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The Role of Science, Technology and Innovation (STI) in Promoting Agriculture, Agro-Industry and Agribusiness in Africa

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Zusammenfassung

In diesem Beitrag werden zunächst die wesentlichen Wirtschaftsprobleme Afrikas diskutiert; insbesondere wird auf die Stagnation der Flächenerträge in der Landwirtschaft, auf den Trend der De-Industrialisierung im Bereich des verarbeitenden Gewerbes und auf die Marginalisierung im Welthandel auch und besonders bei verarbeiteten Produkten eingegangen. Diese *drei negativen Trends* beziehen sich auch auf die gesamte Wertschöpfungskette von den landwirtschaftlichen Rohprodukten bis hin zur Agroindustrie und zu allen Serviceleistungen im Agribusiness. Die Lage der Landwirtschaft, der Agroindustrie und des Agribusiness in Afrika ist so, dass diese Trends bisher nicht umgekehrt bzw. beeinflusst werden konnten, was erstaunlich ist, gilt doch Afrika als Kontinent mit komparativen Vorteilen in der Landwirtschaft.

Ein wesentlicher Grund für diesen Befund liegt in der unzureichenden Unterstützung der Entwicklung dieser Sektoren durch Wissenschaft, Technik und Innovation (STI-Science, Technology, Innovation). Obwohl es in Afrika in den letzten Jahren zahlreiche *Initiativen auf den Ebenen der Afrikanischen Union und der regionalen afrikanischen Wirtschaftsgemeinschaften* gegeben hat, um diese drei Trends umzukehren und die STI-Infrastruktur zu fördern, ist ein nachhaltiger Erfolg von diesen Initiativen bisher ausgeblieben.

In diesem Beitrag werden *drei Aktionsebenen* diskutiert, um diese negativen Trends nachhaltig zu verändern, wobei STI-Inputs auf verschiedenen Ebenen eine maßgebliche Rolle spielen. STI-Inputs werden im Entwicklungsprozess an verschiedenen Schnittstellen verstärkt, um Landwirtschaft, Agroindustrie und Agribusiness direkt fördern zu können. Die *erste Aktionsebene* betrifft die Verstärkung der Linkages zwischen den Subsektoren von Landwirtschaft, Agroindustrie und Agribusiness und dem STI-Sektor. Proaktive Politiken werden in diesem Zusammenhang diskutiert; verschiedene Möglichkeiten werden aufgezeigt, um STI mit diesen Subsektoren besser zu verbinden. Auf der *zweiten Aktionsebene* geht es um die Stärkung der Wertschöpfungskette durch STI-Inputs auf allen Ebenen und Rängen, von der Rohproduktion bis hin zur Agroindustrie und zu den Serviceleistungen des Agribusiness. Auf der *dritten Aktionsebene* geht es um die Transformation von komparativen Vorteilen in kompetitive Vorteile von Firmen und Farmen und um die Rolle, die STI-Inputs dabei spielen können.

Eine *Strategie für Afrika* kann nur erfolgreich sein, wenn auf allen drei Aktionsebenen Fortschritte bei der Inkorporierung von STI erreicht werden. Die aktuell hohen Wachstumsraten in einigen afrikanischen Ländern dürfen nicht über das Fehlen von Strukturtransformation hinwegtäuschen. Ohne grundlegend verstärkte STI-Inputs auf diesen drei Aktionsebenen kann es zu einer so dringend erforderlichen Trendumkehr nicht kommen. Ein *Aktionsprogramm für Afrika* muss daher Ansätze auf verschiede-

nen Ebenen verbinden; die relevanten Konzepte sind mit den Namen großer Ökonomen (wie D. Ricardo, J. Schumpeter, A. Lewis, A. O. Hirschman, E. Helpman, P. Krugman, D. North, M. E. Porter, I. Adelman, D. Rodrik, u. a.) und auch mit wichtigen Schulen der neuen Ökonomie (Innovations-, Evolutions- und Institutionenökonomik) verbunden. In diesem Beitrag geht es aber nicht um die Theoriediskussion, sondern darum, wie Veränderungen auf zentralen Aktionsfeldern möglich sind, um Strukturtransformation in Afrika voranzubringen.

Abstract

This contribution starts with an identification of the three major economic problems of Africa. These are the stagnation of yields in African agriculture, the de-industrialization with regard of manufactures production, and the marginalization of trade in respect of manufactured exports. These *three negative trends* are also prevalent along the value chain from production of agricultural raw materials to agro-industries and the services produced by agribusiness. The situation of agriculture, agro-industry and agribusiness in Africa is unsatisfactory; so far all attempts from national, regional and international actors have failed to reverse these negative trends. This is a surprise in so far as it is assumed that Africa is richly endowed with land and agricultural resources so that it has a clear comparative advantage in these areas.

An important reason for this failure is the inadequate support to these sectors (agriculture, agro-industry and agribusiness) by Science, Technology and Innovation (STI). Although Africa has seen in recent years various *initiatives at the level of the African Union and at the level of African Regional Economic Communities* to reverse these unfavorable trends and to establish an adequate basis of STI infrastructure, sustainable successes from these initiatives remained so far very limited.

In this contribution *three action levels* are considered to reverse these negative trends. At all the three levels STI-related inputs play a significant role. STI inputs have to be incorporated at specific junctions in the development process so as to support agriculture, agro-industry and agribusiness directly. The *first action level* concerns the building up of linkages between the subsectors of agriculture, agro-industry and agribusiness and with the STI infrastructure. Pro-active policies are discussed in this context. There are various possibilities to link up the (already existing and the successively built up) STI infrastructure with these subsectors. At the *second action level* the strengthening of agro-industry value chains by incorporating STI inputs matters. This refers to all levels and ranks of the value chain, from agricultural raw materials production to processing in agro-industries and to services provision by agribusiness. There are various possibilities to go ahead with this task. At the *third action level* the conversion of comparative advantages into competitive capabilities of firms and farms

is the key issue, and STI has a strong role to play for a successful conversion process to take place. Lessons from Asia and Latin America are used so as to propose guidelines in this regard.

A *Strategy for Africa* will only be successful if there is progress with regard of all the three action levels by incorporating STI inputs. The high growth rates in some African countries are not based on a structural transformation but have more to do with wind-fall earnings. By strengthening STI infrastructure along these three action levels a reversal of the three negative trends mentioned above will be possible. An *Action Program for Africa* has to be based on various approaches which are derived from “classical” development economics, and so most of the ingredients are known. These ingredients for successful and effective structural transformation are linked to theories and concepts of great economists (like D. Ricardo, A. Lewis, A. O. Hirschman, E. Helpman, P. Krugman, D. North, M. E. Porter, I. Adelman, D. Rodrik, etc.) and also to insights from influential schools of thought in modern economics (like economics of innovation, evolutionary economics, and economics of institutions). In this contribution, however, not a review of these theories, concepts and schools of thought is presented; it is attempted to use these theories concepts along three action levels for African development (linkages, value chains, and competitive capabilities/comparative advantages). So far the discussion about STI and structural transformation in Africa is not related to distinct action levels, and it is argued that this is necessary in order to develop operational strategies.

Keywords: African Development; Science, Technology, and Innovation (STI); Linkages agriculture, agro-industry, agribusiness; agro-industry value chains; converting comparative advantages into competitive capabilities

Stichwörter: Afrikas Entwicklung; Wissenschaft, Technik, Innovation; Verflechtungen Landwirtschaft, Agroindustrie und Agribusiness; agro-industrielle Wertschöpfungsketten; Transformation von komparativen Vorteilen in kompetitive Fähigkeiten

JEL Classification: O1, O3, O4, O55, Q1

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Abbreviations and Acronyms

ADLI	Agricultural Demand-Led Industrialization
3ADI	African Agribusiness and Agro-industries Development Initiative
3ADI	Accelerated Agribusiness and Agro-industries Development Initiative
AfDB	African Development Bank
AGOA	African Growth and Opportunity Act (of USA)
AU	African Union
BOI	Bank Of Industry (Nigeria)
BRICS	Group of countries (Brazil, Russia, India, China, South Africa)
CAADP	Comprehensive Africa Agriculture Development Programme
CBN	Central Bank of Nigeria
CCAA	Competitive Commercial Agriculture for Africa
DIIS	Danish Institute for International Studies
DR of Congo	Democratic Republic of Congo
EAC	East African Community
EMC	Export Marketing Council
UNECA	United Nations Economic Commission for Africa
FAO	Food and Agriculture Organization
FAC	Future Agricultures Consortium
GDP	Gross Domestic Product
IBRD	International Bank for Reconstruction and Development (part of World Bank Group)
ICT	Information and Communications Technology
NIS	National Innovation Systems
NPPAN	National Palm Produce Association of Nigeria
PR	productivity revolution

PE	productivity evolution
RR	rainbow revolution
REC	Regional Economic Community (in Africa)
R&D	Research & Development
SSA	Sub-Sahara Africa
STI	Science, Technology and Innovation
UNIDO	United Nations Industrial Development Organization
UNS/DESA	United Nations Secretariat/Department Of Economic And Social Affairs
UNU-INTECH	United Nations University - Institute for New Technologies, Maastricht
UNU-MERIT	UNU Maastricht Economic and Social Research Institute on Innovation and Technology
UNU-WIDER	United Nations University-World Institute for Development Economics Research
USA	United States of America
VCPC	value chain participant council
WBI	World Bank Institute (of World Bank)

The Role of Science, Technology and Innovation (STI) in Promoting Agriculture, Agro-Industry and Agribusiness in Africa

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1 Introduction: Three Major Economic Problems as Barriers to Sustainable Growth in Africa

Africa is considered as a continent with plenty of agricultural opportunities, with abundant land, livestock, water, forest, and fishing resources. Despite of these resources, the continent is affected by food insecurity, food import dependence and by its inability to convert the comparative advantage in terms of land availability into competitive advantages. Africa is producing all types of food and beverages, such as dark chocolate, high quality roasted coffee, fruit syrups, but is not able to compete on world markets (with some few exceptions at the level of firms and countries). The same is true for all categories of agro-based products and agro-industry products. Africa is importing escalating volumes and values of food, raw food as well as processed food. For some economists this is a miracle as the continent enjoys comparative advantages in agriculture, but is not able to exploit these advantages. Major explanations are the existence of very high transaction costs, especially trading and transport costs, and in more general terms difficulties which are associated with doing business in Africa (Collier 2000).

Africa has three major economic problems:

The *first* problem is that agriculture in Africa is stagnating. The figures for yields of cereals production for Sub-Saharan Africa show that the progress over forty years (1961/63 - 2003/2005) was only 29%, compared to Asia's increase of 177% and Latin America's increase of 144% (Staatz 2011, p. 60). Production increases in Africa are largely based on new land use, while in Asia and in Latin America production increases are based primarily on productivity increases. Other indicators are also alarming; Sub-Saharan Africa (SSA) has less than 4% of its arable land under irrigation, while the share is much higher in Asia and in Latin America (Staatz 2011, p. 62).

The *second* problem is the trend of de-industrialization in Africa. Despite of the huge opportunities for processing agricultural goods and supplying agriculture and pro-

¹ The paper benefitted from consultancy work by the author of this study for UNIDO and from participation and discussions at UNIDO/FAO/AU conferences in Addis Ababa and Abuja.

cessing industries with production inputs, machinery and equipment, the continent has lost in manufacturing capacity; the share of manufacturing value added in Gross Domestic Product (GDP) has declined to the year 1995 and is since stagnating at around 12%, what is a much lower share than the one in other developing countries with around 20% and in China with 35 - 40% (Sandrey/Edinger 2011, p. 8). The decline has to do with the low export rate of manufactured goods, which itself is related to the comparatively low productivity of Sub-Saharan African manufacturing firms (Sandrey/Edinger 2011, p. 8). Markets are therefore very small in volume. The share of Africa in global manufacturing is only 1 per cent, and there have been severe declines for all types of labour-intensive manufactures. This de-industrialization trend implies severe losses in terms of dynamic effects (productivity effects, linkage effects, technological spillover effects, and inter-sectoral and/or intra-sectoral structural changes). Food and beverages, and tobacco products dominate industry in SSA, while other agro-industries (textiles and apparel, shoes, leather products, rubber products, paper and wood products) have quite low shares in most SSA countries (UNIDO 2011a, UNIDO 2011b, UNIDO 2012).

The *third* problem of Africa is the marginalisation in foreign and intra-African trade activity (as well regional, inter-regional and global trade). The share of SSA in world trade has fallen since the 1950s from around 3% to 1%; the share of manufactured products in world trade is very low, and also the share of agro-based industrial products is of minor importance (while emerging economies in Asia and Latin America gained ground in exporting processed food and other agro-industry products; see UNIDO 2011a). Also weak is the integration of African firms into global industrial value chains (with a low number of African lead firms in the chains). USA is a key market for Africa and so its market data are used to assess the global competitiveness of Africa relative to China and Latin America. While Asian and Latin American countries increased their presence in the USA for all industrial goods, also of agro-industrial ones, Africa is exporting (data are available for this comparison only for the year 2008) to the USA mainly oil and mining products (89%), while textiles and apparel have a share of only 2% and other agro-industrial products a share of around 1.7%, while the rest of exports to the USA is made up by cash crops, some other industrial goods (like chemical products, machinery and transport equipment) and other unprocessed agricultural products (Sandrey/Edinger 2011, p. 10 - 12). Still worse, some of these “export successes”, like in textiles and clothing, are highly concentrated on a few countries and are dependent on rather generous preferential trade conditions (like the African Growth and Opportunity Act/AGOA). African countries depending on such export items, like Kenya, have “to rush and to push” for a prolongation of the so called “third country provisions” so as to be able to continue exporting textiles and apparel to the USA based on Asian yarn and fabrics; although this is contrary to the

original intention of the AGOA objectives - to have an integrated value chain located in Africa from raw cotton to apparel – it is favoured by the successful exporters to the USA. The problem is however that all the advantages and benefits of developing integrated agro-industry value chains in Africa are lost. Recent analysis reveals that even South Africa, member of the BRICS (Brazil, Russia, India, China, South Africa) group of countries, has lost positions in agro-industry exports (Case Study South Africa , in: UNIDO 2011b, 2012). This is the more surprising as South Africa has a base in STI (Science, Technology, and Innovation) and is building up its science & technology policy. However, the other sections will show that more is needed to become and to remain a successful competitor on world markets.

These three problems areas (stagnation of agriculture, de-industrialization, and marginalisation in trade) have led to intensive policy discussions at the level of the African Union (AU) and the African Regional Economic Communities (African RECs), but also at national level. Main issue is how to link agriculture, agro-industries and agribusiness towards a revitalization of these vital sectors.

In this essay *section two* is discussing the African development initiatives in this regard with focus on STI. In the *sections three to five* there is a discussion of the three action levels to come to new development patterns which are exploiting better the comparative advantages in Africa; the three action levels refer to policies on linkages, value chains and competitive advantages. In *section six* there are concluding remarks.

2 Towards New Development Initiatives for Africa and the Role of Science, Technology and Innovation (STI)

What is done in Africa to overcome stagnation in agriculture, de-industrialization with regard of the manufacturing base, and the marginalization in trade, especially so for manufactures? What is the role of STI in this reframing of Africa's economic policies?

Unleashing the African agricultural potential is seen in the context of either a “productivity revolution/PR” (like the African Green Revolution and the Millennium Initiative) or a “productivity evolution/PE” (like a Green Renaissance Strategy with organic and sustainable farming and herding initiatives) or a “rainbow revolution/RR” which combines the two other forms of productivity increase according to the prevailing land-use potential of agriculture (of relevance is if it is a high potential area or rather a marginal land which is used). These three positions have strengths and weaknesses (the authors working with one of these three positions are Sachs 2008 for PR, Bass 2012 for PE and FAC 2012 for RR). The developmental and operational issues of these variants are quite different.

There is no clear position at African Union (AU) level on these three positions; however the PR was given preference for many years, although some changes of views have occurred recently. The STI input of these three positions is quite different. PR has at its base a massive science & technology input, while PE and RR are based much more on holistic STI systems, reflecting also on socio-cultural factors. Africa has since years an umbrella agriculture development programme, and “core commodities” and agro-financing issues play a major role in it. The Comprehensive African Agriculture Development Programme (CAADP) has various pillars, but there is also a strong STI component. Although CAADP is still based on the PR model, the alternatives are more and more acknowledged and reflected in Africa. New agricultural policy approaches along the lines of PE and RR are now propagated that emphasize more holistic science, technology and innovation systems (FAC/ Future Agricultures Consortium 2012).

For the agro-based manufacturing sector/agro-industry development side of Africa, new attempts are underway to revive in Africa the concept of industrialization based on agricultural development by exploiting the backward and forward linkages as well as the final demand linkages to the agriculture sector (see the overview on the recent global agro-industry development trends Da Silva et al., Eds., 2009, and Wilkinson/Rocha 2009 specifically on the development impacts). Although the ADLI (Agricultural Demand-Led Industrialization) strategy still has relevance (and is even guiding Ethiopia’s industry development strategy), new elements need inclusion into this strategy concept, such as converting comparative advantages into competitive advantages and adding STI components at all levels of industry policy formation. The Strategy for the Implementation of the Plan of Action for the Accelerated Industrial Development of Africa (AIDA) and the African Agribusiness and Agro-industries Development Initiative (3ADI), now re-named Accelerated Agribusiness and Agro-industries Development Initiative, contain also various pillars to strengthen new policy approaches in Africa towards agro-industry and agribusiness development; building human capacities and developing STI infrastructure are important elements of the strategy (see UNIDO 2011a/Yumkella et al., eds., 2011 on the seven pillars for Africa’s agro-industry and agribusiness development, and Wohlmuth 2011 on the STI development concept for Africa’s agriculture, agribusiness and agro-industries).

For overcoming the problem of marginalisation of Africa in overall trade and as well in agro-related trade new policy approaches are as well designed by African institutions in the form of trade capacity building, promoting regional value chains, initiating export diversification programmes and supporting intra-African trade initiatives (UNECA et al. 2010, and UNECA/African Union 2007, 2009); the idea is to learn from Asian and Latin American success stories, especially with regard of processed food exports (UNIDO 2011a/Yumkella et al., eds., 2011, pp. 31 - 37). While the

emerging countries in Asia and Latin America became important exporters of processed agricultural products and of many other agro-based products and services, Africa failed to develop into this direction despite of its comparative advantage in agriculture. STI components are important along the whole value chain from agriculture to processing and servicing the product to global markets. Converting comparative advantages into competitive advantages requires concerted action, including STI factors at all stages of market development (Wohlmuth 2011, pp. 170 – 178). Case studies for Africa show that STI inputs are lacking at all levels of the value chain (UNIDO 2011b, 2012). STI is the policy factor most neglected over the whole value chain from agriculture to agro-industries, agribusiness and agro-sector servicing.

New agriculture development policies, new industry development policies, and new trade development policies matter at national and regional policy levels in Africa. For all the three policy areas, developing a coherent frame for STI policies matters; as well important is the strengthening of the still rudimentary National Innovation Systems (NISs) in Africa. All these measures will support firms and farms in their technological learning processes. In order to promote agriculture, agro-industry and agribusiness in Africa more than “science-push” and “technology-push” strategies are needed; innovation systems approaches are needed where all the relevant actors which are impacting on businesses and farms can contribute to their innovative capacity (UNIDO 2011a, Wohlmuth 2011). Country experiences show that STI is the factor most neglected in agribusiness development despite of so many opportunities in these countries to use more fully existing STI and human capacities, and especially also indigenous research & development and innovation and technology capacities (UNIDO 2011b, UNIDO 2012). Case studies for eight African countries reveal that STI inputs were neglected in all countries – not only in the low income countries Mali, Senegal, Ethiopia and Zambia, but also in the African countries with a higher income per capita such as Kenya, Cameroon, Nigeria and South Africa. The R&D, technological and human skills capacities of these countries were not used fully for agribusiness and agro-industry development (UNIDO 2011b, UNIDO 2012). Available resources and capacities were under-utilized, and actors/institutions were not linked among each other.

It is therefore necessary to look at the action levels where STI inputs can be used more fully for agribusiness development. *First*, the linkages between agriculture, agro-industries and other agribusiness activities matter and can be promoted by various measures. *Second*, it is necessary to promote value chain development for specific products from agricultural production to agro-processing and agro-related services to reach the final consumer. *Third*, concerted promotion efforts are needed to translate the comparative advantages of African countries into competitive advantages. While these three elements of promotional policies were part of the industrialization process

and related policies in Europa, USA, Canada, Australia, Japan and now in the emerging countries in Asia and Latin America, Africa is largely unaffected and not involved in this process of global agribusiness development.

Therefore a new interest in industry policy is seen in order to overcome the stagnation/de-industrialization/marginalization syndrome (UNU-WIDER 2013). Although some African countries are exporters of processed goods, for most of them the share in trade is small or negligible, and the same is true for agro-processed products; although Morocco, Tunisia, Mauritius and South Africa have a considerable share of processed goods in their exports, there is no country in Africa leading development on the basis of an export push based on agro-processed goods. This is remarkable because of the assumed comparative advantage of Africa in agricultural resources. However, especially for Africa such an agribusiness development path and an agro-industrial development strategy make sense as multidimensional development objectives can be reached (growth, global integration, employment creation, poverty reduction, food security, and overcoming rural-urban disparities).

3 Action Level One: Creating Linkages between Agriculture, Agro-industry and the STI Infrastructure

Linkages have to be strengthened between agriculture and various related sectors: industries supplying inputs to agriculture, like machinery, equipment, irrigation systems, fertilizer, and seed products. Linkages matter also between agriculture and processing industries, like food and beverages, tobacco products, paper and wood products, textiles and apparel, shoes and leather products, rubber products, and agro-based building materials. Linkages are also needed between these processing industries and the production of machinery and equipment for these industries. Last but not least, various services industries are needed for agriculture, for input industries for agriculture, for processing industries, and for input industries for processing industries; such services industries matter for development, like trade, transport, marketing, insurance, packaging, design, ICT services, business services, and technological services. All this is agribusiness activity in a broader sense and is related to the agriculture production system. This is a complex productive system and is bound together by material flows and flows of knowledge, information and innovation. Regrettably, this productive system is not fully understood by policymakers and officers. Therefore the support policies are too often incoherent and ineffective.

So far, the real importance of the supporting industries for agricultural development is low in Africa. The share of agribusiness value added to agriculture value added is as low as 0.5, meaning that a 1\$ value of agricultural production is supported by an agribusiness value added of only 50 US cent, while in the USA the relation is 1\$ of agri-

cultural production to 13\$ for the associated agribusiness value added (UNIDO 2011b, Chapter 1; UNIDO 2012, Chapter1; UNIDO 2011a/Yumkella et al., eds., 2011, p. 27). Linkages can be promoted by protective trade policies, by subsidies, by specific private enterprise development policies, by infrastructural development measures, by market development policies, by R&D and technology policies, and by private-public sector cooperation. Seven development pillars were investigated by UNIDO to support the linkages in and the productivity of agribusiness (UNIDO 2011a/Yumkella et al., eds., 2011; UNIDO 2011b, 2012). It is possible to develop a new policy framework on the basis of these development pillars for creating such linkages, but the country case studies show how weak these linkages are at the moment in most of SSA, and South Africa is not an exception (UNIDO 2011b, UNIDO 2012). STI is one of these seven development pillars, and it is of great relevance for linking policies for these subsectors of agribusiness with efforts at technological capacity building and human skills creation (Wohlmuth 2011).

STI inputs are needed in all agribusiness and agro-industry subsectors as the example of Rwanda clearly shows (Watkins/Verma, eds., 2008). Rwanda has proven that it is possible even for a low developed African country to build the human capacities and to develop the STI infrastructure needed for agribusiness development. Systematically agriculture, agro-industry and agribusiness are linked to local capacities for R&D, to extension, education and training programmes, and to business, industry and technology development institutions. A holistic capacity building and industry development strategy was developed for this purpose. Starting from a situational analysis of Rwanda's food industry and Rwanda's value added export sector the key constraints in terms of human capacities and STI infrastructure were identified. If politics continues to support the programme, it can become a model for Africa. Although there is a large development aid component in it (see Watkins/Verma, eds., 2008), local commitment was there for years. It is an open question what the aid suspension to Rwanda since 2012 may mean in this context (because of the UN Report on Rwanda's involvement in the rebellions in Eastern provinces of the DR of Congo).

Based on the existing linkages between agriculture and agro-industry, the potential role of STI requirements and of related human skills were investigated by assessment teams. Restructuring of the food industry producing for the domestic market and promoting the production of high value added cash crops for exports are actions both based on a comprehensive STI strategy. The STI support of these sectors is also to be complemented by the strengthening of the local National Innovation System of Rwanda (as rudimentary as it is at the moment). The food industry needs to identify the existing opportunities for the upgrading of informal processors of traditional products like banana wine, sorghum beer, meat, fruit juices, cereal and cassava flour, and bread. Also the opportunities for import substitution are identified, like in fruit

pulps and juices, dairy products, and meat products; not only the domestic market but also the regional market of the East African Community (EAC) are in focus. Also the opportunities for high value added exports are identified, not only of high-quality speciality coffees but even of new products like fruit juices, dried fruit, and honey. All this is done on the basis of an integrated STI promotion and human skills development strategy (Watkins/Verma, eds., 2008).

There are five major components of Rwanda's STI-based structural transformation exercise: food industry; high value added exports; development and diffusion of appropriate technologies; delivery of clean drinking water and development of geothermal energy; and client-focused agricultural research and outreach. Thereby Rwanda is developing systematically its rudimentary National Innovation System (NIS) in the context of agribusiness development by linking farms and firms of different size first, to R&D infrastructure, to extension, training and education institutions; second, to innovation finance institutions like banks, co-financers and development aid agencies; third to intellectual property agencies and technology and business support systems; and fourth, to public regulatory agencies, such as for registration of companies, licensing of natural resource developers, environmental protection, and for ICT regulation, competition regulation, property protection and land use administration (see Wohlmuth 2011 on the concept and role of the NIS for Africa).

All these actors link up to the NIS of a country, economy-wide and sector-wide, such as for agriculture, agribusiness and agro-industry. More than this, industry and business associations and knowledge and extension institutions are brought into partnership with public regulatory and administrative agencies. Thereby, a dialogue between public and private sectors is emerging; there is evidence of growth-enhancing effects of such a form of cooperation. It can be seen from case studies that all actors in NISs can start with interaction, like the intellectual property agency in Ethiopia when forming an innovation system for the quality upgrading of coffee producers.

4 Action Level Two: Integrating STI Capacities into Agro-industrial Value Chains

At the level of agribusiness value chains, STI components play an increasing role in Africa but much more has to be done by government and by private business to stimulate the innovation capacity along the value chain. Case studies give evidence of a rather high endogenous innovation potential of agribusiness value chains (see Larsen/Kim/Theus, eds., 2009); this can be seen across countries for textile, wood, wine, paper, fruits, tea and coffee, food items, and other value chains. All these chains have an endogenous innovation potential, although the level, scope and source may differ. When comparing country experiences of agribusiness value chains also coun-

try-specific innovation capacity factors come out (Larsen/Kim/Theus, eds., 2009): for Ghana (cassava, cocoa, and poultry), for Kenya (maize, tomato, dairy), for Tanzania (sunflower, cassava, dairy), and for Uganda (fish, bananas, vegetables). All over the countries and the sectoral value chains one can see that value chain participants have an uneven innovation capacity.

To spread the innovation potential Rwanda-type governmental policies towards STI can be recommended. While there is an endogenous innovation potential, science and technology support of the agribusiness value chains is limited. However, there are significant differences between the value chains. Staple food value chains (cassava and maize), high-value added export crop chains (coffee), high-value horticulture chains (green peppers and tomatoes), and fish and livestock value chains have a quite different capacity to innovate. The capacity to innovate depends on various factors (see the cases in Larsen/Kim/Theus, eds., 2009), such as the type and extent of government regulation and its effectiveness; the size and sophistication of the markets and the competition prevailing on these markets; the character of the value chain as supplying local, regional and/or export markets; the strength and origin of leadership of the value chain; and the overall profitability of the value chain (as a base for steady investment). Another study (Ponte 2011) compares the value chain upgrading strategies for fresh fish, organic coffee and cocoa, fresh fruit and vegetables, dairy, cassava, furniture, biofuels, wine, and cotton to garments. A quite diverse picture emerges as there are quite different upgrading strategies (Ponte 2011, p. 88) at work. It is important if product or process upgrading takes place, if functional upgrading occurs, etc. Upgrading strategies, human development strategies and the innovation potential of value chains are interrelated (Ponte 2011); the innovation capacity can be enhanced by value chain participant councils (VCPCs).

Most important for enhancing the innovation potential are changes in the character of the value chain, especially if it is becoming buyer-driven (by large buyers such as global processors and global supermarkets) and governed by a clear group of lead firms (what is the case for citrus, clothing, fresh vegetables, coffee and cocoa), while there is not such a clear group of lead firms in cotton (Gibbon/Ponte 2005). Recent demand changes – from consumers in the Northern countries to consumers in emerging countries of the South - in the global economy and in the African region (because of urbanization and cross-border trade) may lead to value chain restructuring from “upgrading” towards “re-grading” or even “downgrading” (Ponte 2011, pp. 132-133). Some value chains may continue to experience upgrading, some others however may show a re-grading or a downgrading trend, depending on the demand side developments. STI capacity of African countries may be more suitable for value chains supplying these new markets. Therefore, value chain promotion measures have also to take into account the context of the country factor endowments, the specific location

factors for value chains and the global, regional and local demand factors and changes. Again, Rwanda-type strategies may fit even more developed countries in Africa.

Further value chain analyses refer to characteristics of clusters and to innovation systems in clusters (Oyelaran-Oyeyinka/McCormick, eds, 2007). Compared are agribusiness-related clusters in Kenya (textiles and clothing, furniture making and other wood products), Tanzania (handicrafts and furniture-making), Egypt (furniture cluster), Uganda (fish processing), and the Lake Victoria fish cluster (with shares for Kenya, Uganda, and Tanzania). Specific innovation problems in clusters add to innovation problems in specific value chains. Innovation capacity is affected by the type of cluster and the specific value chain. Therefore, innovation potential may be quite different, and the cases compared show that this is so. Also these case studies show that leadership of the chain and sophistication of demand play an important role. Fish value chains for export business have a quite different performance than those with local demand. Also the learning effects in clusters are different; successes in export business can spill over to other producers. Clusters with firms which are supplying local demand may show innovation in specific niches.

Another study presents evidence on the knowledge and technology base of clusters with reference to specific value chains (see: Zeng 2008). Compared are the Lake Naivasha cut flower cluster in Kenya, the handicraft and furniture cluster in Tanzania, the Lake Victoria fishing cluster in Uganda, the textile and clothing cluster in Mauritius, the wine cluster in South Africa, and the Western Cape textile and clothing cluster in South Africa. Key messages are similar to the prescriptions of the Rwanda STI dissemination case: recommended are measures such as encouraging further knowledge acquisition, adaptation, and dissemination; strengthening educational institutions and technology institutes and linking them better with businesses in clusters; enforcing clear regulations, standards and quality assurance mechanisms; and upgrading skills training (Zeng 2008). There are some references to specific value chains in these clusters.

Further analyses of agribusiness value chains can be found in a survey of agro-industry and agribusiness developments of eight African countries (UNIDO 2011b; UNIDO 2012). In the context of the country case studies it is shown that there is a widespread neglect of developing STI infrastructure and building human skills capacities. However, awareness is increasing that agribusiness has an important role for development; also in country visions and plans there is increasing interest in the agribusiness sectors. However, implementation is a problem, as well as finance, infrastructure, and policy coherence. South Africa and Nigeria could do much more, on the basis of their knowledge potential and the financial resources. The available STI infrastructure is not properly used for the development of the agribusiness sectors. Policy factors in these countries are mainly responsible for the unsatisfactory develop-

ment of agribusiness and the lack of structural transformation and innovation in these sectors.

Country studies on agro-industry and agribusiness for The Gambia, Ghana, Kenya, Mozambique, and The United Republic of Tanzania (see FAO 2008) reveal that the value chains are poorly managed because of non-supportive enabling environments; an environment which is friendly for entrepreneurs and for innovators will contribute to the acquisition and spread of new technologies. Diverse other critical bottlenecks, especially in infrastructure provision and the lack of coherence of government policies, also matter (FAO 2008).

Studies on Competitive Commercial Agriculture for Africa (CCAA) give insights into the functioning of West African value chains as the competitive position of six agricultural crops (cassava, cotton, maize, rice, soybeans, and sugar) is compared (see World Bank 2009). High infrastructure and transaction costs impede the competitiveness and the further integration of the value chains towards processing and marketing. This is in line with other studies on the reasons for the difficulties to transform comparative advantages in African agribusiness into competitive advantages (Collier 2000; Wohlmuth 2011). Good news for agribusiness development in West Africa is the fact that smallholders have a critical role to play and are not necessarily disadvantaged relative to emerging and existing large-scale commercial farms because there are quite few obvious and measurable scale economies (World Bank 2009, pp. 86-88). Production systems which are based on smallholders and which are oriented towards decentralised, sustainable and organic agricultural systems can work and can be competitive. Such production systems can also link up to micro and small industries in the rural areas and can be innovative. This supports the call for a “green renaissance” rather than pushing only for a “green revolution” in Africa (see also: Bass 2012). However, successes will come forth if politics and policies support this alternative. New business systems may be beneficial for the integration of the smallholders into value chains with a larger market outlook, but local demand should be the main orientation.

What are the main messages for strengthening STI in value chains? Eight major lessons emerge from reviewing numerous agribusiness value chain case studies (Wohlmuth 2011); comparative analysis is revealing eight determinants of value chain innovation capacity. *Demanding markets* are of importance, especially export successes, but also supplying local markets (small supermarkets) and regional markets (cross-border trade) increases the reach and the stability of value chains. This helps to improve competitiveness. *Standards (for quality and measurement) and regulations (for labour, health, environment and safety)* help not only to improve quality standards and safety regulations. Producers are involved into innovation platforms by externally set or self-regulated and self-imposed standards. *A dialogue between public and private sectors and Public-Private partnerships* matter for innovation, integration

of value chains and technological upgrading as investment decisions are promoted thereby. *Innovative financing mechanisms* are needed so as to facilitate technological upgrading, and the inherent stability, integration and profitability of the value chain may also help to channel funds from external actors to the value chain. *Associations of producers, traders and processors* are of importance to lobby for public goods and services provision; this is relevant for clustered firms and for non-clustered firms. *Access to knowledge institutions* is important at all levels and ranks of the value chain, and technology flows can be improved for firms in clusters and outside. *Chain-wide profitability* is crucial for technological upgrading, value addition and the integration of value chains from raw materials supply to processing and marketing. Governments can contribute to profitability by coherent policies, by selective protective policies, by targeted subsidies, and by a taxation system that is facilitating the integration of the value chain. *Coordinating institutions* for the management of the value chains are important for strengthening the overall innovation capacity; policy factors, joint ventures and partnerships can help in this direction. These eight criteria add up to selection criteria for the strategic support of agribusiness value chains (Wohlmuth 2011, pp. 183-186).

For Nigeria there exists an analysis for ten agribusiness value chains (cassava, cotton, fisheries, maize, fruits, palm oil, poultry, rice, soybeans, and tomatoes); poor government policies, lack of leadership in value chains, gaps in infrastructure, and severe limits of innovative finance mechanisms impede technological upgrading in all these value chains (UNIDO 2010). The two Nigerian value chains for fruits and palm oil are examples to demonstrate what it means that most or all of these eight criteria mentioned above are not met (see UNIDO 2010, pp. 43ff for fruits, and UNIDO 2010, pp. 48ff for palm oil). Despite of a huge potential for fruits, there are extremely high post-harvest losses so that most of the fruit concentrate has to be imported for the processing of fruit juice. An import ban of 2002 for fruit juice just led to the processing of imported fruit concentrate. All the eight determinants of innovation capacity for agribusiness value chains are obviously not met. Similar results are found with the case of the palm oil value chain. Until the 1960s Nigeria was the largest producer of palm oil in the world. Output declined to 1.7% of total world production, what is not sufficient even for local consumption (UNIDO 2010, p. 48). Because of the poor quality of the raw produce local multinational companies in the food industry import palm oil rather than relying on local production (UNIDO 2010 p. 51). None of the eight criteria is met in the sector. Taking only these two value chains as examples, it can be seen that the innovation potential is not exploited at all in Nigeria. The value chain from raw produce to processing and marketing is not working at all. The Kenyan textile industry case commented above in the context of the AGOA “third country provision” shows that the same weaknesses are visible in the case of the value chain “cot-

ton to garment”. Many agribusiness value chains all over Africa suffer from raw materials supply problems (in terms of quality and quantity, reliability of supplies, and price competitiveness). This is not an inherent failure of value chains, but the result of misconceived support policies for agriculture, agro-industry and agribusiness.

For industry policy considerations, much more than relying on a central government industrial policy framework is needed. Value Chain Participant Councils (VCPCs) are proposed (see Staatz 2011, pp. 83-86); these forms of organisation could be the base for a new industrial policy that is value-chain specific, end-market oriented and time bound (Ponte 2011, pp. 133-134). VCPCs can include participants from all levels of the value chain and may encourage the participation of all associations and groups of producers which supply equipment, services and product components towards processing the end product. The VCPCs are delivering valuable inputs to a central industrial policy; relevant information from below (bottom-up) and from the centre (top-down) is provided and is merged and integrated to form the basis of a coherent industrial policy.

5 Action Level Three: Converting Comparative Advantages into Competitive Advantages by using specific STI Inputs

Export successes in agribusiness do not follow simply from liberalization of markets and privatization of agribusiness companies. Much more is needed as the case studies for Latin America (Chile) and Asia (Malaysia) reveal (see: Kjällerström, Monica/Kledia Dallto, 2007; Wohlmuth 2011). The examples of fruits, wine, and salmon exports from Chile and of palm oil and related products from Malaysia give evidence of the working conditions and the success criteria for converting comparative advantages of countries and regions into competitive positions of firms and farms. Numerous other examples from Asia and Latin America could also be cited, but it is difficult to find such cases in Africa, especially in SSA. Recent evidence on the palm oil sectors in Malaysia and Ghana (Fold/Whitfield 2012) give further insights how the conversion of comparative advantages into competitive positions works in Malaysia, but does not work in Ghana. The material is used and confronted with the earlier research work on the case of Malaysia (see: Kjällerström, Monica/Kledia Dallto, 2007). There are six critical factors for this conversion of comparative advantages into competitive advantages to consider (Wohlmuth 2011, pp. 170 - 178):

First, it is necessary to create the infrastructural and legal preconditions for sustainable export successes. This requests governments and businesses not only to work on providing physical infrastructure, but also STI infrastructure and institutions to support directly large-scale export activity. This was an important success factor in Malaysia. In case of Ghana, deficient infrastructure and uncommitted state policy, but

also inappropriate legal institutions to deal with land issues are still the major problems. Neither plantation nor smallholder activity was really facilitated. The situation is not different in Nigeria, although additional problems are existent there.

Second, it is important to design and implement comprehensive long-term strategies for the new sector/products. This was exercised in Malaysia but not in Ghana. Neither long-term STI strategies were developed nor dialogue forums created to link public and private actors towards development of the sector in Ghana. Initiating long-term strategies to develop new and derived products based on palm oil like it was early done in Malaysia did not come forth in Ghana. This is a loss as a great variety of products for health and cosmetics industry and for other industrial sectors with food and non-food uses (UNIDO 2010, p. 50) could be developed successfully. However, even the “economic giant” Nigeria (in terms of industrial scale economies) has not made any progress in this regard (UNIDO 2010, pp. 48 -52).

Third, it is relevant to organize targeted public transfers to specific groups of private sector producers (not granting outright subsidies!). Specific support programmes need to be targeted for large and medium-sized producers, processors and associations as well as for small and informal producers, processors and cooperatives. In Malaysia all this has worked, but in Ghana the mixed systems of production with plantations and out-grower schemes did not really work, leading to side-selling of raw materials by out-growers with negative effects on the planning and capacity utilization of processing units. Also being important but destructive to industry growth, in Ghana the activity of vertically integrated customers, like Unilever, prevented the market entry of independent processors. No corrective government action took effect to support independent processors. The situation in Nigeria is even worse with regard of raw materials supply to processors.

Fourth, it is requested to coordinate and to upgrade global market activity by coherent public and private action. New export markets for improved traditional and/or new export products have to be identified continually and systematically. Export Marketing Councils (EMCs) have to research for the identification of these markets vigorously and systematically; such agencies are to be established jointly by private and public offices. Support from R&D, especially from agricultural and industrial research institutions, is important. All this takes place in Malaysia, but not in Ghana and not in Nigeria (despite of the huge inherited, but deteriorated agricultural and industrial research potential of the country!). Nigeria with its tradition as the former number one world producer of palm oil has not such an institution (and the National Palm Produce Association of Nigeria/NPPAN never tried to move in this direction).

Fifth, it is a must to provide for sustained large-scale actions over a long time horizon and to ensure the committed concentration of effort for a definite period to become a

successful exporter. Success depends on scale of support and on concentration of effort, so that the critical minimum of funding and provision of support services is reached. Supporting large, medium-sized and small as well as informal producers over a long period and on a large scale is necessary. Again, this was achieved in Malaysia but not at all in Ghana (and Nigeria). Smallholders in Ghana were not included at all in the 'modern' industrial palm oil sector. There was no interest in Ghana to upgrade and to include smallholders (and the same is the case in Nigeria).

Sixth, it is a key to success to create appropriate innovation platforms by linking producers and public as well as private research institutions effectively. Adapting health, safety and environmental standards and intellectual property regulations to world class level did work for the palm oil sector in Malaysia but not in Ghana (and not at all in Nigeria). Producers were forced in Malaysia to conform to such (world class) standards and regulations and/or even got incentives to develop themselves local and regional standards and regulations so that - by way of creative self-regulation among producers - an innovation platform was created. A forum for dissemination, exchange and transfer of sector-relevant knowledge is proposed for Ghana (Fold/Whitfield 2012, pp. 38 - 39), while such institutions exist already since long time in Malaysia. Again, the actors in the palm oil sector in Nigeria never went in this direction.

Case studies for Africa – African fish industry, especially in Tanzania, African horticulture business, especially in Kenya, Africa's pineapple industry, especially in Ghana and Ivory Coast, coffee industry in Ethiopia, chocolate production of Ghana, leather industry in Ethiopia, traditional design-textile industry in Mali, and many other examples - show that none or only few of these six criteria are met in Africa (Wohlmuth 2011, pp. 170 – 178; UNIDO 2011a, 2011b, 2012, and the sector case studies for Nigeria in UNIDO 2010). Even South Africa - although being much closer in meeting at least some of the six criteria and being endowed with some successful international agribusiness firms – does not meet satisfactorily these criteria as STI policies of the country are not adequate, being not synchronized properly with trade, taxation, education, small industry promotion, and competition policies (see on the inadequacies of South Africa's STI policies and South Africa's National Innovation System: Wohlmuth 2011). There are also weak points along the value chains in South Africa with regard of establishing new products on the market. For Roiboos and Honeybush teas South Africa is an exclusive world producer, but only a small share of the produce is yet packaged in South Africa (UNIDO 2011a, Case Study South Africa, p. 391, UNIDO 2012, Case Study South Africa, p. 260).

Supporting successful export sector actors is a huge task for development policy, especially so for agribusiness sectors. Important export sector actors in Africa - with regard of successful export activity along promising product lines - are associations of firms, groups of firms, firms in clusters, but also cooperatives of smallholders and

small industry producers and other associations of firms and farms who are linked to processing activities. Most important are dialogue forums between public and private sector actors with interest in promoting new export products, but also informal exchanges between producers/processors/exporters and the research/training/extension community play a role.

6 Concluding Remarks

Two questions are addressed in this paper: What can be done in Africa to overcome the stagnation in agriculture, the de-industrialization with regard of the manufacturing base, and the marginalization in trade, especially so for manufactures? What is the role of Science, Technology and Innovation (STI) in this process of reframing Africa's policies? These two questions are related especially to the role of agro-industry and agribusiness sectors as it is widely assumed that Africa has a comparative advantage in agriculture and related activities.

It is emphasized that Africa has seen recently quite important initiatives at African Union (AU) level to link agriculture, agro-industries and agribusiness development with STI promotion. As the progress is slow in this regard, the paper looks at the action levels for substantial policy changes. The main issue is how sustainable new strategies can be designed and implemented.

Three action levels were investigated with regard of promoting agriculture, agro-industry and agribusiness in Africa. STI policies have an important role at all three levels. At *level 1 - Creating Linkages between Agriculture, Agro-industry and the STI Infrastructure* – the African country cases reviewed show that there is a huge gap with regard of linkages of subsectors and especially so with the STI infrastructure and the human capacities. Feasible strategies and action programmes are outlined to reduce this gap. Only few countries in Africa make progress in this regard, especially so Rwanda (although the recent aid suspension to the country may impact negatively on the STI development strategy). At *level 2 - Integrating STI Capacities into Agro-industrial Value Chains* – much more needs to be done to improve the value chains so that they can become effective instruments for the restructuring of African economies. Analyses show that the main weaknesses can be overcome by new strategies and by the involvement of new actors. At *level 3 - Converting Comparative Advantages into Competitive Advantages by using specific STI Inputs* - it is necessary to ensure that the main criteria for export successes are met. At the moment African exporters meet only some criteria for success (so that the successes are not sustainable), in contrast to quite many producers in Asia and Latin America. Linkages, value chains and competitive advantages matter in a new strategy for Africa's revitalization.

A Strategy for Africa requests that pro-active policies are pursued at all the three levels, by working together with new actors and by cooperating better with the existent STI infrastructure. Such a strategy refers to the subsector level, the value chain level and the competitive product/producer level. On the whole, it is obvious that Africa's potential for agribusiness expansion is at the moment not exploited, and STI has an important role to play in reversing this negative trend. From Asian and Latin American public and private actors Africa can learn a lot how it has to be done to manage a change in this regard. The good news is that the ingredients of success (building linkages, integrating value chains, and creating competitive advantages) are known and just have to be applied.

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