissemination activities. The record of evidence to-date, however, shows that these hopes have not been, and may never be, fully realized. While most farmer associations organized around viable commodity markets readily assume greater responsibility for input provision and marketing of members' produce (as a means of reducing costs and gaining more revenue for their members), there has been much less involvement in actual technology diffusion activities. Those examples that do exist tend to reflect conditions where there is a high-value, specialized cash crop and few or no other alternative sources of technical information.

A second, closely related and equally important issue is that of the significant changes that have taken place in the methodological orientation of extension practice over the past 10-15 years. For governmental extension services, the operational void created by the abandonment of the T&V model has generally been filled by a loosely defined set of 'participatory practices,' generally reflecting the struggle of national extension programs to assimilate the language and practices of more participatory

and multi-actor orientations to technology dissemination that have characterized the work of their smaller NGO cousins.

One of the primary reasons why NGOs have captured the imaginations of donor organizations and have been so successful in mobilizing funds is the perceived notion of NGOs' superior effectiveness and efficiency in meeting the needs of target populations through their streamlined, more flexible approaches to programming and use of innovative, responsive, participatory methodologies. The general shift by NGOs to a more process-oriented, demand-driven style of rural development often involves related adult education, local organizational capacity-building and empowerment themes, most of which were lacking in the contemporary governmental programs of the day.[12]

As one review indicates, however, the optimism of the pro-NGO view is founded more on belief (desire) than empirical evidence.[13] The factual body of evidence supporting the picture of NGOs' superiority rests largely on anecdotal glimpses and isolated case studies. Yet an equally persuasive body of anecdotal material and case examples can be compiled showing just the opposite -- that many NGOs may, in fact, be no more effective, even less efficient, and perhaps no more operationally innovative or participatory than the governmental services they are supposedly superior to. Within this atmosphere of uncertainty, one issue is resoundingly clear: given the shear number of organizations involved, their diverse ideological orientations, unequal resources, disparate levels of trained human resources etc., the resulting challenge of attempting to coordinate or undertake any sort of broad-based, complementary programmatic activities will, in many countries, become prohibitively complex. Underlying this observation, and in contrast to what is known about past governmental programs, it is clear how very little we know at the national level about NGOs -- what they do, where they work, who they target and how they locate new innovations. Given the large portion of financing currently being channeled through NGOs, this basic lack of understanding, and continued 'blind faith' in their support, is troubling to say the least.

A third area of concern, affecting equally governmental services, parastatals, NGOs and, presumably, the yet-to-emerge cadre of private sector extension employees, is the low educational levels of the majority of extension field staff and managers. The rising demands associated with new extension methodologies, and the need to coordinate activities of numerous partner organizations, require field agents and their supervisors to increasingly act as process facilitators, learner-driven adult educators, multi-actor networkers, as well as to assume more prominent roles in up-stream technology development and adaptation efforts.[14] The skill requirements demanded by these activities lay well beyond the educational preparedness of the vast majority of field agents. The one-off, in-service training 'workshops' on 'new' extension methodologies that became one of the cottage industries of the development enterprise in the 1990s were simply not sufficient to overcome the more basic lack of a sound educational background. Furthermore, and perhaps most troubling of all, an assessment of available educational programs within the sub-region that are capable of meeting the professional demands of the new extension realities would likely come up with only one or two notable candidates,[15] a sobering reminder of the massive failure on the part of donors in taking seriously the need for long-term, institution-building investments within the sub-region.[16] The important exceptions of the tertiary education program for mid-career extension agents at the University of Cape Coast, Ghana,[17] and the launching of similar programs in Mali and Burkina Faso, deserve to be closely studied by other countries and donors. In general, however, the level of dis-connect between the existing education-research-extension programs, and the inability of most countries to offer adequate training opportunities for their own scientific and extension professionals, underlies the question of how countries in West Africa will rise to the challenge of driving an autonomous economic development agenda.

One of the perennial 'thorns' in the side of nearly every extension program is the limited base of innovation and struggle to find relevant new technologies. One of the persistent complaints levied against national extension programs over the past 25 years has been over their dogged promotion of the same, tired, old technical messages. Where NGOs have shown their superiority has often been through their linkages to, or mobilization of, alternative sources of technical information. Although not a direct relationship, the growing plurality of organizations involved in technology diffusion has tended to result in a growing (though still limited) plurality of technology sources. While on the surface this would seem a positive trend, the divided, often highly antagonistic, nature of GO-NGO relations has meant that these two levels of diversification – innovation source, and vehicle of dissemination -- have tended to assume and retain stronger lines of vertical integration rather than evolving into true horizontal networks of exchanges. Governmental extension programs tend to get most, if not all, of their 'technology choices' from governmental research programs, while bi-lateral and multilateral funded-projects, as well as large, northern-based NGOs, tend to utilize and promote their own technical innovations (the common pattern for smaller NGOs is to serve as the implementation vehicles of donor-specified activities, which typically come with their own technical assistance components). Only in those cases where some degree of true inter-organizational collaboration has been established (typically in the context of a specific funding initiative) has there been a real broadening in the pool of innovation sources available to all participating diffusion organizations. The socio-political climate for these types of inter-organizational collaboration varies markedly from country to country, and often from program manager to program manager.

In addition to the struggle to find current, new information, one of the sad truths of agricultural research and technology development is that, outside of the established gene banks, there are often no national, let alone

sub-regional or regional, repositories of accumulated wisdom where farmers, extension services, NGOs or others can access a comprehensive range of technological options. Plagued by staff turnover and major policy shifts, individual research organizations tend to operate within their own limited sphere of current activities, which represent neither the breadth nor historical depth of developments within their own organizations and countries, let alone the larger regional and global environment. Over the past several decades, African universities have generally been side-line spectators to the research process, and are only recently beginning to receive the attention they deserve in increasing their involvement in research activities.[18] Set against the backdrop of the long time delays in technology development (few breeding programs, for example, have had anything significant to offer in less than a decade), and the truly difficult nature of problems facing research organizations, any potential loss in opportunities due to the inhibited movement of existing technologies, or the development of new, should be a major area of concern. The bottom line is that without access to the full range of existing, and the addition of new and responsive, technical alternatives, any diffusion program -- public, private or non-profit -- will have little to offer their audiences.

Alternative approaches to extension financing, intermingled with the related topics of operational structure, need for increased market orientation, investment in human resource development etc., have been a lightning rod of debate in recent years among donors and development scholars focusing on extension issues and, more importantly, governmental extension programs.[19] To illustrate the point, the four neighboring countries of Côte d'Ivoire, Ghana, Guinea and Mali have all abandoned their previous T&V-based approaches to extension programming, and are all now pursuing self-described participatory approaches to extension through various mechanisms: Côte d'Ivoire (before the outbreak of violence) through a system of contractual arrangements between line-Ministries and the national extension service for the delivery of specific extension programs; Ghana through its program of national decentralization, which allows for additional district level buy-in to extension programming options (currently focused on expanding the Farmer Field School program); Mali through the increased privatization of services, including experimentation with a limited user-pay program, offered through the traditional regional and commodity-oriented quasi-governmental organizations; and Guinea through the continuation of a fairly traditional, centrally-financed and managed mainline national extension service. Although currently most of these programs receive significant levels of direct and in-direct donor support, financing is intended to devolve entirely to state resources in the future.

The need to fit alternative models of extension financing to unique national policy orientations, levels of market integration of specific target groups and production systems, and other significant historical, institutional and current contextualizing factors, suggest that no one model will emerge for widespread adaptation (in fact, the extensive history of failed efforts to blindly promote blanket solutions, irrespective of context, would argue strongly against such a notion). The current experiments being carried within the sub-region, as well as those from elsewhere on the continent and beyond, will need to be closely monitored for the lessons they provide in terms of identifying which country-level conditions provide the best guidance in matching various financing mechanisms.

3 Major approaches and lessons learned

Due to their underlying differences (dissemination within, as opposed to transfer across geographic and organizational contexts), it is easiest to address issues related to dissemination and technology transfer separately, although in operational terms most organizations are involved in both types of activities.

3.1 Dissemination

The widespread diffusion of the language and practice of participatory development has been one of the major changes to extension practice occurring worldwide over the past 20 years. Within the sub-region, most of this growth in popularity has occurred in the form of a diffuse body of non-unified 'participatory' techniques and discrete methodologies, although at least one major operational approach, Farmer Field Schools, is gaining significant exposure. Data from a nine-country survey of 216 NGOs[20] involved in agricultural and NRM technology diffusion in West Africa indicates that some of the most important examples of participatory methodologies include:

⇒ -Rapid Rural Appraisal/Participatory Rural Appraisal (RRA/PRA). Introduced through short-term, in-service training or standalone workshops starting in the late 1980s, these approaches have become the 'bread-and-butter' tools of most NGO field activities, and it can be safely said that at least an awareness of their general form is now well established within the major dissemination organizations across the sub-region.[21] The widespread awareness of RRA/PRA practices, however, does not mean that the level of quality, or even observance of the basic principles, is always high;

⇒ -Participatory Varietal Selection (PVS). An approach initially targeted at assisting breeders in understanding farmer preference, PVS has since increasingly been used by extension programs to identify and disseminate locally desired varieties. WARDA spear-headed the promotion of PVS application through a multi-year annual training and small grants program, which trained a small core of rice breeders and social scientist researchers in every NARS across the sub-region. Use of the approach has since spread to use with other crops and, through joint field activities, exposure through 'field days'-type demonstrations and various publications, to extension programs;

⇒ -Community-Based Seed Systems (CBSS). As a refinement of NGO and FAO decentralized seed multiplication programs of the late 1980s and early 1990s, the CBSS model involves individual farmers and farmer groups in the commercial multiplication and sale of new crop varieties, cutting up to 5 years off the time it takes new varieties to reach farmers. National-level programs have been established in Guinea and pre-war Côte d'Ivoire, with other countries considering implementation plans. A wide number of NGOs are using the same or similar approaches in most countries in the sub-region;

⇒ -Community-Based Natural Resource Management (CBNRM). Introduced through a broad range of efforts (e.g. FAO, NGOs and bi-lateral assistance), early CBNRM practice was most closely associated with forest management issues, based on a number of well-researched case studies and a period of popularity in establishing community woodlots in the early 1990s. Since then, the CBNRM approach has been successfully used within the sub-region in addressing a broader range of issues including: soil fertility, grazing lands, water resources, fisheries and wildlife;

⇒ -Rural Radio. Although not identified in the survey, the rapid growth in the number and diversity of information technologies in recent years (including radio broadcasting, satellite and land-line internet connectivity) has stimulated interest in using various mediums to accelerate the dissemination of information on new technologies to rural areas. Efforts have been spearheaded by ISNAR, FAO and CIDA, with active programs in several countries within the sub-region, notably Burkina Faso, Ghana and Mali.[22]

In contrast to these tools and individual techniques used by different governmental and NGO extension programs, the introduction and spread of the Farmer Field School approach within the sub-region is unique, in that it constitutes a broader, more comprehensive strategy to extension practice itself. Introduced to West Africa from S.E. Asia in the mid-1990s, through assistance of the FAO Global IPM Facility, significant FFS programs have begun to develop in at least four countries (Ghana, Mali, Burkina Faso and Senegal), covering a range of production systems, from irrigated rice to rainfed cereals, cotton, plantains and vegetables. Involving the use of the principles and practice of adult education, farmer-led experimentation, farmer-to-farmer communication and local organizational development, the FFS model has embraced many of the core features of participatory development and local empowerment. Although not without problems, the potentials offered by the FFS approach appear substantial, and are only now being explored.[23]

The cumulative lessons learned from these experiences are several. First, and perhaps most surprising, is the observation that given the opportunity and support, governmental extension agencies are every bit as capable of being leaders in the development, refinement and implementation of innovative new approaches to technology dissemination as NGOs (e.g., PVS, CBSS, FFS). Secondly, due to their size and established presence at the field-level, the involvement of national structures and larger NGOs have been critical in scaling-up the implementation of new practices. It is important to note, however, that the success of broad-based implementation is closely tied to the successful testing of new approaches in pilot projects and adaptation to local conditions. Where this rule is not observed, the risk of larger scale failures increases exponentially. While programmatic size is important for significant impacts, so is the intelligent phasing of implementation. Third, each of the methodologies highlighted (save RRA/PRA, which, as noted, often suffers from quality concerns in field-level application) are supported by significant capacity-building programs – for example, FFS field training takes place over an entire cropping cycle, and the introduction of PVS methodologies was accomplished through a multi-year training and support program. In the case of Ghana's successful FFS program, there are also important ties to a parallel program of providing extension agents with tertiary university education[24] that deserve greater attention on the part of donors.

3.2 Technology transfer (TT)

As defined previously, TT is used here to describe the movement of knowledge or technologies across contexts -- inter-regional, intra-regional or organizational. Despite the deserved criticism that ill-conceived TT efforts have received in the past, it is important to note that, other than instances where technologies have been developed within a single context, all other innovations that have been broadly adopted by farmers within the sub-region involve some form of TT. Used intelligently, TT represents the greatest mechanism to stimulate and sustain rapid agricultural development within the region. This includes the transfer of farmers' indigenous knowledge and perceptions into the region's institutions of research and dissemination, which over the past 15-20 years has proven to be one of the most important sources of technical innovations, particularly in the area of natural resource management.[25] Two of the most important TT linkages between formal agricultural research and diffusion efforts are:

-CGIAR Centers. WARDA and IITA, which are based in the sub-region, and ICRAF, which also has a presence in the sub-region, have technology transfer specialists on staff, and operate a number of dedicated TT projects (the other CG centers working in the region, ICRISAT and ILRI, apparently do not have TT staff). The importance of having staff dedicated to completing the additional steps of transforming research results into usable technologies and making these available to dissemination agencies cannot be over emphasized. In addition, both WARDA and IITA facilitate regional and sub-regional networks that serve to assist and partner with national and NGO technology dissemination programs (e.g., ROCARIZ, and WECAMAN). These networks have been highly successful in supporting the transfer of genetic material by keep-

ing different member groups actively involved in regionally coordinated activities.[26] In response to the unique opportunity of the once-in-a-generation technical breakthrough, such as presented by the NERICA rice varieties, WARDA, supported by multiple donors, has launched a special standalone effort, the Africa Rice Initiative, to help rapidly move these varieties throughout the region;

-Larger NGOs and Projects. Through their home office technical staff, and hired program officers, the larger NGOs and donor-funded projects essentially constitute separate (independent) technology transfer systems, with the ability to extrapolate experiences and cross-fertilize successes from different project sites and countries. In a number of instances, these organizations and projects have proven to be important contributors in the introduction and movement of new technologies across the sub-region. CARE's work in refining the indigenous practice of using rock lines to control soil erosion and promote greater moisture infiltration in Burkina Faso, and its subsequent spread to neighboring countries, is one of many such examples.

In contrast, the record of the private sector's contributions to significant agricultural developments in the sub-region is rather thin. On the one hand, private companies are without doubt the most important providers of basic input materials (e.g. tillage equipment, fertilizers, pesticides, veterinary supplies and formulated animal supplements). However, many of these inputs have not changed appreciably in decades. In those areas where private companies have attempted to become commercially involved in introducing innovations, the record is uneven. The few private seed companies found in the sub-region have found gaining market share difficult, due largely to the characteristics of the major crops (non-hybridized) and the diffuse, often-poor, potential client populations. Foreign agro-chemical companies are increasingly fighting battles on many fronts as they collide headlong with governmental and NGO efforts to safeguard farmers' health, increase profits and reduce environmental damage. In other cases, targeted assistance that involves partnership between public agencies, private entrepreneurs and other actors has helped commercial businesses to become successful purveyors of new technologies, such as in the case of local equipment manufacturers producing rice thresher-cleaners and selling and repairing imported treadle pumps.

There are several lessons that can be drawn from these examples. First, recent developments by regionally-based CGIAR centers have achieved a certain amount of success in helping to bridge the nether world area between research and extension. Increasing the number of dedicated TT staff positions, effective networking structures, and the initiation of highly-targeted technology promotion initiatives (e.g., Africa Rice Initiative – ARI)[27] are all promising areas of future investment. Second, the larger NGOs and project-based initiatives constitute additional, and potentially rich, sources of technological innovation and adaptation. However, due to their independent status, different approaches will need to be employed to gain access to and integrate with their considerable resources. Third, for the foreseeable future, placing greater reliance on the private sector and market forces to drive the process of technology innovation, transfer and dissemination would probably significantly slow, rather than accelerate, agricultural development within the sub-region, and would likely undesirably skew the type of innovations offered, as well as the access to new technologies based on economic and geographic considerations. More than a decade has passed since the first serious announcements about the coming biotech revolution were issued, and still no major improvements have been delivered. While greater private sector involvement can be achieved, special emphasis will likely need to be placed on establishing the appropriate context and helping fledgling businesses to pick up new technologies and expand their technology dissemination roles.

4 General recommendations

Based upon the preceding discussions of major issues, current approaches and lessons learned, several general recommendations can be made for enhancing the identification and movement of technological innovations within the sub-region. These include:

Taking an aggressive stance on filling key knowledge gaps, the results of which would feed into immediate and longer-term investment planning decisions. Gaps of particular concern include: (i) gaining a regional understanding of NGOs and private sector technology providers' activities, capacities, sources of innovation and the best ways of gaining access and mobilizing their resources; (ii) the current status and capacities of the region's agricultural universities to train the next generation of agricultural professionals, particularly in the areas of extension education, commodity research and agricultural business training and support; and (iii) support to establishing national and sub-regional repositories of accumulated research results (the AGORA – Access to Global Online Research in Agriculture – and TEEAL – The Essential Electronic Agricultural Library – offer excellent access to research results published in international journals. Unfortunately, few results from NARS programs are contained in these journals);

Assessing different options for new ways of meeting the critical need for improved access to innovations (e.g., university-managed technology outreach centers, along the lines of the USAID-supported PEARL – Partnership to Enhance Agriculture in Rwanda through Linkages – project, ATTRA-type[28] information hubs, and increased use of rural radio opportunities); assessing ways of assisting general and targeted efforts to accelerate technology diffusion and transfer (regional 'dare to share' technology fairs; success story study tours and exchange visits; support for ARI-type initiatives to rapidly expand access to technologies with immediate and exceptional promise);

Discussing with IARC and NARS partners ways of improving regional TT and dissemination capacities through strengthening the existing sub-regional commodity networks, sub-regional research coordination bodies (e.g., CORAF/WECARD) and the regionally-based CG centers (e.g., funding additional TT positions, providing additional operational funds to selected TT networks). The major importance of improving regional access to new genetic material warrants specific attention. Issues to consider include ways of unifying and streamlining varietal release systems, the comparative advantages and requirements of alternative dissemination approaches, ways of supporting the development of private sector seed companies, gene bank security, and regional preparedness for post conflict/disaster response measures, among others.

One of the tendencies in academic and home office assessments of technology generation, transfer and diffusion is to overlook, or at best greatly under-value, the human dimensions of agricultural development. A serious review of successes and failure within the development arena would likely show that significant development success were almost universally achieved in spite of deeply flawed project or program designs, inadequate funding and material support, and in the face of major knowledge gaps. Successes are achieved because people made good decisions at the right moments, and persevered in the face of often extreme adversity. Such a conclusion is difficult for most organizations to absorb because it marks a distinct departure from traditional command and control, and process-outcome, development orientations whose major emphasis is on the blueprint and the use of specific tools. Too often we forget that it is people that interpret and implement plans, that must respond to and function within contexts, and utilize, skillfully or not, the many development tools. Yet what portion of resources is spent in attracting, educating, supporting and retaining talented individuals? The future of agricultural development impact will reflect how well organizations address and engage this critical human element.

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Endophyte-enhanced banana tissue culture: technology transfer through public-private partnerships in Kenya and Uganda

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Abstract

The lack of clean planting material is a major constraint for banana production in East and Central Africa. When establishing new fields, tissue culture plantlets will reduce damage by banana pests and diseases. Pest infestation or reinfestation, however, remains a vital concern. Fungal endophytes, when inoculated into banana tissue culture plants, extend the benefits of clean planting material. Endophyte-enhanced tissue culture technology is being developed at the International Institute of Tropical Agriculture (IITA). Tissue culture production facilities in Uganda are in their infancy, while in Kenya the situation is more developed. Public-private partnerships between IITA and Agro-Genetic Technologies Ltd (Uganda), and Jomo Kenyatta University of Agriculture and Technology (Kenya) have recently enabled IITA's project to make great progress towards bridging upstream research and downstream technology transfer. Additionally, unexpected synergisms have emerged through mutual exchange of information and experience. Based on IITA's highly positive experience, such public-private partnerships should be introduced as early as possible in the developmental stages of activities to maximize the benefits to research for development.

Keywords: banana, Central Africa, East Africa, public-private partnership, tissue culture

Introduction

Cooking banana is a key staple crop throughout East and Central Africa, while dessert banana is an important source of income for many farmers. However, accelerated yield declines of banana have been associated with increasing incidence of soilborne pests and diseases. The use of clean planting material is essential in overcoming such constraints, especially when establishing new fields. Pest infestation or reinfestation, however, remains a vital concern, and therefore the International Institute of Tropical Agriculture (IITA) is researching ways, in collaboration with commercial enterprises, to produce long-term clean banana planting material for the region.

The banana weevil, Cosmopolites sordidus, is the most important insect pest of highland bananas and plantains. Banana weevil larvae tunnel into the rhizome (underground stem), resulting in reduced nutrient uptake, weakening the stability of the plant and causing plants to break. The burrowing nematode, Radopholus similis, is globally the most important nematode pest to banana production and a major constraint in East Africa. Nematodes kill the roots by feeding on them. The destruction of root tissues reduces yield, and ultimately destroys plant anchorage, resulting in a typical symptom of toppling of the whole plant. As with the banana weevil, nematode damage is initially low but gradually builds up over crop cycles. This is particularly disastrous for a perennial crop such as banana: accumulation of pests and diseases results in shortage of adequate, clean planting material.

Banana in the region is traditionally propagated by means of suckers, which are rhizomes cut off from the motherplant. These suckers are infested with soilborne pests such as the banana weevil and the burrowing nematode. Consequently, the use of suckers as a primary means of banana propagation decreases yield and plantation longevity, with dire consequences for food security in the region. In the laboratory, banana can now be produced axenically through tissue culture. A part from viruses, tissue culture banana plantlets are by definition a pest- and disease-free planting material. This banana propagating technique is widely adopted in the world, but is not widespread in East and Central Africa, to a large extent due to the subsistence nature of banana production.

Tissue culture technology offers many other advantages besides being pest- and disease-free. Compared to conventional planting material, tissue culture plants give higher yield, and earlier and more vigorous sucker production. Tissue culture plants are uniform, allow for mass production in relatively short periods of time, and are available all-year round: important criteria for commercial farming. Rapid and easy mass production also allows for facilitated distribution of improved cultivars, and can compensate for planting material shortages.

However, during the early transplanting stages, banana tissue culture plantlets need higher levels of care and attention than conventional planting material. Research at IITA has demonstrated that in Uganda, where soils

Farmer co-opted nursery in Kibirigwi, Mount Kenya region, built with the support of Jomo Kenyatta University of Agriculture and Technology.

are depleted and pests and diseases abundant, tissue culture is only superior to conventional planting material if associated with high levels of field maintenance (1). In East and Central Africa, where banana management practices are often suboptimal and banana production is plagued by constraints, the benefits of a sustainable tissue culture banana system could be huge, and especially so if plantlets could be protected against pests such as the banana weevil and the burrowing nematode.

1 Endophytes: Extending the benefits of clean planting material

Almost all plants are naturally associated with endophytes. An endophyte is an organism that, at some time during its lifecycle, lives within plant tissues, yet does not cause any disease symptoms to its host (2). This association is often mutualistic. Foremost, endophytes provide the plant with antagonism against pests and diseases. Mechanisms by which endophytes protect plants are only recently beginning to be understood, and are manifold. Recent interest has focused on the induction of resistance by endophyte infection of the plant against pests and diseases. Induced resistance is the activation of biochemical and structural plant defence mechanisms following contact with elicitors, such as endophytes (3, 4, 5). Induced plant resistance, elicited by an endophyte, provides a susceptible plant cultivar with pest or disease resistance. 'Immunization' of plants with endophytes therefore can help complement current breeding programs. Endophytes also confer other benefits to the plant. Plant growth seems to be promoted by all major endophytic groups, either through facilitation of increased nutrient uptake (6) or through synthesis of plant hormones (7).

Natural entry of an endophyte into a plant is a process that can be manipulated. Once inside the plant, an endophyte occupies a niche with relatively low competition from other microorganisms, provided the endophyte gets there first. Early entry is key, and can be effected through inoculation during propagation of the plant material. In other words, the endophyte becomes an intrinsic component of the planting material when sold to growers. Reintroduction of endophytes into banana tissue culture plants restores the natural equilibrium and extends the benefits of clean planting material.

2 Circumventing the biopesticide hurdles

Biological control using microorganisms has widely been promoted as an alternative to the use of chemical pesticides. Despite a large body of both theoretical and applied research on the topic, the use of biologically beneficial organisms has been limited, mainly because the same paradigms used for conventional pesticides are being applied to microbial pesticides. Using endophytes as microbial control agents might circumvent some of the problems associated with these paradigms.

Many promising microbial control organisms demonstrate excellent performance in the laboratory against pests or diseases. However, this often translates in below-expected performance in the field because they have to compete with the native flora. This competition can be avoided by using endophytes that escape the rhizospere community where competition is fierce.

Some pests and diseases, such as the banana weevil and the burrowing nematode, are embedded within plant tissues and are therefore not easily controlled. Endophytes offer the potential to control these cryptic pests and diseases.

At practical application rates, the use of microbial pesticides tends to be slow-acting, erratic and expensive. Endophytes can be applied as an intrinsic component of the planting material. This tactic allows for targeted control at low initial inoculation levels, improving consistency of endophyte performance and reducing costs. Added benefits of using endophytes that induce resistance are that 1) endophytic inoculum does not need to be present at the time when the plants are attacked by pests and diseases, and that 2) endophytic inoculum can have a similar effect even at very low doses.

Most importantly, tissue culture plants can be made available to farmers as a 'ready-armed' or endophyte-enhanced plant, removing any need for farmers to apply additional products. Costs and know-how associated with formulation, distribution, application and storage are transferred to a commercial laboratory. Expertise and equipment related to applied microbiology is similar to that of a commercial tissue culture laboratory.

3 IITA's research into banana endophytes

IITA has a mandate to develop sustainable food production systems in tropical Africa, and is linked in the worldwide network of agricultural research centres supported

by the Consultative Group on International Agricultural Research (CGIAR). At IITA, research into endophyte-enhanced banana tissue culture was initiated in 1997 under funding by the German Federal Ministry for Economic Cooperation and Development (BMZ). In 2001, BMZ provided substantial funds for a project entitled "Managing micro-organisms to enhance plant health for sustainable banana production in East Africa". This project, which is now entirely focused on the use of endophytes in banana tissue culture, received second phase funding until December 2007 to finalise research needs of this technology. Thereafter, IITA hopes to take the technology into an up-scaling and production phase. Research into endophyte-enhanced banana tissue culture has so far yielded a wealth of information. The protocol used during the research is depicted in Fig. 1 (adopted from 8).

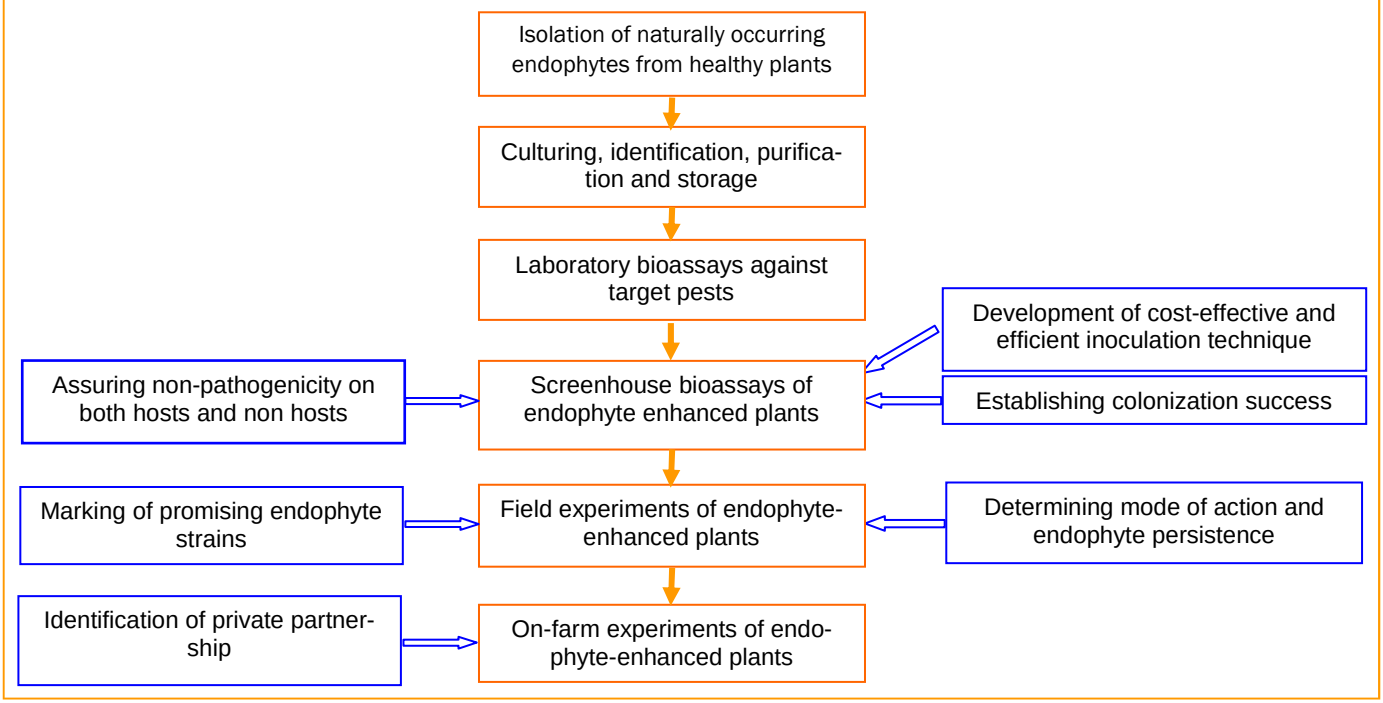
The most critical step in the quest for endophytes is accurate isolation. Since the aim is to find strains that will target specific pests and diseases, IITA's approach is to isolate endophytes from apparently healthy plants growing among high levels of pests or diseases. In addition, the endophytic flora varies with plant cultivar, host plant age and ecological conditions. To isolate endophytes, plant samples are surface-sterilized and plated onto specialized culture media in the laboratory. After identification and purification, they are stored. Following isolations in Kenya, Uganda and South Africa, the most frequently isolated endophytes belong to the genus Fusarium. IITA has therefore focused primarily on this genus.

Based on morphological and molecular analyses, sampling a handful of plants yields a vast array of endophytic strains. Hence, a rapid, easy and cheap laboratory screening protocol was devised to test as many strains as possible against both the banana weevil and the burrowing nematode. Only a handful of strains that show high antagonism against the target pests are further tested. Merging concurrent research into the development of efficient inoculation techniques that yield high colonization, banana tissue culture plantlets are inoculated with these best endophytic strains for screenhouse assessment against the target pests. At present, IITA's best strains are undergoing field testing against both pests.

This logical flow of biopesticide research has been carried out hand-in-hand with upstream research among the partners in the project. Foremost, much effort has been focused towards determination of endophytic modes of action. Fusarium spp. endophytes were found to induce systemic resistance. In addition, many endophytes are individual strains of F. oxysporum, which are ubiquitous soil organisms but can also be destructive wilt pathogens. It has therefore been essential to establish early the non-pathogenic nature of IITA's promising strains, and determine markers to identify them.

The project is comprised of seven partners in five countries: the University of Bonn, Germany; the National Agricultural Research Organization (NARO), Uganda; the University of Pretoria, South Africa; Makerere University, Uganda; Wageningen University, the Netherlands; the Catholic University of Leuven, Belgium; and the Biologische Bundesanstalt fűr Land- und Forstwirtschaft, Germany. Together with IITA, they have laid the groundwork, and endophyte-enhanced technology is now ready to be tested in farmers' fields. Research is not only confined to banana production in Africa. The International Network for Improvement of Banana and Plantian (INIBAP), using a separate source of funding and in collaboration with our German partners, is currently testing endophyte-enhanced tissue culture with large-scale

Figure 1. Overview of research protocol used at IITA for developing endophyte-enhanced tissue banana culture (Based on Dubois *et al.*, 2006).



banana producers in Costa Rica, using Latin American endophyte strains.

4 Banana tissue culture: a constraint to iita's research agenda

One of the greatest uses for endophytes is their application to tissue culture material. The acceptability of tissue culture therefore is critical to the success of this particular work. In large scale commercial banana systems, tissue culture is fast becoming the norm. However, in subsistence agricultural systems in Africa, it is less common, but developing.

IITA does not possess a sufficient in-house tissue culture production facility to accommodate its endophyte-based research. IITA therefore has developed partnerships with key players involved in tissue culture production: the commercial tissue culture laboratory Agro-Genetic Technologies Ltd (AGT), with strong support from NARO in Uganda, and Jomo Kenyatta University of Agriculture and Technology (JKUAT) in Kenya. At first, both public-private partnerships were initiated purely based on a need for tissue culture plantlets as research material. However, these partnerships have proven to be pivotal in steering endophyte-enhanced technology towards the ultimate client: the farmer.

4.1 Agro-genetic technologies ltd, the first commercial tissue culture producer in Uganda

AGT is a privately held Ugandan company that started its operation in 2002. It is owned by Ugandan professionals with several years of experience in agricultural research and entrepreneurship. AGT is currently the sole private commercial tissue culture provider in Uganda. In addition, AGT offers an agronomic consultancy service to its customers. AGT first targeted coffee but is now mainly geared towards banana. In November 2005, AGT opened a new tissue culture laboratory with a production capacity of 8 million plantlets per year, potentially the largest tissue culture laboratory in East and Central Africa.

At present, AGT's main source of sales is through non-governmental organizations and institutions, such as APEP, VEDCO, Caritas, BUCADEF and NARO. However, direct marketing channels with farmers are sought, by conducting seminars in local farming communities, participating in local exhibitions, distributing brochures, and publicity on the radio. To bring the technology near to farmers, AGT has established nurseries and demonstration gardens in 11 locations in Uganda, which act as sales and training centers, respectively. At the nurseries, sales are facilitated through establishment of direct contacts with individual farmers or farmer groups. They are deemed essential to AGT's future business plan. Farmers' nurseries make tissue culture plantlets available directly to the farmers, prevent farmers from sourcing planting materials from neighboring farms and, by doing so, reduce the spread of pests and diseases. They

Endophyte-enhanced banana tissue culture plant produced in the nursery of Agro-Genetic Technologies Ltd,

also allow farmers to acquire the desired cultivars in any numbers and at any time of their choice, reduce transportation costs of the ready-to-plant material, and avoid transportation of soil from place to place since the tissue culture plantlets are delivered to the nurseries in vitro. Using farmers' nurseries also facilitated some indirect spill-over effects, such as knowledge distribution to farmers about modern agricultural practices, job creation through recruitment of nursery operators, and fulfillment of the Uganda Government's policy and ambition of modernizing agriculture.

Furthermore, from the outset, AGT has fostered an approach that aims for sustainable social-economical and agricultural development for Ugandan farmers, because AGT is an innovator and needs to create its own market. Areas of innovation include joint exhibitions with research organizations (including NARO and IITA), tissue culture protocol development and student internships with universities (Makerere University), and participation in national biotechnology and biosafety policies (Ugandan Government).

A major constraint of AGT is absence of awareness and distribution channels. This problem creates a vicious circle, as lack of sufficient sales inherently renders tissue culture plantlets expensive due to lack of economics of scale. Other constrains faced by AGT are lack of protocols and equipment.

4.2 Jomo Kenyatta University of Science and Technology: Research with a commercial twist

The Kenyan situation is different from that in neighbouring Uganda, partly as a result of the greater scarcity of planting material, which drove the use and then demand of tissue culture material. Tissue culture technology took off in Kenya, also because of strong impetus from JKUAT. JKUAT has succeeded in transferring banana tissue culture technology to small-scale farmers in Kenya and now produces, on a commercial scale, close to half a million tissue culture plants per annum based on a highly efficient network of farmer-coopted nurseries that it helped develop (Fig. 2).

In 1991, JKUAT started developing banana tissue culture protocols in Kenya. Reflecting the case with AGT, JKUAT quickly realized that the lack of access to, and familiarity with this technology was a key hurdle to small-scale farmer adoption. JKUAT, however, attracted funding to investigate channels to disseminate the technology.

With support from the Rockefeller Foundation, JKUAT facilitated distribution systems that connected the JKUAT laboratory with small-scale farmers in the Mount Kenya region of Kenya. Using a participatory approach, JKUAT engaged in impact studies that enabled an in-depth understanding of the local farming systems, the environment in which the farmers were operating, and, most importantly, a community action plan for adoption of tissue culture. At the onset of the project, farmers were eager for change, due to falling yields and incomes. Coffee had been replaced by banana, but maize and beans still constituted the main staple food crops.

The quality of bananas grown in the area was poor and many farmers grew local varieties that could not be marketed. Pests and diseases were identified as the main problem for banana production in the area. Farmers also realized that, even if they received clean planting material, they lacked the technology and infrastructure for efficient banana production and marketing.

Clearly, these problems could not be solved by provision of banana tissue culture technology alone, so JKUAT embarked on a training programme. At each of the key sites in the Mount Kenya area, JKUAT introduced banana tissue culture nurseries, for operation by farmer groups as private businesses. Simultaneously, training was provided to nursery operators in tissue culture handling and aspects of banana agronomy. Nursery operators trained their own costumers. Development of an own action plan for each of the nursery communities gave them a sense of ownership of the project. The nursery operators receive acclimatized tissue culture seedlings of approx. 10 cm tall, priced at 40 Kenyan Shillings (72 Ksh = 1 USD). Nursery operators grow the seedlings on to field size (90 cm tall), which are marketable at 80 Ksh. The lack of capital and weak marketing channels were addressed through provision of microfinance.

Based on follow-up impact studies in 2004 and 2005, JKUAT realized adoption levels of over 86% at its pilot sites and effectively connected its banana tissue culture laboratory to village nurseries. Since then, its early adaptors have reaped dividends and a substantial number has switched from subsistence to commercial banana farming. However, since introduction of the technology, follow-up impact studies have revealed an unexpected gender shift from female to male, who predominantly manage cash crops in the region.

Some obstacles remain: one of which is the farmers' identified need for pest and disease control, amongst others. Although banana tissue culture plants are initially pest- and disease-free, JKUAT observed that they easily become infested when planted in pest- and disease-infested soils of the Mount Kenya area.

5 Joint research: Benefits for the public and private sector

AGT has entered into an initial two year agreement with IITA. IITA has complete access to AGT's laboratories to fully integrate endophyte-enhanced tissue culture technology in AGT's tissue culture production line (Fig. 3). IITA also has full access to AGT's nurseries for on-farm testing of endophyte-enhanced material. In addition, plants used for IITA's research purposes are purchased for a much reduced price. AGT receives reciprocal benefits. First, AGT has first-hand exposure to endophyte-enhanced tissue culture technology, including endophytic strains. Since the technology has great potential for impact in East and Central Africa, this exposure allows AGT to rapidly capitalize on its benefits. Secondly, IITA, in collaboration with NARO, has initiated research on farmer acceptance of banana tissue culture in Uganda, using AGT's plants and nurseries. Lessons learnt in Kenya demonstrate that producing tissue culture plants is not enough, and investigating ways to mobilize farmers, mainly through nurseries, are essential for success. Finally, AGT benefits through exposure to IITA's scientific world, ranging from meetings with IITA's stakeholders to joint orders for hard-to-obtain chemicals.

IITA's different approach at JKUAT reflects the difference in circumstances with AGT and Uganda. IITA sought a partner in Kenya who could provide experienced feedback towards developing an endophyte-enhanced tissue culture system. JKUAT has proven to be the ideal candidate. As a research institute, JKUAT also contributes towards scientific progress in the field of endophyte-enhanced tissue culture and widen IITA's geographic scope within East Africa. With its commercial tissue culture laboratory, JKUAT can leverage its vast network of farmer-coopted nurseries to rapidly test the technology in the field. Due to quarantine restrictions against Ugandan endophyte strains, JKUAT has engaged in isolation of Kenyan endophytic strains that may also lend themselves better to local agro-ecological conditions. In addition, banana cultivars in Kenya are different to those in Uganda and, as such, JKUAT is

equally investigating the potential benefits of endophytes in dessert bananas.

6 Public-private partnerships: yielding unexpected synergisms

In addition to the commercial laboratories providing a vehicle for tissue culture plants, the collaboration has driven IITA and the project activities along commercial thinking. Towards achieving the goal of a useful product, this change in forward thinking has been a beneficial exercise, which will hopefully provide farmers with improved, cost-effective products. Such 'fine-tuning' of techniques and adaption to the practical realities is essential to bridging upstream research with downstream application.

A perfect example has been IITA's experimental protocol for endophyte inoculation. Based on extensive research, IITA devised an inoculation technique that seemed optimal: tissue culture seedlings, after they were removed from the tissue culture flasks, were grown in a nutrient solution for an additional month to enhance root biomass. Collaboration with JKUAT and AGT forced IITA to 'think commercial'. IITA quickly abandoned its use of a nutrient solution in favour of fertilizer-amended soil, along the lines of the system used in the commercial nurseries.

Conclusion

IITA's ultimate goal is to develop an endophyte-enhanced tissue culture technology for farmers' use. Because the technology depends on availability of tissue culture and a venue to farmers, IITA opted to engage in public-private partnerships with AGT and JKUAT. Although this seemed precocious at the time in IITA's research agenda, these partnerships have helped greatly to overcome obstacles, and have proven to be essential to achieve the project's goals. Initially, memorandums of understanding had been carefully prepared, but, after timid beginnings, trust has been established and the momentum has been driven by mutual trust and appreciation, both for each others contribution and the projects' ultimate goal – more durable tissue culture plants, which can be delivered simply and effectively to farmers for improved banana production.

Based on IITA's experience, public-private partnerships should be included at a very early stage. Research for development is impossible without facilitating technology transfer to small-scale farmers from the outset.

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INCUBATORS AS CATALYSTS IN DEVELOPING HIGH TECHNOLOGY BUSINESSES: MALAYSIA'S EXPERIENCE

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Abstract

Malaysia has established various incubator centres as the main support system for the creation of homegrown technologies and entrepreneurship. The Malaysian government provided the necessary infrastructure for such incubators through technology parks and created funding systems that allow technology entrepreneurs to gain access to capital. Hence, the creation of venture capital funds and various grant schemes. This article explores how these programmes are being implemented in Malaysia, what are the problems faced by Malaysia in implementing the policies and what are the proposals for reform.

Introduction

Malaysia has, for a long time, been employing investor and business-friendly policies, to attract foreign direct investment into the country. Malaysia has managed to transform its economy from being an exporter of raw materials to being an exporter of high technology products. This evolution is also associated with the expansion of knowledge-based industries (WTO, 2006). The shift in the emphasis is partly influenced by the competition from neighbouring countries, such as China, Vietnam and India, in attracting foreign direct investment. Malaysia can no longer offer cheap labour force required for the capital intensive industries. Instead, it focused on the generation highly educated workforce by investing heavily in human capital. The fact that Malaysia is recognised by the United Nations Development Programme (UNDP) as a potential leader in technology (UNDP, 2001) indicates that this strategy is paying off in making Malaysia more competitive.

The shift in emphasis in economic approach is documented in the Malaysia's Outline Perspective Plan (OPP 3, 2000 – 2010). This author was involved in advising various interest groups in the formulation of this important document that shapes Malaysia's development strategies. Based on the OPP3, Malaysia envisages a knowledge-based economy that will provide the platform to sustain a rapid rate of economic growth and enhance international competitiveness. The overall vision is to achieve the developed nation status by the year 2020 (OPP3). Emphasis on the knowledge-based economy will also strengthen Malaysia's ability to innovate, adapt and create indigenous technology. It also enables to design, develop and market new products, thereby providing the foundation for endogenous growth. The knowledge-based economy will complement and accelerate the change from an input-driven to a productivity driven growth strategy. Thus, the emphasis is to nurture home-grown industries and home-grown technologies.

One of the ways to nurture home-grown industries and home-grown technologies is by creating technology entrepreneurs, or 'technopreneurs'. Recognizing the importance of nurturing technopreneurs, Malaysia embarks on several initiatives through various policy regimes. They include: various policy frameworks and guidelines for the generation of technopreneurship in Malaysia. These also include institutional frameworks for promoting research and development (R&D) and human development strategies for nurturing technopreneurs. The policies are being implemented by various ministries such as Ministry of Science, Technology and Innovation (MOSTI), Ministry of Entrepreneurs Development and Cooperative (MEDC) and Ministry of International Trade and Industry (MITI). These ministries also offer various grants. The initiatives also result in the establishment of incubators in various places under the National Incubator Network (NIN).

1 Incubators in Malaysia

Incubators are being used to nurture new technopreneurs as part of the effort to transform the Malaysian economy into a knowledge-based economy. Technopreneurs are classified as part of the small and medium enterprise sector (SME). The Malaysian Industrial Master Plan (1996-2005) recognizes the importance of a competitive small enterprise sector and provides assistance to this sector through several initiatives such as a strong technical infrastructure, supportive state policies, massive investments and tax incentives for research and human resource development, new structures for university-business linkages, a range of financing instruments for innovation, and continuing support to technology incubators.

Incubators have several special characteristics. Such characteristics include a managed work space providing shared facilities, advisory, training and financial services, and a nurturing environment for tenant companies. In addition, it provides a small management team with core competencies that carefully select promising start-up companies for entering the incubator. On average, 20 to 25 start-ups get selected and are to be graduated generally after 3 years (Scaramuzzi, 2002). Incubator models may vary according to their mandate (for-profit or not-for-profit), the type of sponsorship they have (publicly funded, privately funded or a mixture of both), and their focus or niche (ibid). In the case of Malaysia, most incuba-

tors are related to technology such as the information-, multimedia- and bio-technology.

In Malaysia, incubators are mainly set up by government-owned or government-related organisations. Many of the incubators are situated within technology parks, either within purpose built technology parks or within university campuses. There are two confusing figures about the number of incubators in Malaysia. One study states that there are 24 incubators in Malaysia as of February 2006 (Ghazi, 2006) whereas an official website listed only 19 incubators in the whole country (MSCa, 2006). The Government's target is to have 40 incubator centres by 2010 (Ghazi, 2006).

1.1 Technology Park Malaysia (TPM)

One of the technology parks that run incubator centres is Technology Park Malaysia (TPM). TPM is strategically located on 700 acres of land just outside Kuala Lumpur. It is located between Kuala Lumpur and Putrajaya, the Federal Administrative Centre. It has good train-, rapid transit-, and motorway- connections to the cities as well as the Kuala Lumpur International Airport and Cyberjaya, a city created for technology-related activities. This technology park is managed by the Technology Park Malaysia Sdn Bhd, a company owned by the Ministry of Finance Incorporated. It used to be a division of the former Ministry of Science, Technology and the Environment. The land is owned by the Federal Government through the Federal Lands Commissioner and leased out to TPM for 60 years. TPM is allowed to offer tenancies for its buildings and sub lease certain sites within the park.

The core system within TPM comprises:

⇒ an Innovation House to help initiate start-ups,
⇒ three Incubator Centers for early-stage ventures, and
⇒ Enterprise Houses for those graduating to good industrial space without services (Ibrahim, 2001).

TPM offers a space of around 204960.24 square feet in the Innovation House and Incubator centres (TPM, 2006). The rents are very competitive as compared to the ones in other parts of Kuala Lumpur. The congruence of support includes a Resource Center, Master Center (for rapid proto-typing, flexible manufacturing, and robotics), IT-Multimedia Center, and TPM Academy for advanced training together with wide band internet connectivity, R & D plots, and common facilities for recreation (Ibrahim, 2001).

1.2 MTDC, SIRIM and MCI: additional drivers of the knowledge-based economy

There are several other technology incubator centres, such as those run by the Standard and Industrial Research Institute of Malaysia (SIRIM); The Kulim Hi-Tech Park in the State of Kedah; and the Multimedia Super Corridor Incubator Centre in Cyberjaya (MCI).

The Malaysian Technology Development Corporation (MTDC) has established Technology Development Centers to facilitate university-research-business collaboration in specific sectors: at Universiti Putra Malaysia (MTDC-UPM) (for multimedia work), Universiti Teknologi Malaysia (MTDC-UTM) (electronics and manufacturing), and Universiti Kebangsaan Malaysia (MTDC-UKM) (biotechnology and pharmaceuticals).

SIRIM's Industrial Incubator's areas are primarily focused on Advanced Manufacturing Technology (Industrial Automation/Mechatronic, Industrial & Engineering Design, CAD/CAM, Industrial Instrumentation & Electronic and Artificial Intelligence System, Process Technology and Advanced Materials). This incubator was first launched in 1986 offering integrated facilities for entrepreneurial and SME development. It is now located in Sepang, a town near the Kuala Lumpur International Airport and famous for its Formula One circuit. Among the added-value facilities and services offered by SIRIM are hands-on and technical training skills in technology and quality and advisory services on technology, quality, management, financial, marketing, Intellectual Property advice business plan assistance and access to funding and seed money.

Kulim Hi-Tech Park was inaugurated in 1993. It is a state-owned technology park that incorporates several functions: industrial, research and development facilities, as well as a new township concept with shopping centres, medical and educational institutions and recreational facilities.

MCI began operation in mid-1999. It offers 40 cubicles and 20 executive offices, 29,000 sq ft of general office space and 10,000 sq ft of laboratory office space, all designed to assist in R&D while providing market exposure to tenants. Because of its unique position, the MCI was expected to attract investors interested in new, innovative, commercially-viable products. One of the aims of the MCI is to accelerate the creation of the small and medium enterprises in the information technology sector (IT SME).

At the time of the launching of the MCI, the Government of Malaysia was concerned about the lack of IT SME in Malaysia. In 1998, only 247 IT SMEs were listed on the MDC database. This paled in comparison to that of established IT havens such as Silicon Valley which had 7000 IT SMEs and Cambridge which 1,200 IT SMEs (Mohamed, 1999). The Government of Malaysia's overall target was to create IT SME to about 1,000 in 2003. The MCI was one of the initiatives in this quest. The MCI target is to create 1,500 IT SMEs within its wing by 2003 (Schwankert, 2000).

The Government has managed to achieve the target to create 1000 IT SME in the whole of Malaysia by 2003. In 2003, there were about 2,000 IT SMEs in the whole country (Government of Malaysia, 2004). The latest figure in the Multi Media Super Corridor (MSC) database shows that there are about 3452 IT SMEs across the

country (MSCb, 2006), but not necessarily within the MSC area, let alone created by the MCI. This means that Malaysia has managed to create 3205 IT SMEs within a period of eight years between 1998 and 2006, an average of 400 IT SMEs across the country per annum. However, there is a need for a further study to ascertain the quality, the ownership and the profitability of these companies, to ascertain that they are profitable and involved in promoted areas of the IT sector.

However, the MCI has not managed to achieve its target. In the period between 2001– 2004, only 17 companies were supported by the MCI (Government of Malaysia, 2004). This could be due to several reasons. One is that the MCI is located in Cyberjaya, which requires relocation and not many SMEs can afford to relocate there. Secondly, the target itself is unrealistic, when one compares it with the Government's target of only 1000 IT SMEs by 2003 for the whole country. MCI probably did not conduct a proper study in creating the target. Thirdly, the management of the MSC has been criticised for many years for failing to implement Government policies within the MSC area and this lack of focus and implementation has caused the failure on achieving the target. If the MCI has achieved the target, MSC could have published separate IT SME figures instead of just the figure for the whole country (MSC, 2006b)

In general, government sponsored incubators in Malaysia offers several added-value programmes such as entrepreneurial training. Young technopreneurs in Malaysia are techno-savvy but they lack capital and basic business knowledge experience required to plan and build business operations around the technology concept they wish to develop. This is where entrepreneurial training comes handy. The trainings provided include preparation of business plan, basic company management and looking for financing.

2 Venture Capital Companies

To support the technopreneuers, especially with potentials and located within those incubator centres, Malaysia encouraged the setting of venture capital companies. There are several government-sponsored venture capital funds such as the Malaysian Venture Capital Limited (MAVCAP), Malaysian Super Corridor Venture Fund (MSCVF), Commercialisation of Research and Development Fund (CDRF), Technology Acquisition Fund (TAF), TPM Venture Capital Fund, MTDC Venture Capital Fund and MDC Venture Capital Fund.

In year 2004, RM 1.2b (US$ 315.79m, USD1 = RM3.80) worth of venture capital funds were available in Malaysia with 17% going to life sciences and biotechnology. The bulk of 48% of the venture capital fund went to the information and communications technology (ICT) field. As for year 2005, the total venture capital available in Malaysia was estimated at RM 1.5b (USD 394m) for entrepreneurs and firms engaged in the ICT field alone (NST, 2005).

TAF provides partial grants ranging from 50-70 per cent to companies with majority Malaysian-ownership. These companies undertake technology acquisition activities picked from the List of Promoted Activities and Products for High Technology Companies under the *Promotion of Investment Act 1986* and other strategic industries with support from the Government. The technology activities eligible for partial funding include purchase of high-tech equipment and machinery, technology licensing, acquisition of patent rights, development of prototypes and design, as well as expert-sourcing programmes

CRDF provides partial grants ranging form 50-70 per cent to majority Malaysia-owned companies incorporated under the *Companies Act 1965* to commercialize research results. The activities eligible under the partial funding include market survey and research, product or process design and development, standards and regulatory compliance, and intellectual property protection.

3 Grant Schemes to promote R&D and the application of ICT

There are several grant schemes available to encourage research and development in technology sectors. Such grant schemes include the Industrial Grant Scheme (IGS), Intensification of Research in Priority Areas Fund (IRPA), Industrial Technical Assistance Fund (ITAF), Multimedia Super Corridor Research and Development Grant Scheme (MGS) and the Demonstrator Application Grant Scheme (DAGS).

The IRPA Programme was established to provide funds to support R&D in the public sector for improvements in the socio-economic fields. It has now evolved to focus on R&D activities that are in line with the national R&D Priority Areas. Public research institutions and universities are eligible to apply for these funds.

The purpose of IGS is to increase the private sector R&D and promote closer cooperation between the private sector and public sector institutions and public sector universities through collaborative linkage. The aim is to encourage Malaysian companies to be more innovative in pursuing and adopting existing technologies and in creating new technologies, products and processes to benefit the national economy. The key technology areas that are given priority are the ones that support the Industrial Plan to foster clusters of small companies in complementary industries with good prospects for commercialization.

The purpose of the MGS is to help start-up and young local companies, including joint ventures, to develop multimedia technologies and applications that contribute to the overall development of the Multimedia Super Corridor.

The purpose of DAGS is to encourage Malaysians to adapt and customize current IT and multimedia technologies in applications compatible with local culture and to promote the development of local software and content industries for greater competitiveness in the global market.

4 Weaknesses in Malaysia's Incubator Programme

One could not deny that Malaysia has good policies and infrastructures to develop technopreneurs. It helps explain the success story of Malaysia as a Newly Industrialized Country (NIC). Nevertheless, there are several problems which need to be addressed by the Government, in order to ensure the success of this programme.

One of the problems is that incubators established in Malaysia are not properly managed, with many starts-up going out of business. There are no proper statistics to back this assertion but experience tells that many technopreneurs suffer from birth defects. This could be due to the lack of experience on the part of the managers and lack of support towards the technopreneurs.

Secondly, technopreneurs suffer from lack of funding opportunities. We have seen from the above discussions that the government has set up various venture capital funds and grants. Some of the venture capital funds are managed through banks; either government-owned development banks or private banks. These banks approach technopreneurs and their technology business just like any other business. They either do not understand or do not care about the unique characteristics of technology-related business. Most commercial banks do not fund 'developmental work' and entrepreneurs seeking loans have to offer matching personal guarantees or collateral.

Development banks that have been specifically set up to assist entrepreneurs have not funded technopreneur companies to the level expected. The venture capital companies in Malaysia remain reluctant to provide seed capital financing due mainly to their risk-averse attitude towards investments, and the lack of groundbreaking technology in Malaysian technology firms (Ariff and Abubakar, 2001). For example, during the Eight Malaysia Plan 2001-2005, the Government allocated RM120 million (USD31.58m) to the Government owned MSCVF. MSCVF only disbursed RM75.4 million (USD 19.84m) or to only 17 companies by the end of August 2003 (Government of Malaysia, 2004). Although the amount disbursed represents about 62% of the allocated fund by the Government, the number of companies which received the grant is still small as compared to the whole IT SME companies in the country.

Technopreneurs may also find it frustrating in applying for grants as the process is long and tedious. An applicant may have to wait between three to four months to know whether their applications meet the criteria set up by the agencies, let alone being approved for funding.

Lack of funding causes a big problem among technopreneurs and some would just give up on the project. One could argue that this situation is not unique to Malaysia. For example, a study in Singapore shows that lack of funding is a main problems faced by the IT SME. However, the same study finds that the problem of funding in Singapore has improved. For example in 2004, 65% of those surveyed stated that insufficient cash flow was a hindrance to growth and this figure is now reduced to 35% (DP, 2005). The same survey states that 48% percent of SMEs in Singapore think it was easier to get funding as compared to 9% who do not think the same (ibid). There is no similar survey in Malaysia to provide empirical data to confirm this predicament.

Thirdly, the various funds set up by the Government are not properly disbursed. This could be due to difficult bureaucratic measures, or due to grants being issued to technology companies which employ 'know-who' rather than 'know how'. The former causes applications processes being conducted in intransparent manners. It causes some grants being issued to non-deserving individuals resulting in the depletion of the amount available to those with the 'know-how' but without the 'know-who'. This attitude and approach makes ordinary bidding technopreneurs that do not have contacts in high places become frustrated. This is despite them having the necessary knowledge and qualifications.

Fourthly, technopreneur development in Malaysia is undertaken by various ministries and agencies which may result in lack of coordination or wastage of resources. For example, the MEDC focuses on the indigenous people. This focus is often followed by lacking implementation procedures. They are sometimes managed by bureaucrats who do not have the basic knowledge in entrepreneurship. The MEDC has failed even to create a credible number of retail entrepreneurs, what more in the high technology areas. The problem lies in the implementation of the policies.

The tasks given to MEDC are duplicated in various other agencies within different ministries, such as the Multimedia Development Corporation (MDC) within MOSTI. MDC implements the Technopreneur Development Flagship. This programme has the same objectives like any similar programmes run by MEDC, that is to breed and nurture the growth of technology-based small and medium enterprises or SMEs and start-up companies involved in the ICT and multimedia industries.

Duplications and wastage also exist in the creation of technology parks. Several of these developments started as technology-based development but ended up being real estate-based development. In addition, these duplications are obvious as most of the technology parks are located in the same area. Most of the technology parks are located in the Klang Valley, near Kuala Lumpur. The Kulim Hi Tech Park and MTDC-UTM, are located in the The Kulim Hi Tech Park is located in the north-westen State of Kedah, near the technology hub of Penang, and the MTDC-UTM is located in the State of Johor, close to Singapore.

This means that those who want to use or be part of the incubators and to enjoy the facilities in those technology parks must relocate either to the Klang Valley, Kulim, the Penang area or Johor. There are no comparable programmes created in other states, either in the Peninsular Malaysia or in the States of Sabah and Sara-

wak in the Island of Borneo. The State Governments of Pahang, Melaka and Perak in the Peninsular Malaysia and the State of Sarawak in the Island of Borneo have taken measures to create incubators. But these incubators may not have the same facilities as in the technology parks in the Klang Valley. Potential technopreneurs and technopreneurs who, for various reasons, do not want to or cannot move to the favourable regions will not be able to take advantage of the facilities offered by those incubators centres. This disparity causes regional disparities due to economic disadvantages.

5 Proposals for reform

To ensure that incubators continue to be the main catalysts in creating technopreneurs in Malaysia, the Government must implement several reforms:

1.There must be continuous government support, but with a more coordinated effort, more transparent and less bureaucratic procedures.

2.The Government must provide the appropriate degree of strategic, legal, financial and administrative support.

3.The Government could use the universities as the catalysts in creating new technopreneurs. There are universities in every part of Malaysia, meaning that incubators can be made available in various parts of the country. The universities have scientific expertise that must be tapped. Ideas and innovations by academics must be channelled to the private sector to allow for the optimum use of the R&D within the universities.

4.To overcome the issue of over concentration of incubators in technology parks in the Klang Valley, State Governments must have their own initiatives to create technopreneur centres within their own states. State Governments could form cooperation with universities and higher education institutions in their respective states. It is not an overstatement to say that many State Governments are slow in taking initiatives, as they are so used to political patronage and leadership from the Federal leaders. Failure on the part of the State Governments to assist the Federal initiatives will mean that the shift to a knowledge-based industry will not be widespread.

The government must encourage greater transparency in the management of incubators, venture capital funds and grant schemes. Technopreneuers and potential technopreneurs must know the exact requirements in every step of their applications. In addition, government-owned venture capitals must be more flexible and open in their approach. A very conservative approach towards seed funding will frustrate applications and thus dampen the creation of new innovations and development of local technologies.

It is not unusual that applications take about 7 or 8 months to be processed and some are rejected after having been revised based on the venture capitalist's proposal. Rejection without reasons, even after the request for explanations from failed applications, is common. In addition, venture capital funds provided through technology parks are small and may not even cover the basic costs of the tenants. In this competition for small amounts of funding, 'know-who' plays a greater role in accessing the fund, rather than 'know-how'.

Conclusions

Based on the above-mentioned constraints, it can concluded that, despite having the physical infrastructure for incubators, and the existence of many different funds, Malaysia's effort to create technopreneurs is hampered by bureaucratic and implementation hurdles. Moreover, funds which are supposed to be used in providing capital to the businesses are being wasted through emphasis on real estate developments. If Malaysia were to compete with other countries in the region, Malaysia must be willing to provide easier access to grants and funding, focus more on the coaching of universities in their efforts to become entrepreneurial and reduce red tape. Malaysia must create an environment of opportunities that supports aspiring technopreneurs, tolerates failure, and rewards success handsomely and evenly across the different regions.

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CAPACITY BUILDING FOR BIOTECHNOLOGY IN EASTERN AFRICA: STATUS AND NEEDS FOR PARTICIPATION IN GLOBAL BIOECONOMY

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Abstract: This article analyses the status of biotechnology in developing countries with a view to establish their ability to engage in the global bioeconomy. The paper focuses on four Eastern African countries. It attempts to identify the available capacities, current and future efforts in capacity building in the region as well as highlight the major limitations for their effective participation in the global bioeconomy. Approaches to the challenges facing biotechnology capacity building are also suggested.

Introduction

Biotechnology, a modern science less than 30 years old, is revolutionalising production in both industry and agriculture. Biotechnology has the potential to provide answers to some of the most intractable development challenges including agricultural production, health, nutrition and the environment.

In 1998, in a letter to the President of the World Bank, African Governors observed that "Africa is a continent rich in natural resources but lacked the capacity to transform that potential into a standard of living that would enable the African people to become full partners in the innovation-based global economy [1]. Its share of global trade fell from 3% in the mid 1950s to 1% as of 1997[2], and estimated to be falling further [3]. Thus the continent will continue to be highly vulnerable to commodity prices and global economic developments[4]

Emerging technologies offer new prospects for better integrating the poor into the global market economy [5]. Sustaining the new bioeconomy requires adoption of a global biotechnology governance regime that helps to bring a large number of developing countries into the global trading system. The elements of such a governance system that will minimize public opposition due to presumptions on loss of traditional products market and exploitation by multinationals include development of technological capabilities, access to technology and management of risks and benefits associated with biotechnology use. However, effective participation of developing countries in the bioeconomy, will depend on the level of domestic technological capacity and the kind of global biotechnology governance system that emerges from the current policy debates.

Although biotechnology may be a powerful strategy for sustainable development in the 21st century, its potential is dependent upon effective government action to provide incentives, research and regulation. Biotechnology uses a wide range of disciplines and its safe application draws on various scientific and technical skills combined with effective policy, regulatory and institutional frameworks that can facilitate its sustainable use and safe deployment. The main prerequisite, however, is that there must be the necessary workforce, infrastructure and policy environment for biotechnology deployment[6]. Many developing countries lack both. Lack of capacity building is partly due to the inability of the governments to allocate adequate financial resources to research and development as well as overall lack of commitment to Science and Technology (S&T). This is exemplified by the low spending on S&T which is less than 0.01% of their GDP in many African countries[7]. Therefore, their capacity building needs cannot be considered in the narrow context of biosafety which only deals with risks and hazards posed by the spread of living Modified organisms (LMOs). This calls for an integrated capacity building and management strategy for biotechnology that is mutually supportive and complementary.

1 Biotechnology trade requirements

Market access represents the greatest hurdle to international trade and consequently to accessing technology [5]. It serves as a critical signal to the potential for benefiting from investment in technological innovation in developing countries. The two major barriers are high tariffs and standards (sanitary and phytosanitary) requirements.

The Biosafety protocol adopted in 2000 under the auspices of the Convention on Biological Diversity establishes international principles that govern the transfer, handling and use of genetically modified organisms (GMOs) with a particular focus on transboundary movement. Although the Biosafety protocol is not explicitly intended to be a trade agreement, the fact that its scope includes export and import makes it an implicit or de facto trade agreement associated with international trade in GMOs. In contrast, the World Trade Organisation, with the mandate to facilitate free trade between countries by establishing trade rules and to serve as a forum for trade negotiations and dispute settlement, deals with trade in all products including GMOs. The protocol and WTO are meant to be mutually supportive.

For the implementation of the Protocol countries have to meet a number of targets. They have to:

ensure that the development, handling, transport, use, transfer and release of LMOs are undertaken in a manner that prevents or reduces the risks to biological diver-

sity, taking into account human health (Article 2.2);

establish and maintain appropriate mechanisms, measures and strategies to regulate, manage and control risks identified in the risk assessment provisions of the Protocol associated with use, handling and trans boundary movements (Article 16.4);

endeavour to ensure that imported or nationally developed LMOs have undergone an appropriate observation before being put to use (Article 16.4);

fulfil obligations relating to the effective administration of the Protocol (Article 19 and others); and

promote and facilitate public awareness, education and participation including access to information on LMOs (Article 23).

All this requires human and financial resources, both of which need to be long- term commitments so that biotechnology products can be used routinely and safely within the framework of the Protocol. More importantly, there is a need for continuous availability of competent human resources so that as biotechnology advances, the tools for its safe use are constantly evaluated, upgraded and applied. In other words, biosafety regulations should be a dynamic management tool for biotechnology[8].

The requirement for exporters to meet product standards similar to those found in importing countries is a critical element in international trade. This requires skilled human resource, accredited laboratories for testing and certification and conducive policy environment. Many developing countries do not have sufficient facilities and personnel to conform to industrialised countries' market demands. Market access is an essential element of market liberalisation and special efforts are needed to create better trading opportunities for developing countries.

2 The need for Biotechnology capacity

A host of agricultural products move between countries through international trade. For products of modern biotechnology there may be regulatory compliance implications related to trade in these products depending on the products approval status or decision of the food manufacturer regarding labelling of the final product in a specific country.

As products of biotechnology have entered commerce internationally, over the past decade or so, countries have developed, or begun to develop, safety and identification requirements for new products, and in this process have reviewed the adequacy or applicability of their existing broader regimes for conventional product categories to the new products.

The successful production of GMOs and their products requires an adequate infrastructure, expertise in tissue culture and molecular biology, and a critical mass of researchers with supporting sustainable funding to cover the high cost of such research. In Africa, the only few countries that have the capacity to produce transgenics are still struggling to "commercialize" the products/ technologies to ensure that they reach the end user. Bridging this gap, requires engagement in partnerships with the private sector companies, producer organisations or government institutions which can ensure that the technology/products will be delivered to the market [9].

The biotechnology innovation chain from laboratory to commercialization through regulatory steps requires varied facilities and expertise. The need for capacity building in biosafety arises particularly when a country has an operating biotechnology sector. Capacity is then needed for everything - from ensuring safety in the research laboratory to addressing long-term environmental and food safety concerns. Unless the basic structures needed to harness this collection of powerful techniques are available, the promise may take long to come to fruition or may be lost altogether.

In several African countries, basic infrastructure and facilities even for the simplest tissue culture techniques such as micropropagation are not available. Modern communication systems, telephones, fax and access to e-mail and Internet are also lacking in large areas of Africa which seriously hampers the acquisition of relevant and necessary knowledge, and the application of plant biotechnology which is a rapidly changing and developing field. Furthermore, unreliable power supply in many African countries is a serious constraint for the efficient application of even basic tissue culture techniques. Availability of chemicals and consumables for research is often hindered as a result of poor infrastructure.

3 Status of biotechnology infrastructure and human resource in Eastern Africa

According to Wekundah[10] the status of biotechnology infrastructure and human resource in Eastern Africa was shown to be scanty (tables 1 and 2). The data presented included persons with working knowledge of biotechnology both at MSc and PhD levels. These data further indicate that the available capacity lacks the various experts and facilities to meaningfully engage in biotechnology research for development. The data showed the following common characteristics among the four countries involved:

inadequate numbers of trained personnel in modern biotechnology relevant areas.

few and inadequately equipped laboratories to effectively engage in biotechnology research.

minimal private sector involvement which further limits commercialization of biotechnologies and their products..

From the above highlights, a serious deficit of skilled human resources in the plant sciences and biotechnol-

Table 1. Status of Biotechnology Infrastructure in Eastern Africa

Technology	Ethiopia	Kenya	Tanzania	Uganda	Total
Tissue culture	1	17	5	6	29
Molecular markers	3	2	0	5	10
Recombinant technology	1	5	2	0	8
Transformation	0	2	0	0	2
Biofertilisers	1	2	0	1	4
Biopesticides	1	1	0	1	3
Fermentation	0	3	0	0	3
TOTAL	7	32	7	13	56

Source: J. Wekundah, 2003

Table 2: Biotechnology Human Resource Capacity in Eastern Africa

Technology	Ethiopia	Kenya	Tanzania	Uganda	TOTAL
Tissue culture	11	28	17	10	66
Molecular markers	3	2	0	13	18
Recombinant technology	1	14	21	5	41
Transformation	0	2	2	0	4
TOTAL	15	46	40	28	129

Source: J. Wekundah, 2003

ogy and infrastructure is evident in Africa. The development of human resource capacity and establishment of well equipped laboratories, is necessary to produce biotechnologies/products as well as to handle imported engineered products. Currently, the above described situation may have improved slightly with a number of actors contributing to both human and infrastructure capacity building.

3.1 Biotechnology capacity building efforts in Eastern African Region

Before the launch of The Eastern African Regional Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development (BIO-EARN) Programme in 1999, efforts to harness biotechnology for development in the Eastern Africa region were largely limited to Consultative Group on International Agricultural Research (CGIAR) and International Agricultural Research Centres (IARC) institutions, international research institutes and bilateral arrangements with the north. During the last 5-6 years the biotechnology research landscape has substantially changed, not least through the launch of some major capacity building programmes, icluding, BIO-EARN programme, ASARECA's biotechnology and biosafety programme, the Rockefeller funded programmes of RUFORUM and USHPIEA and a number of bilateral programmes.

The key actors in the region involved in agricultural biotechnology research for development (R4D) and their areas of focus include:

3.2 The Eastern African Regional Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development (BIO-EARN): The BIO-EARN Programme, represents a joint effort to strengthen four East African countries; Ethiopia, Kenya, Tanzania and Uganda, in meeting the challenges of modern biotechnology and realizing the potential of the associated techniques under local conditions. The Vision of BIO-EARN Programme is to develop into a Network of Excellence that will significantly contribute to improved food security, more productive agro-industries, sustainable environment management, a viable bio-resource economy and enhanced livelihoods in Eastern Africa. The Mission of BIO-EARN Programme is to promote the application of biotechnology in agriculture, industry and environmental management in order to contribute to sustainable development in Eastern Africa. The programme involves significant efforts in human and infrastructure capacity building in agricultural, industrial and environmental biotechnology.

3.3 Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA): Is a sub-regional organisation of 10 eastern and central African countries with an objective of promoting regional economic growth by developing, introducing and disseminating agricultural technologies that respond to the markets and to prevailing future economic opportunities for new technologies as well as maintaining the long-term sustainability of the agricultural resource base.

3.4 The Biosciences for Eastern and Central Africa (BecA) is a NEPAD initiative which is in the process of establishing state-of-the-art platform to support eastern and central African countries develop and apply bioscience research and expertise to produce technologies that help poor farmers secure their assets, improve their productivity and income and increase their market opportunities. It will provide a focal point for the African scientific community to support the activities of national, regional, and international agencies as they address agriculturally related problems of the highest priority for alleviating poverty and promoting development.

3.5 CGIAR Centers and IARCs These are collaborating with NARS institutions in developing different biotechnologies. A number of collaborative biotechnology research are ongoing on several crop and animal sectors.

3.6 Programme for Biosafety Systems (PBS): The USAID funded PBS assists countries to enhance biosafety policy, research and capacity. The programme focuses on assisting national governments in studying the policies and procedures necessary to evaluate and manage the potential harmful effects of modern biotechnology on environment and human health.

3.7 Private Sector: This a new emerging sector. There are a few private sector institutions such as the Genetics Technology Limited (GTL) and African Harvest in Kenya and Agrogenetic Laboratories Ltd in Uganda. This small but active emerging sector focuses among other things on commercialization of the technologies including promotion of mass propagation and dissemination of tissue culture planting materials.

3.8 Industrial and environmental biotechnology: In this area, in addition to capacity building efforts by the BIO-EARN programme, there are a number of initiatives focusing on mitigation of environmental pollution resulting from municipal and industrial effluents. They include the Lake Victoria Environmental Management Project (LVEMP), the Sida funded VICRES initiative focusing on wetlands and land use, ASARECA with research on water quality monitoring, the Water Research Fund for South Africa (WARFSA) supporting research related to water use and conservation technologies, and the UN-HABITAT funded "Sustainable Cities Initiative" which supports capacity building in manpower for waste management.

3.9 Biopolicy: In the field of biotechnology policy, the key actors include African Agricultural Transfer Foundation (AATF), whose focus is to facilitate access to patent technologies. The Agricultural Biotechnology Support Program (ABSP II) which facilitates access to GM technologies; and the Programme for Bio-safety Systems (PBS) which is supporting activities for biosafety implementation, biosafety research and public awareness. There are also a number of projects like United Nations Environment Programme – Global Environment Facility (NEP/GEF) which has been supporting the development and implementation of national biosafety frameworks.

3.10 Public awareness and information dissemination: Non-Governmental Organisations (NGOs) such as Biotechnology Trust Africa (BTA), African Centre for Technology Services (ACTS), International Service for the Acquisition and Application of Agbiotech (ISAAA) and African Biotechnology Stakeholders Forum (ABSF) are engaged in advocacy, public awareness activities and acquisition of technologies.

3.11 Biosafety capacity building: In addition to efforts by BIO-EARN and UNEP-GEF to develop biosafety capacities in the region, other key actors include the Programme for Biosafety Systems (PBS) that focuses on enhancing biosafety policy, research and capacity in partner countries; and the Bio-safe Train project, which builds capacity in risk assessment of transgenics.

From the above highlights of other stakeholders involved in biotechnology in the region, it is clear that although the biotechnology landscape has changed since BIO-EARN Programme inception, most of the actors hardly address the issues of capacity building.

4 BIO-EARN Programme contributions and impact on the biotechnology capacity building in the region

Over the past 5-6 years, BIO-EARN Programme equipped 14 laboratories in the region and graduated 20 PhDs in biotechnology related fields (**Table 3**) and 6 MSc students in biosafety. With laboratory capacities improved to handle biotechnology research and availability of human resource, three network institutions (Makerere, Nairobi and Dar es Salaam universities) have introduce courses in biotechnology, bioinformatics and molecular biology at Bachelors, Masters and PhD levels. This is hoped to have a significant multiplier effect in biotechnology capacity building in the region. Fifteen network institutions were assisted to install infrastructure for information and communication technology. This has enhanced access to and communication not only to partners in the region but also a wider world community.

In addition to PhD training, several short courses in biopolicy and biosafety were conducted in collaboration with advanced institutions to build capacity in the region and prepare the region to effectively engage in biotechnology for national and regional development. Since 1999 over 55 individuals from institutions in the region have been trained in biopolicy and 130 trained in biosafety respectively. This capacity has played a key role in their respective countries in shaping and guiding biotechnology policy development processes. In addition, they are involved

Table 3. Biotechnology human resource capacity built under BIO-EARN Programme.

Thematic area	Ethiopia	Kenya	Tanzania	Uganda	TOTAL
Agricultural biotechnology	3	2	2	4	**11**
Environmental biotechnology	1	0	1	1	**3**
Industrial biotechnology	0	2	1	0	**3**
Biosafety	1	1	1	0	**3**
TOTAL	**5**	**5**	**5**	**5**	**20**

in management and implementation of the various biotechnology organisations activities in the region. The BIO-EARN alumni are actively involved in regional and continental biotechnology programmes and projects highlighting increased levels of collaboration efforts to address development challenges. Furthermore, four of the BIO-EARN alumni secured funding for projects indicating improved capacities to proposal and scientific writing.

In an effort to create an enabling policy environment, the programme conducted public awareness creation through national and regional seminars which addressed issues relating to biopolicy, biosafety, technology transfer, intellectual property and public-private partnerships. These efforts resulted in establishment of intellectual property and technology transfer offices in some network institutions.

Similar human and infrastructure capacity building efforts are recognized through the Rockefeller Foundation funded programmes and bilateral cooperation agreements. These efforts therefore have slightly improved the 2003 situation, though a critical mass of human resource and infrastructure is yet to be achieved.

In the next four years (2006-2009) the BIO-EARN Programme hopes to graduate another 8 PhDs and 20 MSc students in various biotechnology thematic areas. These efforts together with those from other regional players, together with improved policy environment are expected to boost the regions capacity to fully engage in biotechnology product development and commercialization.

5 Capacity building gaps

According to the NEPAD high-level panel on biotechnology[11], capacity building gaps for effective engagement and full exploitation of biotechnology opportunities in order of their importance among others include:

- *Building a critical mass of technological expertise*: adequate laboratory capacity and high quality personnel with necessary skills are needed to exploit bioeconomy effectively.
- Establishing accredited testing and certification facilities.
- *Organizational coherance*: need to rationalise and harmonise national and regional policies and their implementation.
- *Communication strategy*: Massive bottom-up and audience-and–language friendly communication and training methods and modules need to be developed.
- *Intellectual property rights*: build capacity in IPR issues and institutionalisation of IP.
- *Public participation and awareness*: effective means of public communication to raise levels of awareness and build public confidence.

Regulatory issues: need for harmonisation and information sharing to minimise duplication and reduce costs.

6 The Challenges

Personnel retention: Another serious constraint is the loss of skilled personnel who have received training in developed countries and have added to the brain drain. In Africa, where working opportunities exist, employment terms are often unattractive due to low salaries and working conditions. Due to limited financial support from local governments, few public Research and Development (R&D) institutions are able to plan for the future and strategically employ key staff with the necessary skills. Furthermore, training gained abroad is often not attuned to local needs because of the different research and infrastructural environments in many African countries. As a result the demands and opportunities present in the home country are often not met or remain unanswered. This is further exacerbated by attrition due to HIV/AIDS.

6.1 Budgetary support by national governments: Up to now there has been minimal input by countries in the development of the R&D sector including the biotechnology industry. The emergence of the industry has been mainly supported by various development partners. However, this support is dwindling and sustainability of the industry is in question, especially in the absence of national policies on biotechnology and biosafety. This calls for national governments to support this sector if is to effectively contribute to national development.

6.2 Lack of conducive policy environment: In Africa, most countries either lack, or are in the process of developing policy frameworks and institutional arrangements to deal with the challenges of biotechnology. Development and implementation of appropriate policies and legal frameworks remains a hindrance for biotechnology development.

7 Addressing the challenges: How should countries address these challenges to meet international standards and quality?

The following are proposed to address some of the above mentioned challenges:

- Encouraging/Facilitating bottom-up tailor-made human resource development programmes at various levels for handling, transport, processing, packaging and sale of commodities. Rapid advances in knowledge pose a formidable challenge for developing countries'

capacity to update their technological stock.

- Establish capacity building projects aimed at developing a critical mass of experts at all levels through organised long-term theoretical and practical training at both formal and informal levels rather than short term workshop/seminars. Countries need to retain capacity more effectively channelling capacity to local needs and opportunities. This calls for visionary policies in decision-making and infrastructure development. Therefore, all biotechnology capacity building strategies should be integrated with the overall R&D framework so that national, regional and international actions are mutually supportive and complementary.

- Have a continuing system of administration to ensure global standards in production, manufacture, and trade in biotechnology commodities and to meet complex domestic and international regulations. The increasing demand to ensure global standards requires a skills administrative and technical skills and dynamic management systems.

- Set-up notified state-of-the-art testing and certification facilities. Certifying and testing facilities are expensive to set up and require skilled human resource designed to the needs of the volume of food trade, the facilities should be established in a cost effective manner. However, research priorities of countries in the region are similar giving hope for development of regional alliances [9]. This would allow countries with limited resources (financial and human, and facilities) benefit from regional alliances by sharing information, human resources and facilities. Therefore, regional and sub-regional testing facilities and their networking is a worthwhile proposition.

Develop effective negotiating strategies. They are needed for technology transfer (including IP management issues) and for creating favourable conditions for trade and sustainable development[8]. Thus a broad based multi-stakeholder approach to capacity building with effective information dissemination that promotes communication in all aspects of risk and benefits of biotechnology could be a step in that direction. This may however, require review and restructuring of existing institutional mechanisms through proper coordination and consultation among the concerned departments within the governments.

In order to effectively participate in the bioeconomy developing countries need to develop a biotechnology sector. This means countries taking steps to upgrade technological infrastructures, enhance human expertise and set up regulatory frameworks. This involves huge investment and countries may be required to enter into complex public-private partnerships and develop the legal, institutional and executive acumen that is necessary to foster biotechnological innovation and its application.

In addition, developing countries need to retain human capacity and open ways of channelling capacity to local level by focusing on interesting and challenging work, working environment and compensation. This calls for visionary policies in decision-making and infrastructure development. Therefore, all capacity building strategies have to be integrated with the overall management of biotechnology so that they are mutually supportive and complementary. The countries also need effective negotiating strategies for technology transfer and for creating favourable conditions for trade and sustainable development. Thus, a broad based multi-stakeholder approach to capacity building with effective information dissemination that promotes communication in all aspects of risk and benefits of biotechnology could be a step in that direction.

Conclusion:

World trade norms are in transition due to ongoing negotiations at WTO. Capacity building in isolation would not be cost effective. Successful implementation of both domestic and international regulations can be achieved through integration, coordination and cooperation among all stakeholders. Even though the biotech industry in many developing countries is facing tremendous challenges in developing novel products from indigenous research and technology, the biotech industry is picking up. A modest investment in biotechnology capacity building and support to bioindustry offers excellent business development opportunities for Eastern African countries in their efforts to add value, make use of and further develop its natural resource base. The proportion of biotech crops grown in developing countries has consistently increased every year. In 2005, more than one third of the global biotech crop area, equivalent to 33.9 million hectares was grown in developing countries. The percentage growth was almost five times as high (23%) in developing countries of the south, compared to that of industrialised countries of the north (5%)[12]. As was the case with information technology, the biotech industry in developing countries is expected to continue to grow in the next couple of years. However, biotechnology is a hardware-intensive sector requiring highly skilled scientists along with strategic infrastructure investment that cannot be readily accommodated by developing countries budgets. Furthermore, there is always a long incubation period before returns on the heavy investment can be realized and success requires innovative ideas and strong desire to use biotechnology for the development of the region.

To ensure that biotechnology is applied safely across a wide range of sectors, capacity building has to take place on an equally broad level encompassing scientific, technological, organizational and institutional aspects to facilitate development and safe deployment of biotechnology.

For the growth of biotechnology industry, conditions that support the creation of knowledge network are innovative ideas, availability of high quality skills, strong public support and perception of opportunities. Emerging biotechnology companies focused on developing a new generation products will play an important role in the shap-

ing the structure of the future bioindustry. With the changed economic scenario and the TRIPS-compliant patent regime, developing countries biotech companies would be required to compete with multinational biotech companies in R&D, innovation and patenting and products affordability.

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A View Point:
A Forced End to Africa's Food Dependency? Implications of High Oil Prices

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One need not be an economist to realize the rapid changes being wrought on agriculture due to the high fuel prices, one just need open ones eyes to what is happening in the US corn belt. A whole new economy is kicking in, with huge public and private investment, with promises of rapid profits, now that the pundits are promising that oil prices will never again drop below $50 a barrel, and it is presently well above $60. Fifty dollars is the magic threshold number that renders the technologies of turning quality grain into ethanol, and food oils to biodiesel profitable in the USA, where they only pay half for fuel at the pump than most of the developed world.

Some of us have ranted for years that we must genetically engineer the 2 billion tons of straws and stovers to contain less and/or modified lignin so far more polysaccharides could become available for cellulase degradation that would support such technologies[1]. The biofuel industry has not targeted this waste substrate; at $50 a barrel they are happy to use quality grain – taking the food out of peoples' mouths. This is not just excess grain – this is whatever the market will bear in competition with petroleum, and will lead to higher grain prices around the world.

This huge investment in factories to quickly reap a bonanza will clearly stabilize the bottom price for grain at a much higher price than at present. The good side is that subsidies will no longer be needed in the west, and the African farmer will no longer have to compete with "dumped" grain, i.e. grain sold below the actual production costs. But the African farmer will have to gear up to production, instead of subsistence. The scary side is that there will no longer be stocks available for famine relief in times of need. There never will be "over production", "set-aside" or surpluses again as long as oil is more than $50/barrel. Even with all excess grain going to biofuel production, it will only make a small dent in the total fuel needs of the west and growing fuel needs in Asia. The magic fifty dollars also renders nuclear energy a viable alternative for much of the fuel, but it takes nearly a decade to build a nuclear power plant, and that is after the decision is made to build one. Such decisions are not fast in coming, and other alternative energy sources (e.g. wind, solar) cannot match the magnitude of the shortfall, no matter how appealing.

The only viable take home message from this is that Africa must quickly prepare itself to go it alone vis a vis its food security. The question: "should we accept transgenic maize as food aid?" will be moot in a very short time, as such maize will no longer be available – it will be running someone's automobile. Africa must quickly come to the realization that it must rapidly go from subsistence agriculture, with yields a third of global averages to productive agriculture to feed Africans. It can do this only by having good seed bred and available, fertilizer available at near international prices, and not an unjustifiable four times these prices. There must be extension services that get to the farmers and teach the most sustainable, cost-effective practices. An infrastructure with good storage facilities is critical to ensure storage for times of need, as well as an equitable price to the farmer. If India could get such a storage infrastructure going decades ago, Africa has few excuses for not doing so other than a lack of will except for a willingness to be dependent on foreign food aid.

The key needs described above started with good seed (and not the long ago discredited but still repeated mantra of "farmer-saved seed", so often mouthed by those who never watched how good seed deteriorates season after season in the hands of all but the very best farmers – the few who grow "certified" seed). The good seed must be of more crop species than presently grown, and it must be adapted to local conditions. It should come with as many built-in resistances as possible; resistance to abiotic stresses, high fertilizer use efficiency, resistance to African insect, rodent, and avian pests during cultivation and storage, resistance to indigenous diseases and the debilitating mycotoxins their pathogens produce, along with resistance to that scourge of much of Africa, the parasitic witchweeds (*Striga* spp.).

Good breeding can surely help, but where decades of breeding have proven ineffectual, the biotechnology sector must kick in[2]. This must be done in more species than maize, as crop biodiversity is also an essential element of food security. Biotech priorities should not be haphazard, but based on evaluations of need. Biotechnology will play an important role, a role that will be useless if the other institutional and infrastructural issues are not addressed. And they must be dealt with quickly, as biofuel plants are quickly coming on line, sucking up the grain that came to Africa. Africa may have thought it need not produce and store grain for winter – but winter is on the way.

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Compulsory licenses for the exportation of generic versions of patented pharmaceutical products: A complete and permanent solution by the World Trade Organization?

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Abstract

The WTO General Council adopted on December 6th, 2005, the "Decision on the implementation of paragraph 11 of the General Council Decision of 30 August 2003 on the implementation of Paragraph 6 of the Doha Declaration on the TRIPS Agreement and Public Health". This adoption will result in a new protocol, leading to the first ever amendment of the TRIPS agreement. This protocol may offer a permanent solution to the problem of WTO member states which face difficulties in addressing their urgent public health problems because they lack the production capacity for pharmaceutical products to address public health problems.

Key words: Public health; WTO-TRIPS; patents; compulsory licences; development.

Introduction

On December 6th, 2005, the World Trade Organisation (WTO) announced a permanent solution to the so-called "paragraph 6 problem" used to identify the situation of – mainly – developing countries which do not have the production capacity in the pharmaceutical sector allowing them to make use of compulsory licences. This announcement is good news, because a consensus on this subject is likely to be celebrated in the future as the main success of the run-up to the Ministerial Conference of the WTO in Hong-Kong, held on December 13 to18th, 2005. Moreover, the provisional solution contained in the Decision on the Implementation of Paragraph 6 of the Doha Declaration on the TRIPS Agreement and Public Health of 30 August 2003, which was not used by any country until now, may become more operational with the inclusion of the solution in the TRIPS agreement. The latter will certainly provide it with more legal certainty and allow WTO member States to adapt their legislation on the basis of a solid legal instrument.

1 Background

The decision of the General Council of December 6th, 2005, deals with the problem of countries that do not have sufficient capacity to produce pharmaceutical products themselves. When such countries face public health crises, how can they help their inhabitants receive the medicines, or, more generally speaking, the pharmaceutical products they need, in order for the disease they suffer from to be treated?

This issue is part of the more general discussion on access to medicines. How can the poor people in developing countries get access to the pharmaceutical products and medical treatments, if they lack the means to pay for them?

The subject was first taken to the WTO TRIPS Council in the year 2000 already, where the group of African countries (also commonly called the African Group) requested that the TRIPS Council deal with the issue of the HIV/AIDS pandemic, especially in Africa. Difficult negotiations led to the adoption of the Declaration on the TRIPS agreement and public health on 14 November 2001, at the Doha Ministerial conference. The main goal of this Declaration was to clarify the use of possible instruments such as exceptions to patent rights – that existed in the TRIPS Agreement – in order to facilitate access to patented products to address public health crises. The Doha declaration was actually nothing really new, but helped give confidence to developing countries, that they were allowed to apply some flexibility when addressing their to public health challenges. These flexibilities include in particular the following:

- In applying the customary rules of interpretation of public international law, each provision of the TRIPS Agreement is to be read in the light of the object and purpose of the TRIPS Agreement as expressed, in particular, in its objectives and principles.
- Each WTO Member State has the right to grant compulsory licences and the freedom to determine the grounds upon which such licences are granted.
- Each Member State has the right to determine what constitutes a national emergency or other circumstances of extreme urgency, it being understood that public health crises, including those relating to HIV/AIDS, tuberculosis, malaria and other epidemics, can represent a national emergency or other circumstances of extreme urgency.

Each Member State is free to establish its own regime of exhaustion without challenge, subject to the most favoured nation and national treatment provisions of Articles 3 and 4 TRIPS.

2 The problem of export under a compulsory licence

The Declaration did remind Member States of their right to issue compulsory licences, but, according to article 31 (f) of TRIPS Agreement, these may be delivered only "predominantly for the supply of the domestic market". Hence a country with no or insufficient manufacturing capacity in the pharmaceutical sector could not make any use of this provision, nor could it import products made under a compulsory licence in another WTO Member State, unless the latter had produced predominantly for its own territory and exported a (smaller) part of its production.

Paragraph 6 of the Declaration on the TRIPS agreement and public health recognized this problem, and requested WTO Member States to "find an expeditious solution to this problem and to report to the General Council before the end of 2002".

The provisional solution was found on 30 August, 2003 with the Decision on the Implementation of Paragraph 6 of the Doha Declaration on the TRIPS Agreement and Public Health.

3 The solution

The Decision on the Implementation of Paragraph 6 of the Doha Declaration on the TRIPS Agreement and Public Health allows WTO member states which have a production capacity in the pharmaceutical sector to derogate from the obligation contained in Article 31(f) TRIPS mentioned above. They may issue compulsory licences for the production and export of generic versions of patented pharmaceutical products to Member States lacking this manufacturing capacity and facing public health problems. Any patented pharmaceutical product needed to address a public health problem may be exported under this system. Diagnostic kits are expressly included. Covered diseases include typically HIV/AIDS, tuberculosis and malaria, but also any other disease causing a public health problem. Importing countries may be least developed countries, where production capacity for pharmaceutical products is deemed to be lacking. Any other WTO member state that deals with a public health problem may import pharmaceutical products under a compulsory license, as long as the state can demonstrate a lack of capacity to produce the needed pharmaceutical product. On the other side, any member state, which has that production capacity, may act as exporting country.

Measures must however be taken in order to make sure that the system is not abused and that products reach those countries really in need. In particular, the importing country will have to notify the TRIPS Council with the name and the quantity of products necessary to face the public health problem it meets; if the importer is not a least developed country, a confirmation is requested, according to which it lacks production capacity for the particular pharmaceutical product; if the product is patented in the importing country, a confirmation is needed, mentioning that a compulsory licence has been, or is going to be, granted.

Under a compulsory licence for export, exporting countries may produce and export only the quantity of products necessary to meet the needs of the eligible importing member state and the entire production under such a licence is then to be exported to that member. The products shall have to be clearly identified by a special colouring and/or labelling, and the information on the above conditions shall be made publicly available on a web-site (which can be the WTO website). Appropriate measures shall be taken to prevent trade diversion. General conditions of adequate remuneration shall also be respected, whereas the value of the license shall be calculated taking into account the economic value to the importing country of the use authorized in the exporting country. In case patents exist in both the exporting and the importing member states, no double remuneration shall be necessary: the condition of adequate remuneration in the importing country shall be waived. Finally, measures in favour of economies of scale and local production shall be encouraged, in particular where least developed countries are at stake. So will technical cooperation and technology transfer.

4 The amendment: Technical or not technical?

The August 2003 Decision on the implementation of Paragraph 6 however still had to become an amendment of the TRIPS Agreement in order to be final and provide all the legal certainty member states need to implement it. Work on such an amendment was initiated by the end of 2003 with a view to its adoption within six months.

With one and a half years delay, the WTO member states now have a solution which gives them the legal security they need. That was not an easy task: Paragraph 11 of the August 2003 Decision mentioned that the amendment was to be based, *where appropriate*, on its content. These terms were interpreted in different ways. For some delegations, mainly representing industrialised countries, the discussions had to remain purely technical, meaning that the consensus found on 30 August 2003 was not to be touched at. The only question was to know how, technically, to incorporate the decision into the TRIPS Agreement, without making it unreadable. Only conditions existing already in the TRIPS Agreement did not need to be repeated for the implementation of the Decision, but all the new rights and obligations resulting from the Decision and the General Council's Chairperson Statement had to be incorporated in the TRIPS Agreement. The industrialised countries feared that a reopening of the discussions may destroy the very delicate balance of rights and obligations that was achieved in previous negotiations.

Other delegations, mainly developing countries, interpreted the terms *where appropriate* more broadly, in the sense that some obligations, which seemed too burdensome, could be rediscussed and possibly left aside from the amendment.

5 The General Council Decision of 6 December 2005

The General Council Decision of 6 December 2005 includes a protocol for the amendment of the TRIPS Agreement, which contains the elements of the August 30, 2003 Decision. It is open for ratification by Members until December 2007, a date that may be extended by a decision of the Ministerial Conference. The protocol will then take effect accordingly to the procedure foreseen in the WTO Agreement (paragraph 3 of Article X).

The TRIPS Agreement, upon entry into force of the Protocol, shall be modified by the insertion of a new Article 31*bis* after article 31 and by inserting an Annex at the end of the TRIPS Agreement. With the new Article 31*bis* and the Annex, all rights and obligations included in the August 30 2003 Decision have been maintained. The General Council Chairperson's statement made at that time, and which allowed the consensus to be reached, is not included in writing in the protocol, but has been made orally again on 6 December by the current General Council's Chairperson. That gives it exactly the same – unclear – value as it had until now. An inclusion in writing would have given it, at least psychologically, more weight than it really had. Leaving it totally aside would also have been wrong, as it was an important element leading to the consensus found in 2003. Its reading at the General Council meeting probably provided just the right balance.

Finally, an appendix is attached to the annex, which includes indications on the way to assess the lack of production capacity in the pharmaceutical sector in the importing country. This appendix corresponds to the annex to the 2003 Decision, which dealt with the same issue.

Conclusion

The adoption of the General Council's Decision of 6 December 2005 must be welcomed. It provides more legal certainty, allowing WTO Member States to incorporate the decision into their national legislation and to import (respectively export) generic versions of pharmaceutical products that are still under patent protection. It may help them address their public health problems more effectively. As regards public health issues, a coherent and balanced system of rights and obligations is now avai-

lable for existing pharmaceutical products. The use of the system will hopefully prove that it is not as complicated as it seems to some at first sight.

Footnotes:

1. Doc. WT/L/540, and General Council Chairperson's statement of 30 August 2003.
2. Doc. WT/MIN(01)/DEC/2 of 20 November 2001.
3. Ibidem, in particular paragraphs 4 and 5.
4. See note 2.
5. Some Member States have stated that they will not make use of the system as importers (OECD countries). Some advanced developing countries have indicated that they would make use of it only in case of emergency.
6. Article 31 (h) TRIPS.
7. Paragraph 11 of the Decision.
8. The incorporation of the entire text of the August 2003 Decision into article 31 TRIPS would have rendered the latter unusually long and complicated. The same is true for its incorporation in a footnote to article 31 TRIPS.
9. Implementation of paragraph 11 of the general council decision of 30 august 2003 on the implementation of paragraph 6 of the Doha declaration on the trips agreement and public health; Proposal for a Decision on an Amendment to the TRIPS Agreement, doc. IP/C/41.
10. See the "Protocol amending the TRIPS Agreement" in doc IP/C/41

Technological Development in Africa: Impediments and Recommendations for Change

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Abstract

Indications are that the gap between African exports and that in non-African developing world is widening. Africa maintains its tradition of exporting unprocessed materials, and sub-Saharan Africa's exports consist mainly of primary products, while other developing countries have diversified. The main structural problem contributing to this appears to be Africa's weak technological and managerial capabilities. Africa pursued IMF and World Bank structural adjustment policy with the expectation that that liberalization would lead to the success of export-oriented countries of East and South-East Asia. However, it has now become clear that other measures are needed.

Introduction

It seems that the manufacturing sector is the main catalyst of economic development and modernisation, hence countries use technology to improve production processes to achieve comparative advantage in manufacturing. In most manufacturing activities, competitiveness can be attributable to the continuous modernization of production processes, organizational methods, networks, firm-wide and region-wide integration of production systems, as well as technological change. The East Asian experience shows that coherent, well-designed technology policies can increase firm's competitiveness, and help businesses to develop and pursue technology development activities.

Unlike many countries which constantly upgrade their technological capabilities, to function in an increasingly liberalized and competitive world, African countries have not, even in the cases where governments have recognized the importance of technology policies, such as Ghana and Tanzania. While some problems with African industrial development are attributable to political and ethnic conflicts; natural disasters; external market shocks in the form of declining terms of trade; debt or falling aid inflows; poor macroeconomic management; and inadequate infrastructure, others are due to inappropriate industrial policy. Africa countries must, like others, industrialize efficiently in order to grow, compete and advance.

1 Technology gap; a summary of five indicators.

The fact that technological gap could be the source of Africa's increasing economic deterioration was confirmed in a case study of four sub-Saharan countries - Kenya, Ghana, Uganda and Tanzania. The study-cited weaknesses in the conditions and policies governing technology transfer, as well as its absorption and use in the manufacturing industry. The study assessed the technological capabilities in these four countries using five indicators:

1. Technological structure of manufactured exports;
2. Industrial performance;
3. Human capita base;
4. Structure of manufactured exports sector;
5. Foreign technology inflows, particularly through foreign direct investment (FDI).

1.1 Technological structure of manufactured exports

Manufacturing in African has many weaknesses: few supply linkages between large and small enterprises, poor productivity growth, low technological efficiency with little dynamism or innovation (Lall and Wangwe, 1998). In addition, African firms are below international "best-practice" technical levels, and below the levels of other developing countries (Biggs, Shah and Srivasatava, 1995). Consequently, manufacturing has slowed down regional economic growth.

Africa lags behind because it is still dominated by a low-level of processing natural resources and the manufacture of simple consumer goods for domestic markets. It is characterized by small and weak indigenous base of industrial entrepreneurship. African manufacturing does not show many signs of upgrading, yet efficient competition requires better technological capability in every country, regardless of resource base and location – even those that are not at the frontiers of innovation.

1. 2 Structure of manufactured exports sector

The amount of manufactured exports is an indicator of technological strength and specialization of the industrial sector (particularly when countries are assessed comparatively). It shows trends for trade activities and provides an overview of underlying technological activity. In general, technology-intensive activities are expected to be more beneficial because:

⇒ There is demand for activities with rapid innovation as opposed to technologically stagnant activities; Newly invented products substitute for other products (final or intermediate) and stimulate demands for other technology-based products; thereby quickening the pace of production, employment and

exports;

- ⇒ Technology-intensive activities are less vulnerable to entry by competitors compared to low-technology activities;
- ⇒ Technology-intensive activities offer higher learning and productivity potential and greater spill over benefits for other activities. Thus, they lead to faster growth in skills, greater diffusion of knowledge and offer greater systemic benefits for learning and innovation;
- ⇒ They are more attuned to technological and market trends, giving the ability to respond more flexibly to changing conditions. In the emerging global environment, therefore, they provide more valuable competitive skills.

Among developing countries, Asia had a two-thirds increase of manufactured exporters compared to 1980, Latin American maintained its 20 % share, but Sub-Saharan African lost ground in its world market shares of manufactured exports in every category, including resource-based exports.

Export growth and technological upgrading seem to be bypassing Africa. Countries are still exporting unprocessed materials, which is the slowest-growing segment of world trade and the least stimulating for structural, entrepreneurial, skill and technology growth. Apart from the Middle East and North Africa and its huge oil-exporting base, Africa is the region with the highest reliance on primary products.

1.3 Industrial Performance

Sub-Saharan Africa lags in terms of volume and technological content of its manufacturing activity. In the past twenty years manufactured exports have not grown significantly (Helleiner, 1999); growth has been very low or even negative. The only African enterprises growing are those with a local cost advantage, or those with niche markets that do not face direct import competition. And while it is possible to remain competitive with unskilled cheap labour and by processing natural resources in some largely traditional activities, this base is eroding steadily.

The revival of growth and competitiveness in Africa must be based on greater technology inflows into Africa and on improvement in enterprises' ability to absorb, adapt and improve on imported technologies.

1.4 Human Capital

Technological activity levels are closely linked to the skills level and skills need to be continuously upgraded. Traditional methods of education and training such as primary schooling, basic technical activities and ad hoc on the job training are not sufficient for technological advancement today. Industrial development now requires high-level specialised training with close interaction between education and industry, including cognitive skills relevant to information technology (Breshnaham, Brynjolfsson and Hitt, 1999).

Facts:

Between 1972 and 2002 income per capita in Sub-Saharan Africa fell by 8 percent, from USD 625 to USD 575 in constant 1995 values.

Between 1972 and 2002 manufacturing value-added per capita in Sub-Saharan Africa fell by 13 percent, from USD 98 to USD 85 in constant 1995 values.

In 2001/2002 the share of Sub-Saharan African in world income was 1.1 percent, the share in world manufacturing value-added was 0.8 percent, and the share in world manufacturing exports was 0.7 percent.

Source: World Development Indicators[1]

A 2002 assessment of the impact of skills on productivity in Ghana, Kenya and Zimbabwe shows that most firms are relatively isolated from world markets both as importers and exporters, and that they import little technology. African countries also lags in research and development (R&D) as a share of national income, and the number of scientist and engineers engaged in R&D. Similarly, they are behind in the number of international standards organization 9000 certificates. These certificates are a good indicator of export levels. Up until 1998 Tanzania and Uganda had not received any certificates.

Comparison of enrolment data across primary, secondary and tertiary levels of formal education show that Sub-Saharan African lags behind the mean for developing countries, Asia and Latin America. Tertiary enrolment in technical subjects such as science, mathematics, and engineering which affects the capability to absorb technology is lower. Moreover, while Sub-Saharan Africa has 12%of the population it accounts for only 4.4% of enrolment in tertiary institutions and 3.1 % of technical tertiary enrolments and 1.7% of engineering enrolments.

To promote national technological growth, African countries must introduce corrective policies and change the traditional mindsets to form interactions and linkages with other firms or institutions, and to build technical know-how, as well as to overcome the problem of brain drain.

1.5 Foreign technology inflows, particularly through FDI

Foreign technology may be introduced in a country through many channels, principally through capital goods imports, royalties and inward FDI. Most developing countries acquire technology via capital goods imports. However, Kenya, Ghana, Uganda and Tanzania import very little new capital goods. In Uganda, capital goods can be brought duty free, however, the tax deductibility (50-70%)

for plant and machinery have not stimulated growth. Poor infrastructure, and costly communication and transportation also raise the cost of importing capital goods.

Developing countries as a whole paid $5.8 billion in licensing fees in 1997 for imported technology. Of this, Sub Saharan Africa, excluding South Africa, paid $84 million and Kenya and Swaziland $39 million each. Ghana's payments for royalties and license fees show that only a trickle of new technology in terms of royalties and licenses enter the country (how much is a trickle).

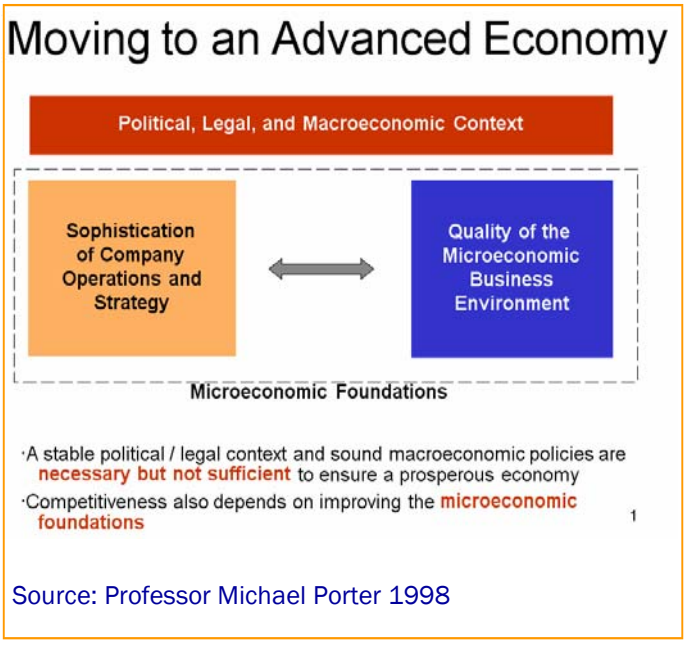
Technology imports seems very low in Africa and technological efforts to adopt, import or adapt foreign technology are limited at the firm level. Even where there are foreign affiliates, such as in Ghana, they do not make much impact on domestic technology development and they operate in the primary and the services sectors as opposed to the manufacturing sector. Moreover, inflows are not by themselves necessary nor sufficient to ensure industrial development or technology upgrading.

2 Role of Government

Although productivity has become an important issue globally, some aspects of productivity are not well understood. First, It is generally known that in thinking about productivity one must think as much about the value of the products as the efficiency with which the products are produced. Even though productivity indexes are indexes of unit volume productivity - yet that is not directly what matters. What matters is the value you can create with a day of work, or a dollar or pound of capital invested, and increasingly we need to think about value productivity. Secondly, ownership of the company and where the company is owned is less and less important to prosperity. What matters to the prosperity of a nation is what companies choose to do in their location, not whether those companies are American, Japanese or UK owned.

What will eventually drive the productivity of (African) countries is what the companies choose to do in Africa. If they choose to do very productive things and use very advanced technology to produce a lot of value per unit of work, then African countries will be prosperous as the wages will be high. So increasing ownership of the company matters much less than the environment provided by a country that allows the company to operate in a productive way. As long as African policy makers see their countries as low cost production sites rather than a high value production site, the trend will never be broken (Michael Porter).

Government policies have a major role to play in facilitating technological development by implementing policies that, promote in-firm learning and skill development; improve the supply of information and skills from markets and institutions, and coordinate collective learning within and across industries. As illustrated by the example of East Asia, strong government intervention can be an engine of technological development if it takes place as part of an export-oriented strategy and is reinforced by policies that boost learning and help one to acquire new skills and access information.



Source: Professor Michael Porter 1998

In the past, many African Governments offered high and indiscriminate protection to industry. They encouraged state-owned enterprises with limited managerial and technological capabilities and this fostered rent-seeking and political interference, which exacerbated inefficiency. Some Governments also nationalized enterprises run by foreign firms or entrepreneurs of non-African origin and created environments that were riddled with high transaction costs and often inhospitable even to local entrepreneurs.

Poor economic conditions, disillusionment with past strategies and intense pressure from other countries caused many African governments to liberalize economic policies with the hope of reviving growth in manufacturing output, exports and employment. They introduced liberalization as part of the IMF and the World Bank structural adjustment programme–regardless of their level of industrial development. Adjustment was touted as having the ability to improve productive sectors by removing inefficient interventions and expose activities to international competition and governments believed that this would lead to efficiency and technological dynamism. liberalization was considered to be sufficient for better performance and most of the burden of policy reform was based on price adjustment.

Efficient use of technology requires the ability to master new technology; to adapt it to local factors and conditions; and to upgrade as technologies improve and new products emerge. It is more than importing machinery. It entails building capabilities, technical understanding and an informational base; acquiring new technical skills and

managerial practices; and forging linkages with other firms and institutions. The main factors affecting technology development are the rules governing competition and trade policies, other important matters are regulations, physical infrastructure, skills, financing, and technology and supply clusters.

3 Intellectual Property

The intellectual property regime in a country is central to technological activity as it covers trademark, patents, copyrights, trade names etc. Patents tend to spur innovation and also facilitate the transfer of technology. Intellectual property protection can raise the cost to developing countries of buying technology and stifle local copying, one way of building technological capability. Generally there is a low level of patents granted to individuals in Kenya, Ghana, Uganda and Tanzania.

4 Science and technology training and policy-making structure

In Kenya, the jurisdiction for science and technology is disbursed across 3 ministries and these overlap tend to lead to conflict. There is also little interdepartmental communication and coherence and coordination in decision-making. The relations between the different bodies in the ministries are also weak. There is no institutional mechanism in Kenya for comprehensively evaluating and setting science and technology priorities. There is no well-developed science and technology plan, and responsibilities are spread over many ministries and institutions. While in Ghana science and technology coordination face difficulties from excessive fragmentation and suffers from sectoral policies and objectives. The educational and training institutions do not produce enough graduates to satisfy the quantity and quality of industrial development. In addition, in most Sub-Saharan countries it is public institutions which undertake research. This is in contrast to other industrializing countries where private enterprise finance and undertake R & D.

5 Summary

The wide technological gap between Africa and the rest of world can be bridged. For this to happen, Africa needs unabated commitment by governments in furthering science and technology. And a strategy and focus that everyone including the public and private sectors can implement. Africa needs to have a vision, a policy. It needs to have something to aim at, a goal to which it is committed, something to budget for. Unless goals are set and clearly defined, there would be nothing to work for. For example India crafted its three-page policy framework on science and technology in 1958 and it is still valid day.

Sub Saharan Africa does poorly in industrial competitiveness. It mostly exports primary products that offer few beneficial learning or spill over effects for technological development. African enterprises have failed to build up comparable levels of technological capability with many developing countries, and few have reached a level where they could compete directly in international markets as a result manufacturing rudimentary dominated by simple activities.

The region lacks technological dynamism and the basic pre requisites for technological development. The skills base is weak and the education system is not attuned to the needs of industrial competitiveness. Low wages in Africa has not led to increases in the global production of low technology consumer product. The region hardly exports any sophisticated products.

Inflows of technology, as measured by contractual transfers, FDI and equipment imports are very low. As a result there is little mastery of simple technologies and technological learning and diffusion are limited. The ability to absorb sophisticated technologies, the cutting edge of industrial dynamism and competitiveness is absent.

Trade liberalization in Africa has not been linked to technological policies. Instead of functioning as the engine of growth and structural transformation, the industrial base is eroding in part due to liberalization and adjustment.

Recommendations

Policy

- ⇒ Undertake a technology foresight exercise involving industry, government, technology institutions, and universities. Have all sectors assess local technological competence by global standards and work out strategies to overcome weakness and to upgrade. In doing this assessment, evaluate the role of technology as distinct from science.
- ⇒ Review and improve technology strategy formulation and entrust one body to analyze technological needs, and to design and implement strategies at the national level.
- ⇒ Improve budgeting and allocate more resources.
- ⇒ Improve the R&D climate. Promote industrial R&D through attractive fiscal incentives, service support systems and have a campaign targeting the industrial and business sectors.
- ⇒ Strengthen the technology infrastructure and institutions such as the bureau of standards, institutions and promote SMEs in high value added industrial activities.
- ⇒ Stimulate and improve technology imports, and base technology upgrading on current technological levels and the needs of the manufacturing and industrial sectors.
- ⇒ Attract FDI in manufacturing offer fast services for investors that are modern and competitive, one-stop shops for permits and licenses.
- ⇒ Consider establishing a benchmarking unit trained to develop, implement and analyse benchmarking in

industry involving the private sector and association. Technology upgrading requires an understanding of technological status and needs of upgrading enterprise. Countries gain such understanding by conducting and promoting benchmarking enterprise.

Education and Training

⇒ Have a skills strategy to create competitive skills for industry.

⇒ Improve human skills will create qualified technical and managerial personnel who will respond to rapid economic and technology development and help the move into more advance technology.

Intellectual Property

⇒ Strengthen IP rights in terms of formulation of competition policy and price regulation.

⇒ Implement targeted subsidies and other transfer mechanism to mitigate the potential negative effects of strong ownership rights on IP on the cost of technology transfer.

⇒ Train patent lawyers.

Support for SMEs

⇒ Make information provision to enterprise the focus of technological transfer. Provide information to export – oriented SME's on the sources, cost and appropriateness of foreign technologies, as non export oriented firms find it difficult and costly to obtain information on the sources of technology. This can be done through online databases in industrial activities.

⇒ Provide technical extension services to help SMES absorb new technology. In East Asia and Hong Kong, not only was information provided but it was backed by advice, finance, consultation, and market support and subsidized assistance.

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Africa in the News

Eastern African Dialogue on Biotechnology Policy

A wide range of stakeholders – including from government, intergovernmental organisations, civil society groups, academia, industry and the media – from the Eastern African region met in Uganda to address the formulation of coherent, informed and inclusive biotechnology policies on trade and sustainable development at the national, regional and multilateral levels. Many countries in Eastern Africa are in the process of formulating their national policies and strategies related to biotechnology ,and translating them into national and regional approaches and multilateral negotiating positions.

The need to respond and adapt to the international developments – including a myriad of trade interests, obligations and pressures – threatens to dominate national agendas. This raises the urgent need for understanding and asserting the space for domestic policy-making in biotechnology supportive of the countries' self-defined sustainable development objectives.

The group asked African governments to be more proactive in analysing and identifying their short, medium and long term needs, policy gaps and priorities. These priorities should ideally be developed with the participation of relevant actors in the public and the private sectors. Countries' policies and strategies for biotechnology development should be based on clearly identified public policy objectives that are specific and formulated through participatory processes. These could include:

- ⇒ Ensuring food security, including access to safe and sufficient food
- ⇒ Increase agricultural productivity, rural development and poverty alleviation
- ⇒ Promote economic growth through diversification in to high-value products and technological development
- ⇒ Promoting public health and food safety
- ⇒ Conserve, sustainably use and equitably share the benefits of biodiversity

Achieving these objectives will entail addressing and integrating a range of policy areas and instruments in order to develop a coherent biotechnology policy framework that were outlined in detail. Action on these policy instruments will be required at both the national and regional levels. At the *regional level*, partnerships, such as NEPAD, and regional economic agreements should be considered as a means to achieving developmental goals. Commercial considerations should be balanced by social, environmental and cultural objectives.

Successful implementation of domestic, regional and international policies and regulations can only be achieved through integration, coordination and cooperation among all stakeholders. This will involve raising awareness of the risks and benefits of biotechnology and promoting official national multi-stakeholder consultation processes that include networks of farmers associations and civil society groups. All parties concerned with science and technology – industrial leaders and researchers, academia, financial institutions and the government – should also be engaged to determine, over a period, the technological course and needs for their country.

To support technology upgrading in Eastern African countries, governments must put in place institutional mechanisms for comprehensively evaluating and setting science and technology priorities and making sure responsibility for relevant policies is coordinated between ministries and institutions.

National and regional biotechnology policies will need to be integrated with trade obligations (eg WTO rules) and trade interests.

One of the main constraints affecting the implementation of effective biotech regulations and the development of biotechnology has been inadequate funding. Governments should review and adapt laws and commercial regulations to enhance funding for biotechnology policy-making and development.

Eastern African Dialogue on Biotechnology Policy-making, Trade and Sustainable Development was held from 15-17 February 2006 in Jinja, Uganda. It was organised by the International Centre for Trade and Sustainable Development (ICTSD) and the African Technology Policy Studies Network (ATPS). It was co-hosted by the African Union (AU) and the New Partnership for Africa's Development (NEPAD).