Perspectives for Germany's scientific-technological cooperation with Subsaharan Africa

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Foreword

The present paper on perspectives for Germany's scientific-technological cooperation with Subsaharan Africa was conducted in the framework of a study which the Federal Ministry of Education and Research (BMBF) commissioned the German Development Institute (DIE) to prepare at the end of 2005.

The point of departure for the study was the interest of the Federal Ministry of Education and Research (BMBF) in identifying possible cooperation partners for German Scientific-technological cooperation (STC) in Subsaharan Africa. In view of the growing internationalization of science and research and the increasing challenges posed by the process of global change, cooperation in science and research with developing countries is assuming more and more importance for Germany as well. Apart from development of new markets and research locations with a view to bolstering Germany's own competitiveness, the focus of this interest is on using cooperation in science and research as a vehicle to help solve global problems. Africa was accorded high political priority at the G8 summit in Gleneagles in July 2005. And cooperation with Africa is likewise on the agenda of the G8 summit scheduled to be held in Heiligendamm, Germany, in the spring of 2007. In Gleneagles the ministers of the G8 countries had already reached agreement on intensifying cooperation with Subsaharan Africa in the fields of science, research, and technology.

In view of the fact that the BMBF generally prefers to cooperate with international partners on the basis of bilateral STC agreements, the object of the present study is to identify those countries in Subsaharan Africa that offer the greatest interest potential for Germany as cooperation partners in science and research. Accordingly, scientific performance and economic sustainability were given priority over development-related goals. There is already an STC agreement in place between the BMBF and South Africa, and for that reason the analysis does not focus explicitly on South Africa. The paper's concluding section sets out five key points for a new BMBF cooperation strategy with Subsaharan Africa.

The study is both qualitative and quantitative in nature. Aside from analyzing available data and literature, the author conducted interviews with German actors involved in STC and development cooperation (DC). The study's aims and analytical framework entailed a number of methodological challenges. For one thing, it is simply not possible to systematically quantify all of the parameters relevant when it comes to the interests of all German actors involved in STC. For another, it is, from the macroperspective chosen for the present study, not possible to come up with adequate assessments of either the quality of the education and research infrastructure found in individual countries or the political developments underway there. Nor is it possible to depict the willingness of possible partner countries to engage in STC.

The objective of the study was for these reasons limited to sketching a rough outline of the education and research landscape found in Subsaharan Africa. The study's results should be understood as an impulse for an intensive discussion among relevant experts in Germany and in Africa; and they are in need of further, intensive verification in situ. The author wishes to take the present opportunity to extend, once again, her heartfelt thanks to all of her interview partners. Special thanks are also due to Julia Ellinger, who edited the study, bringing it into its present form.

Inga Müller September 2006

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Abbreviations

AA	(German) Federal Foreign Office
AAU	Association of African Universities
ACP	Africa, Caribbean, Pacific
ANSTI	African Network of Scientific and Technical Institutions
APRM	African Peer Review Mechanism
AU	African Union
AvH	Alexander von Humboldt Foundation
AVU	African Virtual University
BCI	Business Competitiveness Index
BECA	Biosciences East and Central Africa
BIBB	(German) Federal Institute for Vocational Education and Training
BIO-EARN	East African Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development
BMBF	(German) Federal Ministry of Education and Research
BMZ	(German) Federal Ministry for Economic Cooperation and Development
BNI	Bernhard Nocht Institute for Tropical Medicine
CGIAR	Consultative Group on International Agricultural Research
CIDA	Canadian International Development Agency
CODESIRA	Council for the Development of Social Science Research in Africa
DAAD	German Academic Exchange Service
DC	Development cooperation
DFG	Deutsche Forschungsgemeinschaft / German Research Foundation
DFID	Department for International Development
ECOWAS	Economic Commission for West African States
EDF	European Development Fund
EIER	Ecole Inter-Etats d'Ingénieurs de l'Equipement Rural
EU	European Union
FhG	Fraunhofer-Gesellschaft
GCI	Growth Competitiveness Index
GDP	Gross domestic product
GLOWA	Global Change in the Hydrological Cycle
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
GUC	German University of Cairo
HGF	Helmholtz Association
IAU	International Association of Universities
ICT	Information and communication technology
ILRI	International Livestock Research Institute
IMF	International Monetary Fund
IUCEA	Inter-University Council for East Africa
InWEnt	Internationale Weiterbildung und Entwicklung / Capacity Building International, Germany gGmbH
IWMI	International Water Management Institute
KCCR	Kumasi Centre for Collaborative Research in Tropical Medicine
K(E)I	Knowledge (Economy) Index
KIST	Kigali Institute of Science, Technology and Management
MDGs	Millennium Development Goals

MPG	Max Planck Society
NASAC	Network of African Science Academies
NEPAD	New Partnership for Africa's Development
PRSP	Poverty Reduction Strategy Paper
R&D	Research and Development
SADC	Southern African Development Community
SCI	Science Citation Index
SIDA / SAREC	Swedish International Development Agency Research Department
STC	Scientific-technological cooperation
TWAS	Third World Academy of Sciences
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICI	United Nations Innovation Capability Index
USHEPIA	University Science, Humanities and Engineering Partnerships in Africa
WEF	World Economic Forum
WGL	Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz / Leibniz Association

Introduction: The study's political context and structure

After years of neglect, the decision reached in June 2005 by the World Bank, the International Monetary Fund (IMF), and the African Development Bank to grant debt relief to 14 African countries as well as the Gleneagles G8 summit that followed it have served to return the continent to the focus of international politics. At the latter summit, the ministers of the seven leading industrialized countries plus Russia reached agreement on advancing partnership-based cooperation with Africa in a number of different economic and political fields (G8 2005a).

The paramount objective of cooperation with Africa is achievement of the Millennium Development Goals (MDGs). The aim of the G8 countries here is to provide support for the African countries on their own reform efforts and to forge on with the implementation of the Africa Action Plan.[1] Close cooperation with the African Union (AU) on the New Partnership for Africa's Development (NEPAD) initiative is essential for its implementation, and the German government has stated its express support for these efforts.

Worldwide, science and technology are playing an increasingly important role in efforts to reach the MDGs. As far as its cooperation with Africa on science and research is concerned, the German government has placed its focus on investment in human resources. One important component of this endeavor is cooperation between German and African universities and support for African countries in their efforts to modernize their university systems. Another point on which agreement was reached in Gleneagles was reflected in the decision to support the efforts of African countries to develop centers of excellence in research and technology, in particular in the fields of agricultural and vaccination research, and to develop networks between African and German research institutions. The priority goals here include efforts to improve the training of African experts (capacity-building) for the public and private sectors, to strengthen institutional structures, and to support the diffusion of information and communication technology (ICT).

The Federal Ministry for Economic Cooperation and Development (BMZ), via the German Academic Exchange Service (DAAD), the Alexander von Humboldt Foundation (AvH), and the German Research Foundation (DFG), is already providing support for scholarship and promotion programs for African students in their home countries as well as in third countries and in Germany, for university partnership programs and university management programs, for research grants and research cooperation programs, and for follow-up contact programs. In addition, the BMZ also provides support for the work of the Consultative Group on International Agricultural Research (CGIAR) in its efforts to promote agricultural research in Africa. It should, though, be noted here that neither research cooperation nor university cooperation is among the priorities defined for German DC.

1 The Africa Action Plan, adopted in 2002 in Kananaskis by the G8 and its African partners (AU / NEPAD), sets out concrete measures designed to reduce poverty and violent conflict. The G8 countries reached explicit agreement here to support the African initiative New Partnership for Africa's Development (NEPAD). For information on the contents of the Africa Action Plan and the steps that have been undertaken to implement it, see G8 (2002 and 2005b).

Against the background of the G8 summit, the Federal Ministry of Education and Research (BMBF) has now decided to examine possibilities of engaging in more intensive cooperation with Subsaharan Africa. At present Germany has – with the exception of South Africa – no relevant bilateral agreements in the region. One of the main interests of the BMBF – unlike the BMZ – is to engage in mutually beneficial cooperation with partner countries that are at once economically viable and good performers in the sciences.

The aim of the present study is to identify countries in the region that have the potential to become involved in the BMBF's general STC. Chapter 1 starts out by discussing the goals of the BMBF and the German research and research-promotion institutions in their international cooperation efforts and presenting some examples of ongoing cooperation between German and African partners. In keeping with the identified interests and goals of both the BMBF and the actors of German STC, Chapter 2 then goes on to analyze, on the basis of predefined criteria, the cooperation potential of the countries of Subsaharan Africa.[2] Beside the results of the country analysis, Chapter 3 presents a number of proposals for a new BMBF cooperation strategy with the region. In view of the fact that in its DC the German government is mainly engaged in efforts to implement the G8 goals, the chapter looks into possible synergies between cooperation in research cooperation and development cooperation (DC).

1 Goals of German STC actors and experience gained in cooperation with Subsaharan Africa in the area of education and research

1.1 The BMBF's goals in international cooperation

The BMBF's paramount goal in international cooperation is to raise the competitiveness of the German system of science and research, boosting German research expertise by developing and harnessing new knowledge. To this end it supports, worldwide, exchange, cooperation, education/training, and networking in science, research, and technology. The social relevance of the concrete research in question and the practical applicability of its results are of secondary importance as selection criteria in this connection. On the one hand, the BMBF carries out cooperation projects on a bilateral basis, in the framework of intergovernmental agreements on scientific-technological cooperation. On the other hand, it makes use of its engagement in multilateral organizations and its participation in the EU Research Framework Programme to seek to expand international cooperation in the field of education and research.

One of the motives behind the BMBF's cooperation with developing countries and emerging markets is the ministry's external mandate to contribute to solving global problems by engaging in cooperation in education and research. At the same time, one of the ministry's interests is to develop new markets and research locations. In this connection the BMBF seeks to concentrate its activities on important partner regions and to become engaged primarily in fields of research that are of particular interest for Germany. In the framework

2 Because of the ongoing, intensive partnership between Germany and South Africa, the latter is not discussed in any detail in what follows. In other words, the term "Subsaharan Africa" refers here – if not otherwise stated – to the overall region, exclusive of South Africa.

of bilateral partnerships it in some cases also provides support for the development of education and research systems (BMBF 2002a, 12; see Box 1). The fields generally eligible for more intensive cooperation with individual countries in Subsaharan Africa include research, university cooperation and vocational training, and support for political dialogue (e.g. on cooperation with science and research ministries).

However, the initial conditions encountered in Subsaharan Africa have proven difficult for the BMBF. While some of the countries in the region have good scientists and institutions that could be of interest for Germany, by international comparison the research and education infrastructure in all countries in the region is relatively underdeveloped. In addition, only in recent years have many of these countries begun to promote science and research, and cooperation projects with them therefore call initially for supportive investment in capacity-building and infrastructure development geared to strengthening national knowledge systems. Prior to any efforts to intensify cooperation with countries of the region, it would be essential for the BMBF to decide whether and to what extent it is prepared to engage in the measures required. As a location for science and research, Germany would have to realize that the benefits of such cooperation could take years to materialize.

Box 1: A selection of the projects supported by the BMBF in Subsaharan Africa

In the framework of joint international projects, the BMBF is currently providing support for three thematic research programs with partners in Subsaharan Africa. At present this cooperation consists of individual projects that are not embedded in the major research projects receiving official German support.

- Support is being provided for research work carried out in the framework of the **Global Change in the Hydrological Cycle (GLOWA) projects** in **Benin, Ghana,** and **Burkina Faso**. The aim of these projects is to transfer new water technologies and to adapt them to local conditions as well as to improve both global and local water resource management. There are also plans to set up centers of excellence for global-change research at several universities.
- Operating on the basis of close cooperation between researchers, decision-makers, and the citizens immediately affected, the "**Megacities of Tomorrow**" project, launched in May 2005, is conducting research on sustainable innovation concepts bearing on the development of megacities in developing and newly industrializing countries. On the German side, the Helmholtz Association and the DFG, among others, are contributing to the project. The Subsaharan African cities of Johannesburg (**South Africa**), Dar es Salaam (**Tanzania**), and Addis Ababa (**Ethiopia**) are involved in the project.
- In the framework of the **Biodiversity and Global change** (**BIOLOG) research program**, the BMBF is providing support for application-oriented, interdisciplinary biodiversity research; the goal is to develop strategies designed to conserve and make sustainable use of the biosphere. In this connection a number of projects are being carried out in Subsaharan Africa, viz. in **Kenya**, **Uganda**, **Burkina Faso**, **Benin**, **Côte d'Ivoire, Namibia,** and **South Africa**. The current, first project phase is focused on capacity-building in situ, setting up of research stations, and training for staff members.

1.2 Objectives and current country priorities of German research and research-promotion institutions in their cooperation with Subsaharan Africa

Aside from the BMBF's orientation, one of the key factors involved in deciding on a country's suitability as a partner for German STC must be seen in the priorities defined by the relevant German research institutions (Max Planck Society – MPG), Fraunhofergesellschaft (FhG), Helmholtz Association (HGF), Leibniz Association (WGL), the German universities, and the German institutions created to support students and scientists (DFG, DAAD, AvH)), which are in part funded by the BMBF. Generally speaking, both the

German research institutions and the DFG have a substantive focus on scientific-technical fields of research. As far as the funding they provide is concerned, the DAAD and the AvH are equally open to all fields of research and study. The following section will outline both the goals formulated by these institutions and their specific specialization profiles and – if relevant – their possible geographic focuses.[3]

German research institutions and universities

The **MPG** engages in non-university basic research in the fields of biology-medicine and chemistry-physics as well as in the humanities. It concentrates its efforts on especially innovative fields that have not yet found their way into the focus of university research and that are particularly costly in terms of time and money. The International Max Planck Research Schools are one German initiative conceived to promote young researchers in the context of international cooperation. The aim of these schools is to enable especially talented German and non-German scientists to prepare for their PhD studies in the framework provided by a structured course of training. Another of the initiative's explicit aims is to win over non-German students to do their doctoral work in Germany as well as to awaken their interest in later cooperation with German research institutions. The MGP thus also has an explicit interest in strengthening Germany's hand as a research location. To name one example from Subsaharan Africa, the Max Planck Institute for Nuclear Physics is currently engaged in a cooperation project with the University of Namibia.

The **HGF**, which consists of 15 major research institutions, is Germany largest science organization (BMBF 2005a). One of the HGF's aims is to link knowledge-oriented basic research with innovative application perspectives, and to this end it cooperates with both national and international partners from universities and industry. The HGF's strategic-programmatic state-of-the-art research is keyed to the following six research areas that include all of the association's research centers: transportation and space, energy, key technologies, Earth and environment, health, and the structure of matter. The HGF sees in international networking with centers of excellence an instrument important to arriving, quickly and efficiently, at innovative results. The association's individual research institutions cooperate both among one another and with national and international partners from universities and industry.

The **FhG** is Germany's leading sponsoring organization for institutions engaged in applied research. It conducts contract research for industry, service companies, and the public sector as well as offering a range of information and other research-related services. The FhG has also set its sights on creating networks beyond the boundaries of the European Union EU). In this connection international exchange serves above all to secure Germany's competitiveness as a location for research and science and to develop new markets. Cooperation projects are expected to entail a flowback of scientific knowledge from partner countries in the field of new technologies. At present the FhG's non-EU priority partner countries include Japan, the US, and Korea.

3 To this end the author conducted interviews with representatives of relevant institutions. DAAD, AvH, DFG, and Leibniz Association were kind enough to make internal statistics available to the author.

As a service provider, the FhG is more reliant than the other institutions under consideration on private-sector demand for research services, and the association can act only in cases where it is able to profitably market its services. Cooperation projects require a well-functioning private sector that demands research results and is able to translate them into practical applications. In 2002, in cooperation with developing countries, Bavaria's Ministry of Economic Affairs, Infrastructure, Transport and Technology and the Fraunhofer Gesellschaft together set up a body providing consulting and coordination services (BIKE). The aim of this initiative is to have Bavarian corporate consortia develop projects sponsored by the World Bank and other development banks. The only Subsaharan country involved in the initiative is Madagascar (FhG 2006).

The **WGL**'s 84 non-university research and service institutes are engaged in research primarily in the fields of economic and space sciences as well as natural, engineering, and environmental sciences. The WGL here links fundamental research with an applications orientation. One important instrument which the WGL uses to promote international science and research cooperation is the scholarship and grant program it conducts together with the DAAD; the program's aim is to support non-German doctoral and postdoctoral students by offering them an opportunity to work at the Leibniz Association's research institutes (WGL 2006). The WGL has, through its individual institutes, been engaged in some in part long-standing cooperation projects in Subsaharan Africa; these would include e.g. a project involving the Kumasi Centre for Collaborative Research in Tropical Medicine (KCCR) in Ghana and the Bernhard Nocht Institute in Hamburg (BNI 2006).

Another important pillar of education and research cooperation must be seen in the **German universities** themselves. There are partnerships between German and African universities in nearly all countries of Subsaharan Africa; these partnerships do not appear to involve any geographic focuses. University cooperation of this kind tends to be focused mainly on agricultural and forestry sciences, medicine, geography, resource management, and health sciences as well as on fields concerned with issues specific to Africa (e.g. ethnology, linguistics). These partnerships are geared primarily to the research interests of the German institutes involved in them. Apart from exchanges of German and African teaching staff and students, university partnerships are also always focused on capacity-building and efforts to strengthen university structures on the ground.

German research promotion institutions

The **DFG**'s core activity is promotion of research at German universities based on support for research training groups, special fields of research, priority programs, and direct promotion of groups of researchers and individual researchers. DFG funds are awarded on the basis of competitions designed to identify the best project proposals submitted to it. The DFG concentrates exclusively on basic research. The DFG awards most of its funds for basic bioscience research in Germany. While all of the projects promoted by the DFG are explicitly designed to support international cooperation, in the end only a relatively small share of the funds granted by the foundation are aimed directly at supporting international scientific contacts (DFG 2005, 4). International research and training groups, another DFG vehicle conceived to strengthen international research cooperation, have thus far been limited to industrialized countries and China, and they likewise account for only a small share of the DFG's budget. The DFG's objective in international cooperation is to promote a continuous exchange of scientists. The DFG's subordinate goal, in particular in its cooperation with de-

veloping countries, is to "raise the research capacity and the scientific efficiency of the participating scientists and researchers in the partner countries and, thus, to contribute to solving the development policy problems faced by these countries." (DFG 2001, 1).

In Africa the DFG above all supports – for the most part with the financial involvement of the BMZ – individual research projects of German scientists carried out together with African colleagues in the countries concerned. Thus far institutional agreements have been signed with Egypt, Morocco, and South Africa. Aside from individual projects with reference to nearly all African countries, the DFG, in cooperation with these three countries, provides support for longer-term research programs on issues bound up with ecological and cultural change. Beside South Africa, one other current priority country of the DFG's research promotion efforts in Subsaharan Africa is Ethiopia, where at present 24 projects are being funded by the DFG. The DFG's other priority countries in the region include Namibia, Cameroon, Kenya, and Tanzania. The priorities set here are agricultural and biodiversity research.

The most important German institution active in the field of international university cooperation is the **DAAD**. With the mediator role it plays in Germany's external cultural policy, university and science policy, and university-level development cooperation, the DAAD may be said to be working at an important interface between educational, research, and development cooperation. While Germany's international cooperation has led to the definition of priority countries, i.e. individual countries that have gradually developed close political-cultural ties to Germany, the DAAD is fundamentally interested in distributing its programs, as broadly as possible, across all countries, and in doing so in such a way as not to be unduly restricted by narrow political principles (DAAD 2004a, 20 ff.). In the practice of its research promotion efforts, the DAAD does not pursue any substantive priorities and is fundamentally open to all disciplines.

The DAAD uses funds provided by the German Federal Foreign Office (AA) to promote German language education abroad as well as to support the training of young non-German elites at German universities and research institutions. It also uses funds provided by the BMBF to offer – in particular to young German scientists – the opportunity to spend time abroad for purposes of study and research, to engage in bilateral science exchanges, and to promote study or training partnerships designed to develop international courses of study or joint PhD projects. The aim is both to establish German study opportunities abroad and to develop internationally competitive offers for non-German students and scientists in Germany. One noteworthy project currently being promoted financially by the BMBF is the start-up phase of the German University of Cairo (GUC) in Egypt.

Using funds provided by the BMZ, the DAAD supports the development of university structures in developing countries and countries in the process of reform (DAAD 2005b). The services it provides include on the one hand scholarships and grants for training and advanced training in Germany for university teaching staff and other specialized and management staff as well as sur place and third-country scholarships[4] in partner countries. The

4 The DAAD uses sur place and third-country scholarships and grants to promote the transfer of knowledge between North and South. Its scholarships and grants serve to promote future university teachers at reputed regional institutes and universities in the recipients' countries of origin. The sur place projects have been supplemented by a sandwich program for PhD students from countries in the South. These

DAAD further offers support for the development of partnerships with German universities, promotes university management partnerships and advisory programs in the fields of curricula planning, research, and administration, and it promotes alumni programs as a means of developing specialized networks.

With its broad catalogue of goals, the DAAD potentially has an important role to play in coordinating German DC and STC in developing countries. In view of the fact that the award procedures for individual support measures are focused on the individual scholarship or grant holder, the economic and political frameworks in the home countries of recipients play no more than a subordinate role for the DAAD.

In the fields named above there are ongoing cooperation projects in nearly all of the countries in Subsaharan Africa. Most of the PhD scholarships awarded thus far have gone to students from South Africa, Ethiopia, Cameroon, Nigeria, Sudan, and Kenya. Awards of sur place and third-country scholarships have tended clearly to be concentrated on Kenya, but the DAAD has also funded scholarships and grants for scientists and students in Uganda, Tanzania, Namibia, and – since 2003 – Ghana. In Namibia most of this support is provided for future university teachers interested in taking a master's degree abroad – for the most part in South Africa. In particular, the number of sur place scholarships awarded in Uganda has risen appreciably since 2000.[5] Generally speaking, the regional focus of the scholarships and grants provided by the DAAD is East Africa. No individual scholarships or grants at all have been awarded thus far in francophone West Africa. This may possibly be due to a lack of knowledge in the region about the possibilities of applying for German scholarships and grants. The DAAD's Nairobi office is almost certain to have increased levels of awareness of these support opportunities in East Africa (DAAD 2006a).

Table 1: Headquarters of centers of excellence and research networks supported by the DAAD in Subsaharan Africa

Center of excellence / research network	**Country**
Association of African Universities (AAU)	Ghana
African Network of Scientific and Technological Institutions (ANSTI)	Kenya
International Centre of Insect Physiology and Ecology (ICIPE)	Kenya and Ghana
Ecole Inter Etats d'Ingénieurs de l'Equipement Rural (EIER)	Burkina Faso
Natural Products Research Networks for Eastern and Central Africa (NAPRECA)	Tanzania
Centre d'Etude Regional pour l'amélioration de l'adaptation à la sécheresse (CERAAS)	Senegal
Centre for Peace and Conflict Studies (CEPACS)	Nigeria
Association of Faculties of Agriculture in Africa (AFAA)	Kenya
Kwame University of Science and Technology (KNUST)	Ghana
Source: DAAD, internal.	

generally link field research and doctoral studies in the recipients' home countries with scientific training in Germany. DAAD scholarships cover both the recipients' stay in Germany for study and research in Germany and, in some cases, a share of the field research conducted in the recipients' home countries (DAAD 2004b).

5 See Tables 6-8, Annex, for an overview of the DAAD research grants (PhD studies) awarded between 2000–2004 and the sur place and third-country scholarships granted in 2003 and 2004.

Aside from individual scholarships and grants, the DAAD awards grants to selected African research networks and regional centers of excellence that serve primarily to develop local training structures. Most such centers of excellence are to be found in Kenya and Ghana; they tend to be specialized in agricultural and biological research (see Table 1).

The **AvH**'s programs also play an important role in promoting the exchange of highly qualified scientists from all countries of the world. The AvH is funded mainly by German federal agencies (BMBF, AA, BMZ); it awards up to 600 research grants per year and up to 150 research prizes for non-German scientists holding a PhD. The AvH awards post-doctoral grants to enable highly qualified non-German researchers to carry out research in Germany and to develop contacts with German scientists (BMBF 2004, 17). The eligibility requirements include a PhD and a research project to be carried out in cooperation with a German partner institution. The Georg Forster Program, which is funded by the BMZ, promotes only scientists from developing countries. The eligibility requirements include both a research project with relevance to development, scientific ties to the developing-country in question (e.g. publications), and a PhD earned in the applicant's home country. The aim of the research project in Germany is to pave the way for a transfer of knowledge and technologies to developing countries.

Furthermore, the AvH offers highly qualified researchers the opportunity to carry out long-term research projects at universities abroad. In these cases the partner organization abroad is required to contribute to the grants concerned. What African institutes need to engage in a cooperation project is thus scientific excellence and a certain measure of solvency.

Since the 1990s Nigeria has been one of the priority countries in Subsaharan Africa when it comes to awards of grants. Most Nigerian grant holders are active in the fields of agricultural and forestry science and the biological and chemical sciences. In recent years a relatively large number of grants have also been awarded to scientists from Kenya and Cameroon, although the absolute number of grants awarded per year in these countries – one to two on average – is far lower.[6] Beyond promotion of individuals, the AvH also co-operates with Nigeria. Apart from South Africa, Nigeria is the only other country with which the AvH is engaged in an institutional partnership (AvH 2005, 106).

The **Federal Institute for Vocational Education and Training (BIBB)**plays an important role in the field of vocational training. The institute promotes national and international programs designed to further develop vocational training as well as bilateral exchange programs and training partnerships. The BIBB's cooperation with developing countries is mainly geared to provision of advisory and support services for the further development of national vocational training systems. In Subsaharan Africa the BIBB is presently engaged in bilateral programs with Ghana, Ethiopia, and South Africa.

Alongside its cooperation with the BIBB, the BMBF is currently providing support, in the field of vocational training, for UN training and advanced training, e.g. for the Bonn-based UNESCO International Centre for Technical and Vocational Education and Training (UNESCO-UNEVOC). The center, which was founded in 2002, is part of UNESCO's

6 See Table 9, Annex, for an overview of the AvH grants awarded per country from 1953 to 2004. It should be noted that the figures for grants refer to a relatively long period of time.

"Education for All" initiative,[7] and it serves as a training center for specialized staff and management personnel from developing countries and newly industrializing countries. Its primary goal is to promote the national research and development capacities of UNESCO member countries. The center's aim is to promote vocational training as a contribution to sustainable development, and this means that some of the activities supported by the BMBF are already operational at the interface to DC.

In cooperation with the AA, the could specifically promote science advisors at German embassies and seek to strengthen their regional and international networks as a means of gaining influence on the policy dialogue between Germany and Subsaharan Africa on science and technology. The task of these science advisors is to observe and analyze the scientific-technological developments in the countries concerned and to intensify cooperation between institutions and persons in Germany and partner countries. However, at present most German embassies in Subsaharan countries are very small and are therefore without science advisors.

Box 2: Promotion of research by private foundations: the example of the Volkswagen Foundation

With its initiative "Knowledge for Tomorrow – Cooperative Research Projects in Sub-Saharan Africa," the **Volkswagen Foundation** has set itself the goal of promoting the development of and strengthening all science-related disciplines in the region. This involves supporting cooperative research projects developed and carried out by African scholars and scientists in close cooperation with their German partners. In this connection the Volkswagen Foundation starts out by providing support for thematic workshops at which individual scientists and scholars provide inputs. Competitions for projects of several years' duration are then developed from these workshops. The Volkswagen Foundation's aim here is to promote cross-country networking of good scientists. In regional terms, Volkswagen Foundation workshops have already been conducted in both East and West Africa (Kenya, Uganda, Ghana) and in southern Africa (South Africa) (Volkswagenstiftung 2006).

All in all, the primary goal of the STC actors presented above is a worldwide networking of leading research scientists, with the aim of promoting Germany as a research location. Accordingly, efforts are made to engage in cooperation with institutions and countries that play a trailblazing role in science, research, and university education. Generally speaking, if we look at the projects currently underway, we are unable to identify any priority countries. With exception of the DAAD, whose explicit aim is to promote capacity-building, most of the institutions under consideration have no explicit interest in contributing to building capacities in developing countries, even though many of the cooperation projects concerned do in effect contribute to boosting capacities and strengthening institutions on the ground.

7 At present, the "Education for All" initiative is UNESCO's largest education initiative; the decision to create it was taken at the World Education Forum in Dakar in 2000, where 164 countries voted in favor of it (UNESCO 2006a; UNESCO 2006b). The BMBF is involved in the initiative with a number of different projects.

2 Potential of the countries of Subsaharan Africa as partners of German STC

Chapter one showed that the BMBF and the German STC institutions are already cooperating in various field with partners in Subsaharan Africa. It was further shown that instead of being oriented to joint country priorities, the projects concerned are geared either to the research interests of German institutions in individual disciplines or to the cross-country promotion of qualified scientists.

What follows will seek to identify, on the basis of a potential analysis, the countries in Subsaharan Africa which are in possession of the educational, scientific, and research wherewithal required for more intensive country-level cooperation with the BMBF and the German STC institutions. The potential analysis is based on three criteria. The first and most important criterion is whether or not a given country already has the requisite foundations in education, science and research. This condition given, the second criterion is whether or not a partner country has the political stability and economic performance needed to engage in STC. The third important criterion is whether or not a country is able to assume a regional network function that extends beyond bilateral cooperation. The latter criterion is bound up in particular with the BMBF's interest in limiting bilateral research cooperation to important partner countries in the regions concerned and using cooperation projects to achieve spillover effects.

Any attempt to come up with a comparative assessment of individual countries in terms of their suitability as cooperation partners for German STC actors is bound to run up against numerous methodological problems. In the first place, the macroperspective chosen for the present study necessarily rules out any sufficiently in-depth assessment of both the quality of the educational and research infrastructure and the political and economic qualifications of individual countries. Another factor working counter to a reasonable assessment is that the data on the countries of Subsaharan Africa needed for the purpose are either incomplete or unavailable. On the one hand, there are simply no relevant data available for some countries, the reason being that many African countries have not yet developed sufficiently high levels of activity, in particular in the field of Research and Development (R&D). On the other hand, some countries in Subsaharan Africa collect data only on an irregular basis or with the aid of inadequate methods.[8] Second, it is not possible to measure the willingness of potential partner countries to engage in cooperation. It is entirely conceivable that cooperation with countries proposed as partners may prove difficult, or indeed impossible. Third, many German research institutions are concerned with specific issues such as biodiversity, tropical diseases, desertification, etc. In choosing cooperation partners they reach their decisions primarily on the basis of geographic criteria, not of scientific excellence. Even though the diversity of the research interests involved makes it impossible to systematically map these decision criteria, they should nevertheless be given consideration in coming to final decisions on a choice of partner countries.

8 A growing awareness of the relevance of R&D and university training is evident in the initiative launched by African science and research ministers to develop a database designed to capture the R&D and education indicators of African countries (AU / NEPAD 2005, 18).

2.1 Scientific performance of the countries of Subsaharan Africa

A country's scientific performance is a selection criterion relevant for both German research institutions and research promotion institutions. This is in particular the case when development goals are only of secondary importance and the focus is on cooperation with excellent scientists and researchers.

Technology transfer alone is not sufficient to make a country competitive in research and science and to enable it to cooperate on equal terms with bi- and multilateral researcher networks. Against the background of the ongoing process of technological change, it is particularly important for countries to build capacities of their own and to continue to develop them in new and creative ways. In addition, existing technological competence plays a crucial role in the locational decisions made by corporations with international reach (Stamm 1999, 69). Generally speaking, it is possible to measure national activity in the field of research on the basis of inputs (funding, infrastructure, human resources) and scientific outputs (scholarly publications (UNCTAD 2005, 111). However, the poor data situation for Subsaharan Africa sets clear-cut limits to any attempt to conduct country analyses based on internationally comparable indicators.[9]

If, in the long term, research outputs are to be absorbed by society and translated innovatively into practical applications, a country is in need of well trained scientists and researchers. Only in this way is it possible to ensure that there will be sustainable demand for research outputs. This is the reason why a country's education level pays an important role in assessing its scientific effectiveness. Two key factors here are good universities and a critical mass of students enrolled in scientific-technical disciplines.

2.1.1 Foundations of research and development: scientific in- and output

Scientific input: financial and infrastructural resources

If it is to create the essential preconditions for a good cooperation potential, a country's government must recognize the relevance of research and be prepared to invest in R&D. A country's R&D expenditures may be seen here as a good initial indicator. Second, it is essential to look into whether or not a country is already in possession of sufficient relevant infrastructure. Quantifiable and comparable data on the financial and infrastructural resources available to countries in Subsaharan Africa are very hard to come by, if not entirely nonexistent. What follows will seek to sum up the statistical data available on public R&D expenditures and the diffusion of ICT infrastructure.[10]

9 For example, there are hardly any data available for any one African country on public expenditure for R&D. And there are no data available at all on private-sector R&D spending (UNCTAD 2005, 118).

10 UNCTAD's Innovation Capability Index (UNICI) is an aggregate indicator used for drawing international comparisons of the innovation and technology potentials of individual countries. Since individual reference variables used in the UNICI will be looked in depth in what follows, the aggregate index will not be used here. For an overview of the rankings of Subsaharan African countries determined by UNCTAD, see UNCTAD (2005, 114).

On the whole, most countries in the region make available far less than 0.2 % of their gross domestic product (GDP) for public R&D investments (see Table 2). R&D appears to enjoy higher priority in Uganda. An exception in this respect, Uganda devotes 0.81 % of its GDP for public investment in R&D – the lion's share of which goes into agricultural research.[11] Generally speaking, however, the data picture regarding the public R&D expenditures of Subsaharan African countries is extremely patchy. And for this reason it is very difficult to come up with any really viable statements on the science and research situation in Subsaharan Africa. The same goes when it comes to determining the number of researchers and engineers in a given country or the number of patent applications filed by nationals. The relevant data are presented in Table 2.

Information and communication technology (ICT) is an important precondition for knowledge-based development, the development of technological skills and competence and competitiveness, and the ability to network internationally in the field of technology. In addition, a country's ICT development level is an indication of the extent to which it is able to adopt and harness technologies that have already been developed.

Table 3 presents an overview of the diffusion of information and communication technology in Subsaharan Africa. We note that in particular that island states, like the Seychelles and Mauritius, as well as South Africa, Botswana, and Namibia are already in possession of comparatively good infrastructure, with e.g. the number of mobile telephones in use rising sharply between 2000 and 2003. In Namibia PC use more than doubled from 42 to 99 per 1000 population. In the same period the number of mobile telephones rose from 46 to 116 per 1000 population. Mobile telephones are relatively widespread in Mauritius, Gabon, Congo, Swaziland, and Cameroon as well. Still, in none of the countries under consideration is the availability of ICT, in particular PCs, comparable to the status quo in industrialized countries.[12] Lack of ICT infrastructure makes it difficult for many countries in the region to network with the international knowledge community. ICT is very weakly diffused in Ethiopia; and measured in terms of its population, Nigeria's ICT infrastructure is likewise underdeveloped (e.g. only six Internet users per 1000 population). But one explanation for these figures is that a) Nigeria and Ethiopia have the largest populations in Subsaharan Africa and b) the rural populations of both countries account for a very high share of their overall populations. In developing countries ICT tends for the most part to be concentrated in urban centers. Despite the low level of diffusion of ICT in Nigeria and Ethiopia in relation to the two countries' overall populations, it is thus entirely possible that both countries have individual universities and research institutions that are well endowed with ICT infrastructure.

11 According to UNCTAD (2003, 101), the National Agricultural Research Organization is Uganda's largest research institution.

12 In Germany, for example, the 2003 figure for Internet use was 473 per 1000 population, and 485 of 1000 population had a PC of their own (World Bank 2005a).

Table 2: R&D indicators for the countries of Subsaharan Africa

	Public R&D expenditures (in % of GDP	Researchers (per 1 million population)	Engineers (per 1 million population)	Patent applications filed by nationals
	2001	2001	2001	2001
Angola	..	..	..	..
Benin	..	..	..	..
Botswana	..	..	..	2
Burkina Faso	..	..	..	..
Burundi	..	..	..	..
Cameroon	..	..	..	..
Cape Verde	0,04**	131**	33**	..
Central African Republ	..	..	..	..
Chad	..	..	..	..
Comoros	..	..	..	..
Congo, Dem. Rep.	..	..	..	..
Congo, Rep.	..	29*	32*	..
Cote d'Ivoire	..	..	..	..
Djibouti	..	..	..	..
Equatorial Guinea	..	..	..	..
Eritrea	..	..	..	..
Ethiopia	..	..	..	3 *
Gabon	..	..	..	..
Gambia, The	..	..	..	1
Ghana	..	..	..	2
Guinea	..	286*	104*	..
Guinea-Bissau	..	..	..	..
Kenya	..	..	..	2
Lesotho	..	42**	26**	1
Liberia	..	..	..	..
Madagascar	0,12*	15*	47*	4**
Malawi	..	..	..	2
Mali	..	..	..	..
Mauritania	..	..	..	..
Mauritius	..	..	..	..
Mozambique	..	..	..	1
Namibia	..	..	..	..
Niger	..	..	..	..
Nigeria	..	..	..	..
Rwanda	..	..	..	..
Sao Tome and Principe	..	..	..	..
Senegal	..	..	..	..
Seychelles	0,11**	452**	30**	..
Sierra Leone	..	..	..	1
Somalia	..	..	..	..
South Africa	0,67**	192**	74**	184**
Sudan	..	..	..	2**
Swaziland	..	..	..	1
Tanzania	..	..	..	2

* Data for 2000; ** data for 2002; *** data for 2001; ..no data available

Source: World Bank 2005a).

Table 3: Basic infrastructure for modern information and communication services

	2000	2003	2000	2003	2000	2003	2000	2003
Angola	5	7	2	..	1	..	1	..
Benin	8	9	9	34	2	10	2	4
Botswana	83	75	122	297	15	..	37	..
Burkina Faso	5	5	2	19	1	4	1	2
Burundi	3	3	2	9	1	2	1	2
Cameroon	6	..	10	66	3	..	3	..
Cape Verde	126	156	45	116	18	44	57	..
Central African Repub	3	..	1	10	1	1	2	..
Chad	1	..	1	8	0	..	1	..
Comoros	10	17	0	3	2	6	4	6
Congo, Dem. Rep.	0	..	0	19	0	..	..	..
Congo, Rep.	7	2	24	94	0	4	4	4
Cote d'Ivoire	18	14	32	77	3	14	6	..
Djibouti	15	15	0	34	2	10	10	22
Equatorial Guinea	13	18	11	76	2	..	4	..
Eritrea	8	9	0	..	1	7	2	3
Ethiopia	4	6	0	1	0	1	1	2
Gabon	32	29	98	224	12	26	10	22
Gambia, The	26	..	4	..	9	..	12	..
Ghana	12	13	6	36	1	..	3	..
Guinea	3	3	6	14	1	5	4	6
Guinea-Bissau	9	8	0	1	2	15	..	..
Kenya	10	10	4	50	3	..	5	..
Lesotho	10	..	10	..	2	..	..	..
Liberia	2	..	0	..	0	..	..	..
Madagascar	4	4	4	17	2	4	2	5
Malawi	4	8	5	13	1	3	1	2
Mali	4	..	1	23	1	..	1	..
Mauritania	7	14	6	128	2	4	10	..
Mauritius	235	285	151	267	73	123	101	..
Mozambique	5	..	3	23	1	..	4	..
Namibia	62	66	46	116	17	34	42	99
Niger	2	..	0	2	0	..	0	..
Nigeria	4	7	0	26	1	6	7	..
Rwanda	2	..	5	16	1	..	..	..
Sao Tome and Principe	31	46	0	32	44	99	..	..
Senegal	22	22	26	56	4	22	17	21
Seychelles	235	256	320	595	74	..	136	..
Sierra Leone	4	..	2	..	1	..	..	..
Somalia	4	..	..	..	0	..	..	..
South Africa	114	..	191	364	55	..	66	..
Sudan	12	27	1	20	1	9	3	..
Swaziland	32	44	33	84	10	26	12	29
Tanzania	5	4	6	25	1	7	3	6
Togo	9	12	11	44	22	42	22	32
Uganda	3	2	8	30	2	5	3	4
Zambia	8	8	10	22	2	6	7	8
Zimbabwe	22	26	27	32	4	..	17	53

.. No data available

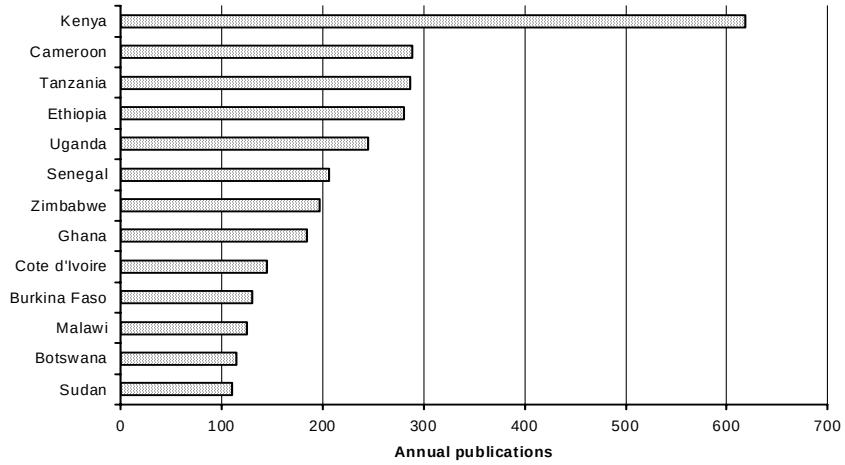
Source: World Bank 2005a).

Scientific output: publications in scientific/scholarly journals

Figures for scientific publications in internationally recognized scientific/scholarly journals can be used as an approximate value for successful research activity in a given country. In a contributions for the Globelics Conference in South Africa, [13] Ulrich Schmoch from the Fraunhofer Institute for Systems and Innovations Research (ISI) in karlsruhe, Germany, looked into the knowledge base in Subsaharan Africa for the field of researche and technology; his point of departure was publications in scientific journals – based on the Science Citation Index (SCI)[14] – as well as data on internationals and European patent applications.

He found that researchers South Africa and Nigeria lead the field, accounting the largest number of scientific publications in Subsaharan Africa. However, the output of publications in Nigeria has declined since the 1990s, with political instability there inducing many researchers to leave the country. Beside South Africa and Nigeria, most of the Subsaharan African scientists who published their research results in 2003 / 2004 were from Kenya, Cameroon, Tanzania, Ethiopia, Uganda, Senegal, and Zimbabwe (see Figure 1).

Figure 1: Countries in Subsaharan Africa (without Nigeria and South Africa) with the largest publication outputs in 2003 / 2004, based on the SCI



Note: **It should be noted here that the SCI contains mainly English-language journals and that the Francophone countries therefore tend to be underrepresented.**

Source: Schmoch (2005, 5).

Ghana too can point to an appreciable output of publications. Moreover, the number of publications co-authored by scientists from Subsaharan African countries and colleagues from technologically more highly developed countries has grown in recent years. This, Schmoch notes, must on the one hand be seen as an advance for African scientists, who are increasingly included in research as competent and experienced partners. On the other hand, though, these figures can also be read as an indication of the dependence of African scientists on researchers from scientifically more advanced countries (Schmoch 2005, 6).

13 The Globelics Africa Conference 2005 on „Innovation systems promoting economic growth, social cohesion and good governance" took place from 31 Oct. 2005 to 04 Nov. 2005 at Tshawane University of Technology in South Africa.

14 The SCI convers an annual total of some 1 million new articles from 6000 scientific journals (Schmoch 2005, 2)

In view of the fact that the SCI covers only the world's leading journals and the knowledge base in most African countries has not yet reached an international level, it is on the whole difficult to come up with more than a highly selective picture of the scientific output of researchers from the region. But we can still observe some clear-cut trends: Following South Africa and Nigeria, Kenya has a leading position in the region. However, the fact that there are very few patent applications in Nigeria and Kenya appears to indicate that it is difficult in these countries as well to translate existing knowledge into innovation. As far as scientific output is concerned, the disparity between South Africa and the other countries of the region continues to be very marked.

2.1.2 Education situation in Subsaharan Africa

The university sector has an important role to play in supporting research activities. Sound university training, especially in sciences and engineering, is the sine qua non for the development and application of innovative technologies. If research outputs are to be demanded and absorbed by society, what a country needs is a critical mass of students. By supporting the development of a qualified knowledge base, universities can add to the sustainability of the overall education system and provide an important contribution to a country's political and social development. Viewed from the national perspective, however, developing countries often fear that tertiary training entails the risk of brain drain, with qualified young talent migrating to other, more highly developed countries.

Despite a rapid rise in the past 20 years, enrollment rates in the tertiary education sector in Subsaharan Africa continue to be the lowest in the world (Bloom / Canning / Chan 2005, 5). In addition, the rise in the numbers of students in these countries has not been supported by higher public investment in the tertiary education sector. In some Subsaharan African countries this has led to a decline in the quality of university education. Lack of public funds has impaired the quality of education infrastructure and further contributed to brain drain (AAU 2003, 2; Ahmed 2005a, 68).

Most African countries continue to have few universities; even university teaching staff may sometimes be without a recognized university degree; and university research is often poorly coordinated with national research needs. In addition, the poor physical infrastructure found at most African universities even further restricts their research capacities. For the most part, some 90 % of the time of well-trained scientists is taken up by teaching, which leaves them very little time for research. And there is little exchange between universities and national non-university research institutes or business enterprises (Ahmed 2005a, 76 ff.).[15]

15 This is also confirmed by analyses presented by the Coimbra Group, which was commissioned in 2002 by the European Commission to conduct a study on a potential cooperation program in the field of university education between the EU and the ACP countries (Coimbra Group 2003). The Coimbra Group is an association of European universities with high international standards. In this connection 34 experts carried out a total of 21 field studies on the university sector, 18 of them in Africa (Ghana, Sudan, Botswana, Ethiopia, Uganda, DR Congo, Congo Brazzaville, Senegal, and Gambia, Angola and Mozambique, Zambia, Madagascar, Mali, Burkina Faso, Rwanda and Burundi, Tanzania, Malawi, Kenya, Benin und Togo, and Cameroon and Gabon).

Subsaharan Africa, according to the aggregate Knowledge Assessment Methodology

Before looking in greater depth into the (university) education sector in individual Subsaharan African countries, we will take a brief, comparative (international /regional) look at the knowledge bases of the countries of Subsaharan Africa. For this purpose we can make use of the World Bank's Knowledge Assessment Methodology 2006. This aggregate indicator analyzes the knowledge base of 128 countries (25 of them in Subsaharan Africa). It covers national economic incentive regimes and basic institutional conditions, education and human resource bases, innovation system quality, and diffusion of ICT (World Bank 2006). In other words the knowledge assessment covers, in addition to school and university enrollment rates, important framework conditions for education, and national capacities to efficiently translate acquired knowledge into practical applications.

The Knowledge Index (KI) is used to map a country's general knowledge potential. The KI is the simple average of the normalized performance scores of a country or region on key variables assigned to the factors "education and human resources," "the innovation system," and "information and communication technology." The Knowledge Economy Index (KEI) also takes the economic environment and institutional regime into account.[16] The underlying variables are normalized on a 0-10 scale, with 10 standing for the best performance.

Table 4 shows the results for the KI and KEI indices and for the four factors making up the indices for Subsaharan Africa. If we look at the knowledge potential in the Subsaharan African countries using the KEI (Table 4), we find that South Africa, Mauritius Botswana, Namibia, and Kenya are above the African average, while Zimbabwe, Senegal, and Ghana are slightly below average. In Zimbabwe's case the main reason for this is the country's inadequate incentive regime; in Ghana and Senegal it is due to lower-than-average innovation and education resources and innovation systems. If we restricted our view to economic incentive structures and institutional regimes, we would find that Ghana and Senegal (as well as Zambia and Uganda) are far above the African average. In a worldwide cross-country comparison, only South Africa is found among the top 50 %.

We further note that the individual variables in the countries above the African average differ in their significance. Botswana e.g. offers very good institutional and economic framework conditions, a fact that is certainly due to the country's governance, which is very good by both African and international comparison. Kenya, on the other hand, ranks in the lower third here, although the country has a relatively high innovation potential. This is consistent with the analyses presented above on R&D indicators. **Mauritius**'s edu-

16 The four pillars of a knowledge-based society consist of the following main variables: *"The economic incentive and institutional regime"*: tariff and nontariff barriers; regulatory quality and rule of law; *"education and human resources"*: adult literacy rate, secondary and tertiary enrollment; the innovation system: researchers in R&D, patent applications granted by the US Patent and Trademark Office, scientific and technical journal articles; *"information and communication technology"*: telephone lines, PCs, and Internet users per 1000 population. For the exact makeup of the variables, see World Bank (2006).

The KI and KEI indices are available in two forms: unweighted and weighted for total population. What follows focuses on the unweighted indicators because they better depict absolute knowledge by cross-country comparison. Some of the index's variables have already been referred to in the course of the analysis of scientific inputs and outputs. These, though, are not among the main reference variables and therefore play only a minor role.

cation base is second only to South Africa's, and it has the highest diffusion of ICT infrastructure of all the countries under consideration here. Its very good education base is due,

Table 4: Knowledge Assessment for Subsaharan Africa (based on the most recent data available)*

Rank	Country	KEI	KI	Econom. Incentive Regime	Innovation	Education	Information Infrastructure
1	South Africa	5,40	5,16	6,10	6,31	4,17	5,00
2	Botswana	4,23	2,98	7,99	2,68	2,73	3,54
3	Mauritius	3,88	3,67	4,51	0,72	3,86	6,43
4	Namibia	3,35	2,45	6,07	0,63	2,89	3,81
5	Kenya	2,82	3,25	1,54	5,48	2,00	2,28
	Africa	2,70	2,66	2,83	3,90	1,51	2,55
6	Zimbabwe	2,43	3,04	0,58	3,20	2,60	3,33
7	Ghana	2,13	1,68	3,45	1,73	1,76	1,58
8	Senegal	2,12	1,50	4,00	1,04	0,71	2,74
9	Zambia	2,02	1,56	3,40	1,76	1,63	1,31
10	Nigeria	1,86	2,40	0,23	3,99	1,79	1,43
11	Uganda	1,82	1,22	3,61	1,68	1,16	0,82
12	Cote d'Ivoire	1,76	1,96	1,15	2,49	1,32	2,08
13	Madagascar	1,76	0,59	5,27	0,35	0,87	0,54
14	Sudan	1,73	2,18	0,39	2,76	1,69	2,11
15	Mauritania	1,66	0,92	3,87	0,12	0,82	1,81
16	Cameroon	1,52	1,68	1,02	1,69	1,82	1,54
17	Benin	1,49	1,22	2,29	1,81	0,84	1,00
18	Tanzania	1,48	1,23	2,21	1,69	0.92	1,09
19	Mozambique	1,36	0,84	2,92	1,34	0,34	0,83
20	Malawi	1,35	0,83	2,90	1,22	1,05	0,23
21	Ethiopia	1,26	1,46	0,65	3,70	0,58	0,11
22	Burkina Faso	1,18	0,61	2,87	1,26	0,16	0,42
23	Angola	0,77	0,96	0,21	1,43	0,45	0,99
24	Eritrea	0,76	0,59	1,29	0,24	0,97	0,55
25	Sierra Leone	0,45	0,36	0,73	0,47	0,34	0,27

* In most cases data for 2003 / 2004.

Source: World Bank (2006).

among other things, to a primary school enrollment rate of close to 100 %. One important factor in Namibia is the country's relatively widely diffused infrastructure and innovation-friendly economic and political environment. Yet the country has the lowest innovation potential of all the countries under consideration, and Namibia is therefore suited less for research cooperation than for university-level cooperation. Nigeria and Zimbabwe are marked by a good innovation potential, although a cross-country comparison shows these countries to have extremely poor institutional regimes and regulatory conditions. Sudan and Ethiopia likewise have comparatively good innovation systems. One striking fact is that several countries (e.g. Zambia, Madagascar, Benin, and Tanzania) rank considerably better than e.g. Kenya or Nigeria when it comes to institutional regimes and regulatory conditions, although both countries are rated lower on education and innovation potential. If we prepare a ranking based only on innovation levels, the results are comparable to those

noted in the analysis above: Only Nigeria, Kenya, and South Africa are above the African average, while Ethiopia and Zimbabwe are slightly below it. For Sudan and Ethiopia we find a very large disparity between the weighted and unweighted values (the weighted values are not considered here). While, in absolute terms, both countries have a relatively high innovation potential, they are far below the African average when weighted in terms of their total populations.Viewed across Subsaharan Africa, Mauritius, Namibia, Botswana, Zimbabwe, and Kenya rank best on education. While Cameroon, Nigeria, Ghana, Sudan, and Zambia are above the African average, their low values place them among the world's poorest 20 %. Sierra Leone, Eritrea, Angola, Burkina Faso, Malawi, Mozambique, Mauritius, and Madagascar have not yet adopted some important measures that would put them on the road to a knowledge-based society.[17] While, on the whole, Ethiopia also shows major shortcomings, it should not be immediately excluded from cooperation because it does have a relatively high innovation potential.

If, in concluding, we take a look at the trends in selected countries since 1995, we find distinctly positive developments on the road to a more knowledge-based society especially in Ghana, Senegal, and Kenya.[18] To cite an example, in 1995 Kenya ranked among the lowest 10 % (value: 0.66) of the countries under consideration. At present it has a value of 2.28, and thus ranks above the African average. Ethiopia has substantially improved its standing on innovation potential. Uganda has also improved considerably over the past ten years, although it still remains at a relatively low level. This positive development in Uganda is due above all to tangibly improved institutional structures. Countries like Benin and Zambia have lost some of their innovation potential, even though the institutional regimes in both countries have improved perceptibly. Nigeria's innovation potential is also declining, a fact evidently due above all to a deterioration in the country's basic political and institutional conditions. On the whole, Subsaharan Africa's relative position has deteriorated since 1995. This goes in particular for the items "innovation system" and "ICT infrastructure." Here, though, there is good reason to suppose that the county's absolute level has in fact not deteriorated and that instead the levels in the over 100 reference countries have improved more in relation to the countries of Subsaharan Africa.

As far as Subsaharan Africa is concerned, the analyses of the knowledge indicators show that Mauritius, Botswana, Kenya, and Namibia have the relatively highest potential to develop in the direction of a knowledge-based society. As far as research output (innovation) goes, Kenya, Nigeria, and Ethiopia show positive trends.

Education data for selected countries

Since the aggregate knowledge indicators describe only relative cross-country trends of a country's knowledge base and potential, these indicators are specified and supplemented here by giving consideration to some individual education indicators. It turns out that the indicators best suited for comparison are national literacy rates and school enrollment rate in different areas of education. These indicators are important to ensuring that a country will have, in the medium to long term, a solid science base. There is also good reason to

17 While the basic conditions in Madagascar are relatively positive – it has a value of 5 on the scale – the country lacks a critical mass of well-trained researchers. In addition, its ICT infrastructure is quite underdeveloped.

18 The 1995 data are not presented here. For the exact data, see World Bank (2006).

assume that a country that has high illiteracy rates and has not taken steps to ensure universal access to basic education will have little interest in setting its priorities in the field of research and university education. Taking a separate look at public education expenditures also reveals whether and to what extent a government has in fact recognized the relevance of education and is prepared to promote it.

If we start out by looking at average **literacy rates** (see Table 11, Annex) for the period from 2000 to 2004, we find that the countries with high rates include South Africa and Zimbabwe, but above all the island states. One striking fact is that the countries of southern Africa (Botswana, Namibia, Swaziland, and Lesotho) as well as Kenya, Congo, and Equatorial Guinea have literacy rates of over 70 %, while the rates for the West African countries (in particular Benin, Senegal, and Côte d'Ivoire) are appreciably lower. For example, Senegal's average literacy rate, under 40 %, is extremely low. Tanzania, Uganda, Cameroon, and Nigeria have relatively good literacy rates – well over 70 % for youths. One result of intensified promotion of education in recent years is that even in the other countries under consideration youth literacy rates are generally appreciably higher than they are for adults. Mali Niger, Burkina Faso, and Sierra Leone, which have literacy rates of less then 30 %, will not be eligible for research and university cooperation.

As far as public **education expenditure** is concerned, the data situation is relatively patchy. In tendency, though, here too we can make out relatively large disparities between southern African countries and West African countries. Measured in terms of their GDP, Kenya, Namibia, Swaziland, and Lesotho spend most on education. Kenya and Namibia spend 7 % of GDP on education, and the figures for Lesotho and Swaziland are even higher.[19] As far as expenditure for tertiary education is concerned, Rwanda and Equatorial Guinea show impressive levels of over 30 %. The tertiary education expenditure rates for the other countries under consideration are as a rule below 20 %. In their Poverty Reduction Strategy Papers (PRSPs), only Cameroon and Ethiopia have set out the goal of increasing their spending for tertiary education (Bloom / Canning / Chan 2005, 9).

University enrollment rates and distribution of disciplines

In looking into possible university and research cooperation, one significant factor is the **university enrollment rates**[20] of the countries under consideration. Mauritius has the region's highest university enrollment rate (over 15 %); it is followed, far back, by Nigeria (just over 8 %) and Cameroon (5.5 %) (see Table 12, Annex). However, it is chiefly the absolute figures that are interesting in identifying a critical mass of university students (Table 5): Here Nigeria even outdoes South Africa with its national figure of 948,000 students, the by far highest figure for tertiary education found in all of Subsaharan Africa.

19 This is a high percentage even by international comparison. Between 2000 and 2002 Germany e.g. spent 4.6 % of GDP on education; the corresponding figures for France and India are 5.6 % and 4.1 %, respectively. For an exact overview of the education expenditures of all countries, see UNDP 2005, 254 ff.

20 School and university enrollment rates are derived from absolute attendance figures for schools and universities in relation to the population figures for the age cohort matching the education level in question. However, these figures do not permit us to make any statements on the quality of education. Data on vocational training and "on-the-job training" are not considered here.

Table 5: Student enrollment figures for selected countries (most recent data, in 1000)

Botswana	9
Cameroon	81
Ethiopia	172
Ghana	70
Kenya	99
Madagascar	33
Mauritius	17
Namibia	14
Nigeria	948
Rwanda	20
Senegal*	29
South Africa	675
Sudan	201
Tanzania	31
Uganda	74
Zambia	25
Zimbabwe	56

*) These data refer to 1998 / 99.

Source: UNESCO 2006a, 345 ff.

South Africa, then, is followed by Sudan, Ethiopia, Kenya, and Cameroon. The number of university students in Uganda and Ghana – 70,000 and more – is likewise relatively high. These last, high figures are not necessarily the result of good conditions for university studies, indeed they are for the most part due to the size of these two countries. Nigeria, followed by Ethiopia, is by far the most populous country in Subsaharan Africa. Kenya and Sudan likewise have relatively large populations. This circumstance potentially enables these countries to assemble a critical mass of scientists. On the other hand, while Botswana and Mauritius have good education systems, they are, in population terms, small countries, and their absolute university enrollment figures (9,00 and 17,00, respectively) are accordingly low. This make it questionable whether Botswana, with its low university enrollment figures, will, in the longer term qualify cooperation with the BMBF.

One factor of particular relevance for STC is the percentage of students enrolled in mathematical-scientific subjects. In Kenya, Ghana, Malawi, and Mauritius this figure is relatively high, over 20 % of all students (UNESCO 2006a, 385 ff.). In all, we find in that in all countries of Subsaharan Africa most students are enrolled in the subjects of education and social sciences (including law and economics). According to UNESCO surveys, Mauritius, Kenya, Ghana, and Madagascar have a relatively high percentage of students enrolled in the pure and engineering sciences (UNESCO 2006a, 352 ff.). In 2002 / 2003 such students accounted for 20 to 30 % of these countries' student populations (UNESCO 2006a, 358 ff.). If we look at the absolute enrollment figures for these subjects, we find that in 2001 Nigeria clearly led the field here as well. The corresponding figures for Ethiopia, Cameroon, Ghana, and Kenya (2001) were over 10,000.[21]

21 The most recent date available are from 2001. In 2001 a total of 64,000 students were enrolled in the pure and engineering sciences in Nigeria; the corresponding figures for Ethiopia and Cameroon were

There are relatively few students enrolled in agricultural sciences in all of the countries under consideration. The relatively low level of interest shown by students in many Subsaharan African countries in the pure and engineering sciences is due for one thing to the poor physical endowments of universities. For another, the striking lack of links between universities and the private sector, a potential employer of university graduates, has negative impacts on the attractiveness of these subjects (Coimbra Group 2003, 37). As along as there is a lack of concrete employment perspectives for graduates, there is no reason to expect the percentage of students enrolled in the pure and engineering sciences to rise (Stamm 1999, 70).

Primary and secondary education

Finally, we will take a look at primary and secondary education, a field of considerable importance for the training of young scientific talent. On the whole, a cross-country comparison shows trends similar to those for tertiary education: The highest primary education rates are found in the island states as well as in Lesotho, Rwanda, Botswana, South Africa, and Tanzania (see Annex, Table 12). Ethiopia's low primary school enrollment rate, only slightly above 50 %, is conspicuous in this context. The primary school enrollment rate for Nigeria, 67 %, is also relatively low. This is another illustration of the relatively low development level of these two countries, measured in terms of their total population. However, thanks to their large populations, the absolute figures for these two countries are higher than those of the other countries in Subsaharan Africa. On the whole, there is a large disparity between primary and secondary education in the countries under consideration. This indicates that most African countries have placed priority on developing primary education, with secondary and tertiary education remaining somewhat underdeveloped. Botswana and Mauritius, but also Ghana and Namibia, have good secondary school enrollment rates.

2.1.3 Universities and non-university research institutions

Nigeria and Sudan have by far the largest numbers of **public universities**. In 2002 Sudan had a total of 26 public and 30 private universities. Namibia and Botswana, on the other hand, each have only one public university, while Mauritius has two and Ghana has five. Kenya and Ethiopia each have five public universities, while Senegal has two. Above and beyond their public universities, all of the countries under consideration have a number of private universities, technical colleges, technical institutes, and vocational training institutions.[22] On the whole, it may be noted here that in many Subsaharan African countries the university sector is in the midst of a process of change (see Box 3).

The number of open, or distance universities has risen sharply in recent years. One example here would be the African Virtual University (AVU), which was founded in 1997 on

just above 17,000, and Ghana and Kenya had science/engineering enrollment figures of roughly 14,000 (UNCTAD 2005, 296).

22 All of the data cited are based on the Coimbra Group's university sector analyses. The Coimbra Group did not conduct any studies on Nigeria's university sector. According surveys conducted by the International Association of Universities, Nigeria has over 30 public universities (see IAU / AAU / UNESCO 2004).

the initiative of the World Bank. The AVU offers internationally recognized correspondence courses; at present its curricula are primarily technical in nature. The AVU cooperates with both African and international universities and with the private sector (Coimbra Group 2003, 18).

As in most countries, the number of **private education institutions** in Africa has risen in recent years. A lack of standards in the region has thus far made it impossible to come up with a uniform system of quality control (Coimbra Group 2003, 12), although Tanzania, Kenya, Ghana, and Uganda are already working on uniform accreditation systems. Some African countries charge tuition fees, with the government as a rule covering the costs for campus housing, teaching materials, and staff costs. In Kenya, Uganda, Ethiopia, Ghana, and Tanzania, students are at present required to cover a large share of current costs.[23] In many cases tuition fees constitute a real obstacle to universal access to university education, though without being able, at the same time, to assume the function of much-needed public investment.

Box 3: Situation in the university sectors of Kenya, Ghana, Botswana, and Uganda
(Coimbra Group 2006)

In Kenya continuous efforts have been underway since the 1980s to further develop and expand the country's university system. There are now numerous partnerships between Kenyan universities and other universities throughout the world. The focal areas of Kenyan university research are the health and environmental sciences, Financial reforms carried out in the mid-1990s have made university education extremely costly for students. Even so, the Kenyan government still has considerable difficulties paying its university professors on time. One of the major challenges facing the Kenyan university system is management and quality assurance of university curricula. The system also lacks the capacities it would need to meet the large demand in the country for university training.

In recent years efforts have been stepped up in Ghana to forge links between the country's universities and industry. As in most other African countries (apart from Senegal and Mozambique), the country's public education sector has little autonomy and is in large measure dependent on targets and standards set by the education ministry. The country's most important university, the University of Ghana, has an international office as well as partnerships with various universities abroad.

Botswana's education infrastructure must be seen as the best that Subsaharan Africa has to offer. Both institutional endowments and the quality and the quality assurance of the country's university curricula are very good. However, due to its small population and the extremely high incidence of Aids in the country, Botswana is forced to rely heavily on outside teaching personnel, and the country is not able to offer all disciplines and curricula at its own universities. Most students in Botswana are enrolled in education and the social sciences. Other subjects in demand include biology and environmental sciences.

Uganda sees its greatest development potential in the training of human resources. Several new universities have been opened in the country since 1988. One positive circumstance that deserves to be emphasized is the efforts underway in the country to decentralize the university system; the aim of these efforts is to strengthen university autonomy and to provide support for the country's ongoing democratization process. The most important fields of research in the country are economic and health sciences; relatively few students in Uganda are enrolled in the pure and engineering sciences. Makarere University in Kampala attracts students from the whole of East Africa.

23 At Makarere University in Uganda, for example, 30 % of current costs are presently financed through tuition fees (Bloom / Canning / Chan 2005, 14).

Academies of science, centers of excellence, and research networks[24]

Above and beyond universities, academies and research networks and institutes may play an important role in improving a country's attractiveness as a location for science and research. The present membership of the – Nairobi-based – Network of African Science Academies (NASAC) consists of 13 African academies of science, including the academies in Cameroon, Ghana, Kenya, Madagascar, Nigeria, Senegal, South Africa, and Uganda.[25]

Box 4: How Subsaharan Africa fares on a worldwide university ranking [a)]

A worldwide university ranking conducted by the Institute for Higher Education of Jiao Tong University in Shanghai rates only four South African universities among the world's best. A ranking for the region of Subsaharan Africa (without South Africa) gave the best marks to the University of Dar es Salaam (Tanzania), the University of Zimbabwe (Zimbabwe), the University if Namibia (Namibia), Makarere University (Uganda), and Cheikh Anta Diop University (Senegal). The universities of Mauritius and Botswana as well as the Kigali Institute of Science and Technology also received relatively good ratings. Kenya's Moi University and Jomo Kenyatta University of Agriculture and Technology are also ranked among the region's best universities. The best-rated university in Nigeria is the University of Ibadan

a) For exact rankings and the methodology used, see http://www.webometrics.info/top100_continent.asp cont= africa.htm.

Some proposals on integrating African science into the EU's 7th Research Framework Programme were worked out in February 2006 between NASAC members and the EU (Cordis 2006).

Box 5: Thematic orientation of research centers in Subsaharan Africa

Most of the research centers under consideration here, and especially those in Kenya, Ghana, and Nigeria, are engaged primarily in research in the agricultural and biosciences. The agricultural research centers in particular are already receiving strong support from bi-and multilateral donors e.g. World Bank, Swedish International Development Agency (SIDA), BMZ, Department for International Development (DFID), and they are engaged in an international exchange of scientists. In view in particular of the fact that Kenya's agroindustry offers major potentials for growth and innovation, agricultural research must be seen as playing a vital role there. The situation in Ethiopia is similar, as it is in Tanzania and Ghana as well.

Other thematically relevant fields include water, energy, biotechnology / bio information technology, as well as health, environmental, and geosciences. If we take a look at the disciplines in which Humboldt Africa scholars are engaged, we find that the most prominent role is played by chemistry /pharmacology, biosciences, and agricultural and forestry sciences. There are hardly any scholarship or grant holders active in the engineering sciences.

24 The reader will find a list of important centers of excellence and research and university networks in Table 12, Annex.

25 NASAC was founded in 2001 as part of the Third World Academy of Sciences (TWAS). NASAC's goal is to develop strategies for a future research policy in Africa, to support research projects of national academies, and to network African research institutions on a worldwide basis. The participating academies include: the Cameroon Academy of Sciences, the Ghana Academy of Arts and Sciences (GAAS), the Kenya National Academy of Sciences (KNAS), Madagascar's National Academy of Arts, Letters and Sciences (AcNALS), the Nigerian Academy of Sciences, the Académie des Sciences et Techniques du Sénégal, the Academy of Sciences of South Africa (ASSAf), the Uganda National Academy of Sciences (UNAS). See Interacademy Panel on International Issues (IAP) (2006).

In Subsaharan Africa centers of excellence are as a rule located at universities. These centers are geared to application-oriented research, promote exchange among researchers, and contribute to building scientific capacities. In addition, they also play a vital catalyst role in disseminating research results in Africa, offer specific training courses for postgraduates, and their reputation and attractiveness extends beyond national boundaries.

Important centers of excellence can be found in particular in Kenya, Nigeria, Ghana, and Senegal. The *Ecole Inter-Etats d'Ingénieurs de l'Equipement Rural* (EIER) in Burkina Faso and the Kigali Institute of Science, Technology and Management (KIST) in Rwanda are additional examples of research centers with regional spillover effects that are already well networked at the international level – although it should be noted that they are in countries that the analyses presented here do not indicate to be candidates for closer consideration as possible cooperation partners.

— EIER is an intergovernmental education and research institution that has, for 30 years now, trained management personnel from various African countries (esp. West and Central Africa) in the engineering sciences (water, energy, environment, infrastructure). EIER is part of an international network, and it maintains partnerships with institutions in both the North and the South. One of EIER's special features is the close links its has with the private sector. It cooperates with Germany via the DAAD and the University of Bonn. Its teaching and research staff stems from twelve different countries. EIER has plans to develop a graduate research training group in 2007 (EIER 2006).

— KIST, founded only in 1998, was established on the initiative of the Rwandan government in cooperation with United Nations Development Programme (UNDP) and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ). It also receives some funding from the Japanese and Dutch governments, and it works closely together with the private sector in Rwanda. KIST trains students in engineering, technology, and management; some of its professors have been trained abroad (mainly in Uganda, Kenya, South Africa, the US, and India). As far as Germany is concerned, KIST is also engaged in cooperation with the universities of Flensburg and Aachen and the Münster University of Applied Sciences. The institute is currently also receiving support from the German state of Rhineland-Palatinate (KIST 2006).

— One of Kenya's most important centers is the International Livestock Research Institute (ILRI). ILRI is one of 15 international agricultural research institutes selected for support by the Consultative Group on International Agricultural Research (CGIR); it cooperates closely with national agricultural research institutions, the private sector, and nonstate organizations. Biosciences East and Central Africa (BECA), a center of excellence, was set up at the ILRI with support from the Canadian Development Agency and on the initiative of NEPAD. BECA serves as a node for a regional network of research institutes active in the field of biotech research (Chataway / Smith / Wield 2005, 16f.). Kenya is also home to the International Council for Research in Agroforestry (ICRAF), a CGIAR member, as well as the Kenya Agricultural Research Institute (KARI). Another important center of excellence in Kenya is the International Centre of Insect Physiology and Ecology (ICIPE), which conducts research in the fields of molecular biology and biotechnology and population science and ecosystems. Apart from agricultural and biotech research, medical research also plays an important role in Kenya – e.g. the Kenya Medical Research Institute (KEMRI). In addition the African Economic Research Consortium (AERC) is located in Nairobi; it trains a large number of scientists, PhD candidates, and masters students and engages in policy-relevant economic research.

- Nigeria is home to another of the above-mentioned 15 international agricultural research centers; it is affiliated with the University of Ibadan. The International Institute for Tropical Agriculture (IITA) employs scientists from 30 countries, most of them in Subsaharan Africa, and it has offices in 10 Subsaharan African countries. The institute's main fields of research are cultivation and postharvest systems. Two other important centers in Nigeria are the Centre for Peace and Conflict Studies at the University of Ibadan and the National Centre for Energy Research and Development.
- Two of Ghana's important centers are the Ghana-India Kofi Annan Centre of Excellence in ICT and the International Water Management Institute (IWMI). Apart from Accra, the IWMI also has regional offices in Addis Ababa (Ethiopia) and Pretoria (South Africa).[26] In addition, the IWMI cooperates with universities in Nigeria, Senegal, and Burkina Faso, as well as with international partners and NGOs. Another research center – which is not yet very well networked at the regional level – is the Kumasi Centre for Collaborative Research in Tropical Medicine (KCCR). The KCCR was set up by Ghanaian health ministry, the University of Science and Technology (KNUST), and the Hamburg-based Bernhard Nocht Institute for Tropical Medicine; it serves as an international platform in the field of tropical medicine research. The KCCR cooperates with the Munich Tropical Institute as well as with medical research centers in the Netherlands and Belgium.
- One institution of particular importance in Senegal is the Council for the Development of Social Science Research in Africa (CODESRIA). CODESRIA is a supraregional social science research institute; it provides post-graduate research grants, publishes two journals, and offers regular advanced training programs.

Aside from centers of excellence, institutional networks also play an important role in promoting science and research in Africa. One such arrangement that deserves to be mentioned in this connection is the Nairobi-based African Network of Scientific and Technical Institutions (ANSTI), whose members include science and engineering faculties and other education institutions in nearly all Subsaharan African countries. However, ANSTI's large membership and weak administrative structures often pose problems when it comes to coordinating new programs. ANST is already receiving German support through the DAAD and the GTZ.

2.1.4 Interim results

The analyses presented thus far indicate that the on the whole low levels of public R&D expenditure and the lack of private-sector investment in Subsaharan Africa represent unfavorable preconditions for research cooperation with countries in the region. The extremely low number of patent applications by nationals is one indication that on their own most countries in Subsaharan Africa are not able to boost their competitiveness through systematic efforts to modernize or improve products. One important reason for this must be seen in structural deficits in the (university) education sector. Rising numbers of students in a situation marked by declining or stagnant public investment in tertiary education increase the risk of brain drain. The fact hat universities are usually not networked with

26 The IWMI works in the following fields: integrated water resource management, technology adaptation and dissemination, policies and institutional capacity-building, malaria risk associated with irrigation, und safe use of wastewater and solid waste in (peri)-urban agriculture (IWMI 2006).

the private sector or with potential employers leads to a mismatch between demand for and supply of research outputs, reducing the attractiveness of certain courses of study, in particular in the pure and engineering sciences. This situation is further exacerbated by general management problems and deficits in quality management.

Despite the deficits referred to, there are, as noted, countries in the region whose education and research bases is more advanced than those of other comparable countries. The former have e.g. a noteworthy volume of scholarly publications, a relatively good education system, and a critical mass of students, or they have developed important centers of excellence in recent years. These countries would include: Kenya, Nigeria, Ghana, Ethiopia, Senegal, Mauritius, Tanzania, Uganda, Botswana, Namibia, Cameroon, Zimbabwe, and Sudan. In the following chapter these countries will be examined in terms of their political and economic framework conditions. The other countries in the region will not be given any explicit consideration in what follows.

2.2 Political and economic framework conditions for bi- and multilateral research cooperation

In particular when it comes to applied research projects and cooperation with the private sector, good governance and economic efficiency are essential preconditions for any sustainably successful STC. It will not be possible to go into the political and economic framework conditions given in the countries of Subsaharan Africa at any length here. With a view to coming up with a rough outline of the basic political and economic conditions encountered in the countries identified above, the following analysis will therefore be restricted to an evaluation of aggregate indices. Even though this approach is no substitute for an in-depth look at country-specific conditions, these indices do provide some approximate values that can be used for an initial assessment.

A look at the governance situation of a selected number of countries

As far as possible cooperation projects with the BMBF are concerned, the key locational factors are political stability and domestic security, rule of law, and efforts to control corruption. These conditions are crucial to any efficient, long-term use of research and technology as well as for a country's attractiveness for highly qualified scientists and researchers.

With a view to sketching a picture of these conditions, the present analysis will be based on the internationally recognized governance indicators developed by Kaufmann / Kraay / Mastruzzi (2005).[27] These indicators cover the population's political voice, the stability

27 Since 1996 these indicators have been used in two-year intervals to assess a present total of 209 countries. An assessment ranging between –2.5 and +2,5 is determined per country; +2,5 is the highest possible performance score. Due to the high standard deviations for some countries, no exact country ranking is prepared. Instead, country performance is broken down into four quartiles. The author's of the index deliberately avoid presenting any exact ranking, the aim being to avoid a situation in which the countries covered engage in a race for positive rankings. The concern is, instead, to point to the governance problems of individual countries.

and effectiveness of government and public institutions, and the accountability of government, police, and judiciary.[28]

According to Kaufmann / Kraay / Mastruzzi, Mauritius, Botswana, and Namibia are on the whole marked by relatively good political stability and domestic security, although the situation in these countries has worsened since1996. Ghana, Tanzania, and Senegal have a medium ranking within the region. Senegal deserves special notice here: between 1996 and 2004 it improved appreciably on its ranking for political stability and domestic security. According to the index, the quality of political stability and domestic security has declined since 1966 in Kenya, Uganda, and Ethiopia.

If we look into the issue of corruption-control measures in the countries referred to, we largely find this picture confirmed. Internationally, Botswana and Namibia rank among the best 25 %. We also find clearly positive developments in Ghana, Tanzania, Senegal, and Cameroon. While Kenya and Ethiopia have improved on corruption control since 1996, they still remain in the lower quartile.[29] Special mention in this connection is due to Tanzania, where appreciable progress has been made since 1996 in fighting corruption. If, in 1996, Tanzania was ranked overall as one of the world's most corruption-prone countries, it now has a better track record on corruption control than nearly 60 % of the countries covered by the index.

A third relevant indicator for political framework conditions is confidence of the population and business in the judiciary and the effectiveness of police and courts (rule of law). Mauritius and Botswana's legal systems are ranked on the index as relatively reliable. Namibia also ranks among the world best 50 %. The reliability and effectiveness of Tanzania and Uganda's judiciary improved between 1996 and 2004. According to the index, rule of law in Kenya and – in particular – Ethiopia has developed negatively since 1996. These findings are largely consistent with the rankings determined on the basis of the other two governance indicators.

On the whole, a look at basic trends in good governance is sobering. In particular, countries – like Nigeria and Kenya – that offer good preconditions for research cooperation tend to be characterized by unstable political conditions, inadequate efforts to combat corruption, and inadequate rule of law. Even though political considerations would rule these two countries out from recommendation for cooperation, their relatively high potential in science and research would nevertheless commend them for possible participation in German-African science cooperation. Instead of cooperation with the private sector or on applied research projects, Nigeria and Kenya cold be given consideration for direct univer-

28 The individual indicators: Voice and accountability (popular election of government, political and civil rights, independent media); political instability and violence (government stability); government effectiveness (independent civil service, government credibility, quality of civil service, quality of public administration); regulatory quality (quality of government regulation in banking, foreign trade, and business development); rule of law (popular confidence in the system of justice, enforceability of contracts, incidence of crime, and thus effectiveness of police and courts); and control of corruption (use of public power for private ends, large- and small-scale corruption, public-sector self-enrichment).

29 Moreover, the Githongo Dossier has turned out to be one of the major corruption scandals in recent years for the Kenyan government, and more of the like is coming to the public attention. This casts fundamental doubt on the present government's legitimacy, and it may, in the short term, even destabilize the political situation in Kenya (Perras 2006).

sity-level cooperation. In Ethiopia and Cameroon as well, the conditions required for cooperation are undermined by high levels of corruption and deficits in the rule of law. Here it would be necessary, prior to embarking on any cooperation, to conduct an exact analysis of the political conditions presently found there. Under the political conditions currently given in Sudan and Zimbabwe, both of which are assessed very critically, it will not be possible to develop any new cooperation projects with them. Both countries are for this reason not given any further consideration in what follows.

In view of the basic political conditions given in countries like Ghana, Senegal, or Tanzania – none of which, though, is especially relevant when it comes to research – consideration might well be given to cooperation with them. In the last ten years these countries have largely developed in positive directions. Mauritius, Botswana, and Namibia are likewise rated very well on corruption control, political stability, and credibility of the judiciary.

Macro- and microeconomic performance

What is needed – in addition to a stable political framework – if STC measures are to be sustainably successful is a positive economic development potential. Cooperation partners should be in a position to bear their share of the costs of research projects, and their economies should have sufficiently large demand for research outputs. Key macroeconomic data offer one initial impression of whether these structural conditions are in place. Another important factor that should be known in order to be able to judge whether positive ongoing trends are likely to continue and present economic dynamics are in fact sustainable is a given country's microeconomic investment and business climate. These interrelationships are mapped by the World Economic Forum's (WEF) Global Competitiveness Indices; they serve to asses the economic performance and competitiveness of a present total of 117 countries. The indices includes the Growth Competitiveness Index (GCI) and the Business Competitiveness Index (BCI).[30]

On the whole, the GCI indicates that the competitiveness of all Subsaharan countries is far below the international average. The exceptions include – alongside South Africa – Botswana, Mauritius, and Ghana. Even though Namibia is also ranked as relatively competitive, the country has fallen behind in comparison to the ranking it was given in 2004. The GCI sees very poor quality for the macroeconomic environment in Zimbabwe and Cameroon. According to the BCI, South Africa, Ghana, Mauritius, Botswana, and Kenya have a relatively positive microeconomic environment. Compared with 2004, a clear-cut improvement in the investment and business climate is seen above all for Ghana and Tanza-

30 The most recent assessments refer to the year 2005. Some of the data from the Global Competitiveness Surveys used here are also used by Kaufmann / Kraay / Mastruzzi for their governance indicator. But the Global Competitiveness Indices will be dealt with separately here on account of their specific consideration of the economic environment. The – macroeconomically oriented – GCI includes assessments of a country's overall macroeconomic framework, the quality of public its institutions, and its technology level. The – microeconomically focused – BCI supplements the former index by measuring the conditions given for private-sector activities in a given country. The assessment includes estimates of business innovation capacities as well as of the quality of the business climate. On the whole, the GCI and the BCI are calculated on the basis of both quantitative data (e.g. state of public finances, use of public funds, Internet access at schools, numbers of university students) and qualitative data (e.g. regarding independence of the judiciary, institutionalized corruption, and inefficient state intervention private-sector activities). The results must be seen as approximate values on which an initial assessment may be based. For exact country ratings on GCI and BCI, see WEF (2005).

nia. In Ghana this is due to advances in the quality of public education institutions, in Tanzania to improvements in working conditions (WEF 2005, 21). As far as the framework conditions for private-sector activities are concerned, Namibia, Nigeria, and Uganda show little potential when looked at in the overall African context. While Senegal is not included in the GCI or the BCI, its growth prospects are good, the economic framework is stable, and the country is attracting growing amounts of direct investment (bfai 2006).

As far as their basic micro- and macroeconomic conditions are concerned, Ghana, Mauritius, and Botswana thus offer – in relative terms – the best potential in the region. In addition, Ghana in particular has in recent years appreciably improved its framework conditions and its growth prospects. In recent years Tanzania too has substantially improved it macroeconomic framework, and today its is, after Kenya, the East African country with the greatest absolute economic strength (measures in GDP terms).[31] While the macroeconomic picture in Namibia has deteriorated in recent years, the country does, compared with other Subsaharan African countries, continue to have efficient public institutions and favorable growth prospects. In view of its sheer absolute economic power, Nigeria should not be excluded as a potential cooperation partner on purely economic grounds, although the country will not be eligible as a partner for German research institutions such as the FhG or the MPG, both of which attach importance to economic performance and, at the same time, an investment-friendly business climate. The same applies for Ethiopia and Cameroon. While Ethiopia is seen as having good growth prospects, it is presently among the ten countries in the world with the lowest standards of living (UNDP 2005), and here it ranks among the poorest 10 % of the countries covered by the aggregate indices under consideration here. As far as both its macroeconomic situation and the country's business climate for private-sector companies are concerned, Cameroon too has a relatively poor rating by cross-country comparison.

2.3 Regional network function of selected countries

The analyses presented thus far have shown that by cross-country comparison most Subsaharan countries have relatively weakly developed bases for research and education projects. They often lack the critical mass of good scientists needed to develop sustainable research projects. For lack of capacities, some individual African countries are frequently unable to participate effectively in international research and to become engaged in the associated policy debate. On the other hand, some countries with good preconditions in education and research have major shortcomings when it comes to their political and economic framework conditions. It would therefore appear reasonable to refrain from placing research and science cooperation with them exclusively on a bilateral footing (see Box 6). Instead, it would be possible to strengthen regional research and education networks there by promoting high-potential universities, centers of excellence, or regional associations of universities in promising locations, the aim being to engage in cooperation extending beyond national boundaries. Some countries with low capacities could e.g. be included in STC, while, on the other hand, cooperation projects involving German STC actors would provide for a high level of regional visibility.

31 For exact economic data on individual countries, see Table 10, Annex.

Box 6: Examples of university-level regional initiatives

In 1999 the East African Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development (BIO-EARN 2006) was created in East Africa with the support of the Swedish International Development Cooperation Agency (SIDA). BIO-EARN is a regional network linking research institutions and the technology and science ministries of Ethiopia, Kenya, Tanzania, and Uganda. BIO-EARN's goal is to strengthen regional research capacities in the field of biotechnology. Among other things, the project contains an exchange program for African PhD students at Swedish universities.

The University Science, Humanities and Engineering Partnerships in Africa (USHEPIA) organization was set up in 1993 on the initiative of the Association of African Universities (AAU); the organization is an association of eight universities in eastern and southern Africa.[32] USHEPIA, which receives support from international donors, is in large measure managed by the University of Cape Town in South Africa. USHEPIA's goal is to develop and strengthen African research networks and to promote the exchange of scientists and students in joint masters and PhD programs in the region.

Some Subsaharan African countries already have a certain regional network function. They are engaged in international cooperation and are home to important regional or intergovernmental science and research centers. Furthermore, some countries with economically and political stable conditions may come in for consideration as regional centers of STC cooperation. In view of the fact that in new cooperation projects the BMBF pursues the aim of achieving a certain level of project visibility and heightening the (supra)regional profile of German know-how in education and research, cooperation with Mauritius would, despite the country's good initial conditions in education and research, not appear to be a viable option. Mauritius has neither important regional networks nor – due to its geographic location – any really pronounced political and economic significance for the African continent.

Kenya has an important regional network function in **East Africa**. As shown above, the country is home to some important agricultural and biodiversity research centers, and it is integrated within a number of research networks. Moreover, the African Academy of Sciences is headquartered in Nairobi. As was also shown above, Kenya also has a relatively good education and research base and its macroeconomic performance is relatively good. One reason why Ethiopia plays an important political role in East Africa is that its capital, Addis Ababa, is the headquarters of the African Union (AU) and the UN Commission for Africa. However, Kenya is far ahead of it when it comes to networking in science and research. As headquarters of the Inter-University Council for East Africa (IUCEA), Uganda has an important network function.

In its capacity as headquarters of the AAU and home to some important regional research institutions, Ghana could play a role for possible university and research cooperation in **West Africa**. In addition, the UN Food and Agriculture Organization has its Africa office in Ghana. This fact is relevant to the extent that the agricultural sector plays an important role – in education and research as well – for all African countries. As the headquarters of the Economic Commission for West African States (ECOWAS), Nigeria plays a relevant role for the region of West Africa. However, for historical reasons relations between Ghana

32 Makarere University (Tanzania), Jomo Kenyatta University of Agriculture and Technology (Kenya), University of Nairobi (Kenya), University of Dar es Salaam (Tanzania), University of Zambia, University of Zimbabwe, University of Botswana, University of Cape Town (South Africa).

and Nigeria are strained.[33] As a Francophone country with one internationally known university, Senegal plays a central role in West Africa, a region in which French is very widely spoken.

In both political and economic terms and in the education sector, South Africa by far plays the most important role in **Southern Africa**, and this fact has already found expression in numerous forms of cooperation. In implementing a new cooperation strategy in southern Africa it would be possible to make use of relevant partner institutions in South Africa. Aside from South Africa, Botswana, as the headquarters of the Southern African Development Community (SADC), plays a particularly relevant role for southern Africa.

3 Conclusion and recommendations for future projects involving German STC actors

3.1 Conclusion and list of countries with cooperation potential

Efforts to identify countries suited for cooperation with the BMBF aimed at intensifying STC with the region of Subsaharan Africa indicate a goal conflict between research goals and development goals. On the one hand, the BMBF's primary interest is to strengthen the competitive of Germany's system of science and research as well as to engage in cooperation with optimal partners throughout the world. On the other hand, there is – in the scientifically more advanced countries of Subsaharan Africa as well – still a need in the region to build suitable education and research infrastructure and national knowledge systems. In formulating a new Africa strategy, the BMBF would first have to decide whether and to what extent it is prepared to invest in the capacity-building measures pledged at the Gleneagles G8 summit, alongside its cooperation with scientists and institutes in the region.

As we have seen, cooperation between science and private sector in the scientifically more advanced countries of Subsaharan Africa is generally weakly developed. One reason for this is a relatively innovation-averse private sector and a low level of industrialization in the region. Another is that science and research have only in recent years come to assume political importance in the region, and for the most part they are not yet systematically promoted. While a good number of formal R&D promotion institutions have been created in the region, there is still often a pronounced lack of clear-cut programs designed to anticipate and implement ongoing developments in R&D. As we have also seen, the political and economic frameworks are unfavorable in some of the countries in the region that meet the science criteria defined by German STC actors. Yet even such countries should not be wholly excluded from German STC; indeed, they may qualify for indirect, university-level cooperation or cooperation in the form of exchanges of scientists.

The final selection of cooperation partners for the BMBF should in the end depend on which German research institutions or facilities are looking for new projects and what political impulses the BMBF wishes to provide in Subsaharan Africa. It would be particu-

33 In 1983 Ghanaian migrants, many of them highly qualified, were expelled from Nigeria. Both the memory of these events and a number of subliminal animosities continue to strain the relations between these two countries (Brydon 1985, 570).

larly advisable here to seek to expand existing cooperation projects, since this would make it possible to build on existing networks and infrastructure. As was shown above, DAAD and AvH in particular have already gained considerable positive experience with their scholarship and grant programs in cooperation with countries in Subsaharan Africa, and this experience could be harnessed for further cooperation projects. This experience has also been factored into the overall assessment presented here. Generally speaking, ten countries in the region would – with certain provisos – be suitable as partners for the BMBF:

Kenya is one of the regions' countries with the greatest innovation potential in research and technology, it is second only to Nigeria when it comes to scientific publications, and it has a relatively large number of universities. Another relevant factor is the important role the country plays in science and research as home to the NASAC, the AVU, and the ANSTI network, all of which are based in Nairobi. With its well-networked research institutes, Kenya is also in a position to engage in international cooperation in the fields of agricultural and biodiversity research. And Kenya receives a good number of the scholarships and grants awarded by the DAAD. Kenya's important deficits include the country's inadequate institutional structures, precarious domestic security situation, and high levels of corruption.

Nigeria offers a very large pool of well-trained scientists and researchers. As far as its output of scientific publications and its absolute number of students is concerned, it is second only to South Africa, and it is thus one of the region's leaders. In addition, thanks to its absolute economic strength, Nigeria is potentially capable of cofinancing research projects. Through the AvH and the DAAD, Germany is already promoting numerous Nigerian students and scientists. However, the country's present low level of domestic security and poor business climate make it difficult to unreservedly recommend Nigeria for intensive bilateral research cooperation.

The relatively large number of students majoring in scientific-technical subjects in **Ghana** is an especially attractive point for German research institutes with relevant focuses. In addition, Ghana is one of the few countries in the region with good secondary education rates, i.e. it is a country that pays attention to promoting potential young scientists. Compared to other West African countries, scientists from Ghana also account for a large volume of publications. Ghana is also the headquarters of the Ghana-India Kofi-Annan Centre for Excellence in ICT, the Kumasi Centre for Collaborative Research in Tropical Medicine, and the International Water Management Institute, all of which are important research centers with regional spillover effects. In addition, compared with other countries in Subsaharan Africa, Ghana has a relatively good institutional framework for education and research. And with the AAU headquartered in Accra, Ghana also has an important role to play for the African university sector. It must, though, also be noted that the literacy rate in Ghana is relatively low.

While **Ethiopia** has an extremely low literacy rate of under 40 % and poor primary and secondary education rates, the country's sheer size and relatively large growth and innovation potential nevertheless might commend it for cooperation. And not least, being the headquarters of the AU, Ethiopia has a key function in the region in political terms. Ethiopia also has relatively a large number of students and its scientists account for a good number of scholarly publications, both of which must be seen as good foundations for

cooperation, which could build – among other things, on the large store of experience already gained by the DAAD and the AvH in the country.

In recent years **Senegal** has made major progress on its way to a knowledge-based society. This is evident, among other things, in a volume of scientific publications that has risen in recent years as well as in the country's ICT infrastructure, which is very good compared with other African countries. Analyses published by the Coimbra Group indicate that Senegal's universities have the largest degree of autonomy in Subsaharan Africa (Coimbra Group 2003, 12). In addition, the Cheikh Anta Diop University in Dakar rates well on university rankings and maintains international contacts with both German and French universities. Dakar also has a social-science research center, CODESRIA, that is highly relevant for the African continent. However, despite progress in the education sector, Senegal continues to have low literacy and primary education rates.

The University of Dar es Salaam gives **Tanzania** considerable significance in Subsaharan Africa's education and science sector; in addition, the country's research potential has improved appreciably in recent years. This finds expression, among other things, in an output of scientific publications relatively high by regional comparison. However, Tanzania has a relatively low university enrollment rate, which means that the country is unable to train sufficient numbers of potential young scientists. Looked at in terms of domestic security, the rule of law, and control of corruption, Tanzania would, at present, be the East African country best qualified for cooperation.

Investment in human resources and research are accorded high priority in **Uganda**, and the county's output of scientific publications is relatively high as well. In addition Makarere University plays an important role in the region, although, apart from the health sciences, the university has not set priorities in the pure sciences. The country also is home to an important regional university network (the IUCEA). In political terms, however, Uganda is (due, among other things, to insurrectionist activities in the north of the country) currently far less stable than Tanzania.

The quality of **Botswana**'s public education institutions is high, and in recent years scientists in the country have accounted for a growing number of publications. In addition, Botswana has good foundation in both primary and secondary education, and the country is seen as having an innovation potential that is good by international comparison. Despite these positive starting conditions, Botswana's small population places limits on the number of qualified scientists in the country: Botswana has only one public university with a low student population of only roughly 9,000. This may be the reason why Botswana has until now been involved in very few cooperation projects with German STC actors, and this in turn has placed limits on efforts to build on existing networks in scientific cooperation.

Namibia has a well-developed education sector as well as good and widely diffused ICT infrastructure. In addition, the University of Namibia and the Polytechnic of Namibia enjoy a good reputation as far as research in the pure sciences is concerned. In Namibia science and technology are promoted chiefly via the university. Namibia's high level of political stability and investment-friendly business climate place the country in an attractive light for both private-sector and intergovernmental cooperation on the ground. Cooperation projects between Namibia and the DFG and the MPG have created networks on

which new cooperation projects can fall back. One of the county's major minus points is the low number of students enrolled there. The output of scientific publications in Namibia has not been measured.

Cameroon ranks relatively high in the region on scientific-technical publications. The country also has a relatively large number of university students (81,000) and offers good foundations for university cooperation as well as a sufficient number of potential young scientists. In the past, however, the country's high level of corruption and relatively poor economic climate have led to a growing brain-drain problem. In addition, International rankings do not indicate that Cameroon has any particularly promising innovation potential. But the projects that the DFG has already promoted in Cameroon would speak in favor of intensifying STC there. In addition, there are a good number of students from Cameroon studying in Germany with the aid of DAAD scholarships, and this means that good links have already been forged between the two countries in this area.

3.2 Approaches to regional cooperation

None of the prospective countries named above have at the same time good scientific qualifications and stable political and scientific conditions. Instead of embarking on any more intensive cooperation between German STC actors and individual Subsaharan African countries, it would therefore appear more reasonable to envision a regional orientation for cooperation in education and research (see Box 7). In particular, countries with good governance could assume an anchor function for cooperation projects with the BMBF. It would at the same time be possible to include scientists and researchers from the entire region in such research projects.

Box 7: Advantages of a regional orientation for German STC with Subsaharan Africa

- Successful regional initiatives – especially in the fields of biotechnology and agricultural research – show that regional initiatives can prove more effective in harnessing the research capacities of African scientists and researchers than individual, country-specific initiatives.
- The necessary critical mass of excellent scientists is more likely to be given at the regional level than in individual countries. Furthermore, it would in this way be possible to include in cooperation projects scientists from other countries that have not proven eligible for STC.
- Regional cooperation projects generate greater spillover effects, and this may mean that German institutions would in this case be able to gain a higher profile as research partners.
- Regional initiatives are also receiving more and more financial and political support from the AU in the framework of the NEPAD Initiative as well as from bi- and multilateral partner organizations, and this would make it possible make use of synergies with other institutions.
- And in particular, the southern and eastern African countries under discussion here already maintain close links in the field of science and research.

Looking at **Southern Africa**, it would appear reasonable to cooperate with Namibia and Botswana via South Africa. In view of the country's preeminence in the region, both as regards education and research and at the political and economic level, it would not be recommendable to embark on cooperation projects without South Africa. The Southern African Development Community (SADC) also expressly support efforts to develop regional associations and centers of excellence in the field of education and research in southern Africa.

In **East Africa** it would, in the same vein, be recommendable to seek to include Kenya, Tanzania, Uganda, and Ethiopia in regional cooperation projects. Via the BIO-EARN network, intensive contacts have already been developed between research institutions and technology and economic ministries in these four countries. And Tanzania, Uganda, and Kenya are already engaged in an inter-university exchange. In view of the negative political development in Kenya in recent months, it would be more recommendable to give consideration to Tanzania as an anchor for regional cooperation.

There are already far more regional research and education networks in southern and eastern Africa than in **West Africa** (Coimbra Group 2003, 28). While it would be reasonable to embark on cooperation with the Anglophone West African countries proposed above, i.e. Nigeria and Ghana, with Ghana, the more politically stable of the two countries, assuming an anchor function, it is questionable whether a project of this kind would prove practicable because of the historical differences between Nigeria and Ghana. All the same, it would be recommendable to look into regional approaches here as well, possibly with a view to including Cameroon and Senegal at a later point of time.

3.3 Key points for a BMBF cooperation strategy

Having identified a number of potential partner regions for German STC, what remains now is to discuss the issue of how best to formulate BMBF cooperation projects with Subsaharan African countries. While the present study cannot present an exhaustive discussion of the topic, it will nevertheless be possible to set out, by way of conclusion, a number of key points for consideration. These are meant as impulses, and they are in need of intensive discussion with experts from Germany and Africa as well as verification on the ground.

1. *Cooperation with regional centers of excellence and universities with good performance records*

The country analysis presented here has made it clear that relevant research is being conducted at universities and centers of excellence that have a regional or even supraregional orientation. Intensification of its research cooperation through regional centers of excellence (e.g. in cooperation with the DAAD, the DFG, the AvH, and German universities) would best enable the BMBF to profit from local knowledge and to expand its international networks. In addition, cooperation projects would entail regional spillover effects. At the same time, it would in this way be possible to strengthen the potential these centers of excellence have to stimulate and support social innovation and reform and to support Africa's integration into international science. There are centers of excellence of supraregional importance first and foremost in Kenya (e.g. International Livestock Research Institute, International Centre for Physiology and Ecology), but also in Nigeria (e.g. International Institute of Tropical Agriculture) and Ghana (e.g. International Water Management Institute).

The BMBF could seek to intensify its promotion of regionally specific mobility programs for post-doctoral scholars by way of cooperation with universities (e.g. University of Dar es Salaam in Tanzania, University of Ibadan in Nigeria, University of Namibia). Some thought might also be given to developing an international post-graduate research training

group. In thematic terms, this would have to be of interest for partner countries and for Germany alike. Targeted promotion of practice-relevant university research could, in the longer term, also strengthen the cooperation between German and local companies.

2. Orientation of new projects to the NEPAD science and technology strategy

Brain drain must be seen as one of the major obstacles to output of high-quality research in Subsaharan Africa. Trained at African universities, many good scientists later leave the continent for lack of job opportunities or because of the weak political structures given there; others study abroad right from the start. NEPAD is seeking to counteract this effect by building centers of excellence in fields specifically relevant for Africa and by promoting good governance. German cooperation projects should in any case be oriented to the NEPAD science and technology initiative with a view to continuing – as expressly desired by the German government and the other G8 countries – to provide support for the efforts undertaken by African countries in the NEPAD framework. Moreover, it is not possible to ensure that research cooperation projects will be sustainable unless care is taken to ensure that new projects are integrated into national and regional political goal frameworks and development strategies.

In the framework of the initiative, the African Ministerial Council on Science and Technology (AMCOST) and the associated Steering Committee for Science and Technology are responsible for identifying concrete science and technology priorities for the NEPAD countries and developing political programs harmonized with these priorities. In August 2005 a ministerial conference adopted the Africa's Science and Technology Consolidated Plan of Action; it is to be supplemented by the AU Commission's 2004–2007 Strategic Plan for Human Resources, Science and Technology (AU / NEPAD 2005). The express goal is to strengthen national and regional innovation systems by developing networks and centers of excellence in conjunction with specific R&D and capacity-building programs. The funds made available to implement the action plan are being used primarily to develop, use, and ensure the sustainability of water resources as well as to create a sustainable energy base. In particular, efforts undertaken to support specific R&D and capacity-building programs at universities and centers of excellence could be closely coordinated with German DC institutions.

3. Focus on national knowledge systems

In envisioning new cooperation projects between Germany and Subsaharan Africa, or in becoming engaged in existing research programs, care should be taken to ensure that any such joint research programs contribute to increasing the levels of networking between universities, non-university research institutions, and the private sector in the partners countries. Steps should be taken to ensure that research results are also made available to the local private sector. Research cooperation projects can in this way set incentives aimed at reducing brain drain in Subsaharan Africa and at the same time contribute to bolstering national and regional knowledge and innovation systems. This is essential if partner countries are to have a real interest in bearing their share of the costs of research cooperation. Strengthening national knowledge and innovation systems presupposes that research findings are likewise made available to African scientists and that research topics are defied in joint efforts. In the long term this may well also be a good way to strengthen the interest of German companies and technology providers in cooperation with Subsaharan Africa.

4. Cooperation between STC and DC

In view of the fact that all of the Subsaharan African countries proposed for cooperation still lack the high-quality education and research infrastructure they need both to prepare important branches of their economic and research systems for the transition to a global knowledge society and to make them competitive, research cooperation is inconceivable without paying due heed to the political priorities and development goals of the countries concerned. On the German side, one good solution here would be closer cooperation between STC and DC.

Even though neither research cooperation nor university cooperation are among the BMZ's current priority areas, the BMZ does provide support for various university science cooperation programs through the DAAD and the AvH, all of which serve – among other things – the purpose of strengthening university systems and qualifying scientists, engineers, and management personnel in Africa. BMZ funds are also used to cofinance individual DFG promotion programs in Africa. Furthermore, the BMZ provides support for agricultural research through the CGIAR. In other words, synergies are given to the extent that all of the countries proposed for cooperation (except Nigeria and Botswana) are among the BMZ's priority partner countries. Botswana and Nigeria also have important contacts to Germany via the BMZ's implementing agencies (chiefly the GTZ).

BMBF and BMZ could profit from intensified coordination of cooperation with Subsaharan Africa provided that

- BMBF cooperation programs were announced for topics that are among the priorities of the countries concerned. The BMBF could in this way fall back on networks and local knowledge of DC partners, and DC institutions could harness research results to improve their programs;
- the selection of new priority partner countries for the BMBF were coordinated with the BMZ. This would make it possible to gear the activities of the two ministries to joint goals;
- both flanking measures designed to train R&D personnel in business enterprises and vocational training measures bound up with technology adaptation and management were funded and made available through DC (e.g. in cooperation with GTZ and InWent). DC activities could in this way contribute – in the interest of the BMBF as well – to raising the profile of German providers of vocational training in partner regions;
- DC provided advisory support in its cooperation with African science and research ministries as well as in the development of joint cooperation strategies. In view of the fact that research management shows substantial shortcomings even in the region's economically and scientifically more advanced countries, advisory inputs have an essential role to play when it comes to the sustainability of research projects in the fields of research management and institutional development;
- cooperation with DC institutions active in the field of "sustainable economic development" were intensified. This is particularly important in cases where the aim is to forge better links between science and the local private sector. The German science-private sector transfer structure could at the same time serve as a frame of reference in cooperation and be given a more visible profile.

To name some of the thematic DC priorities defined together with governments in the region: the water sector in Kenya, Tanzania, and Uganda; in Kenya, in addition, the health and agricultural sectors; in Tanzania in the field of resources management as well.

In view of the fact that one of the key priorities of DC in Subsaharan Africa is promotion of good governance, it would also be important to examine whether and to what extent the BMBF sees possibilities to focus more on efforts to promote the exchange of scholars active in the social sciences. This would make it possible to raise the visibility of German courses of study in the social sciences that are relevant to developing countries (development economics, regional sciences, political sciences, sociology), which would be in the interest of the BMBF. One particular reason why thought should be given to this is that the social sciences play an important role in the countries under consideration here and local social scientists are in possession of expertise that may be of good use to German social-science research. At the same time, research cooperation could be used to contribute to strengthening democratic structures in partner countries. Moreover, both climate protection and approaches to dealing with climate change are of considerable importance in terms of both research and development policy. Here too, it would be advisable to examine the possibilities offered by combined STC and DC measures.

5. Systematic coordination of German and EU projects

In formulating a new Africa strategy for the BMBF, it would be recommendable to systematically coordinate German projects with current and planned EU projects.

At present the EU is seeking to use cooperation with regional centers of excellence, universities, and scientists as a means to better integrate the countries of Subsaharan Africa into international research cooperation. The EU is working actively to draw up and implement new programs – both in university cooperation and in research cooperation. This would make it possible to identify areas on which the BMBF could focus with a view to becoming more involved in multilateral cooperation projects via the EU. On the other hand, existing programs could serves as an orientation framework for German projects.

To cite an example, the European Development Fund (EDF) Committee recently approved an EU program on university cooperation with countries in Subsaharan Africa. The program's aim is to strengthen the links between research and development work by devoting greater efforts to capacity-building in R&D and by promoting and adapting technologies in African countries. Similar concepts would be conceivable for the German side as well.

Moreover, in February 2006 the European Commission's Directorate-General for Research made additional funds available to make enable scientists from developing countries to become involved in ongoing programs of the 6th EU Research Framework Programme (Hebden 2006). The areas covered by this cooperation are of interest to both sides; they include, among other things, biotechnology and life sciences, but also energy systems and governance research. All 48 Subsaharan African nations are among the program's target countries, and this means that the main concern is to promote scientific excellence on a cross-country basis. Furthermore, in February 2006 members of the EU Directorate-General for Research met with representatives of African academies of science in order to discuss possibilities of integrating Africa into the 7th Research Framework Programme.

With a view to formulating research cooperation strategies in selected priority countries and regions in such a way as to ensure that they are consistent with the strategies of other bi- and multilateral partners, it would be important to liaise with the World Bank as well as with SIDA / SAREC, DFID, and the Canadian International Development agency. In Kenya in particular the agencies just named are working closely together with regional centers of excellence in the fields of energy and biotechnology and are at the same time seeking to establish close links between education and research work.

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Annex

Table A1: DAAD research grants (PhD) in 2000-2004

	2000	2001	2002	2003	2004
Ethiopia	**12**	**6**	**14**	**14**	**10**
Benin	2	2	-	1	3
Burkina Faso	2	1	1	1	-
DR Congo	-	2	-	1	-
Côte d'Ivoire	2	1	-	1	2
Eritrea	-	-	1	-	-
Gabun	-	-	1	-	-
Gambia	-	-	-	1	-
Guinea	-	-	-	1	-
Cameroon	**12**	**9**	**8**	**5**	**5**
Kenya	**9**	**3**	**5**	**7**	**7**
Congo	-	-	-	1	-
Madagascar	-	1	-	-	-
Malawi	1	-	-	-	-
Mali	-	2	-	-	-
Mozambique	-	1	-	-	1
Namibia	-	1	1	-	-
Nigeria	**8**	**8**	**4**	**7**	**7**
Rwanda	-	-	-	-	1
Senegal	1	-	1	-	1
Sierra Leone	1	-	-	-	-
South Africa	1	5	1	6	2
Sudan	**5**	**8**	**4**	**9**	**10**
Tanzania	-	1	1	-	2
Togo	-	1	-	-	-
Chad	1	-	-	-	-
Uganda	-	-	2	-	1
Total	**57**	**52**	**44**	**55**	**52**

Source: DAAD (internal)

Table A2: DAAD scholarships/grants in 2004

2004	New awards				Extensions			
	Sur place	Third country	Master	PhD	Sur place	Third country	Master	PhD
Ethiopia	8		6	2	13		12	1
Ghana	5		5		5		5	
Kenya	**28**	**1**	**6**	**23**	**83**	**6**	**28**	**61**
Namibia	4	15	18	1	3	11	14	
Tanzania	9		8	1	21		15	6
Uganda	24		18	6	57	4	51	10
South Afric	55		41	14	38		23	15
Sudan	31		9	22	64	1	28	37

Source: DAAD (internal)

Table A3: DAAD scholarships/grants in 2003

2003	New awards				Extensions			
	Sur place	Third country	Master	PhD	Sur place	Third country	Master	PhD
Ethiopia	9		8	1	12		12	
Ghana	5		5					
Kenya	**39**	**3**	**17**	**25**	**72**	**4**	**22**	**54**
Namibia	3	14	17		5	17	20	2
Tanzania	10		6	4	17		15	2
Uganda	28		23	5	44	5	45	4
South Afria	55		38	17	25		15	10
Sudan	33		16	17	57	3	25	35

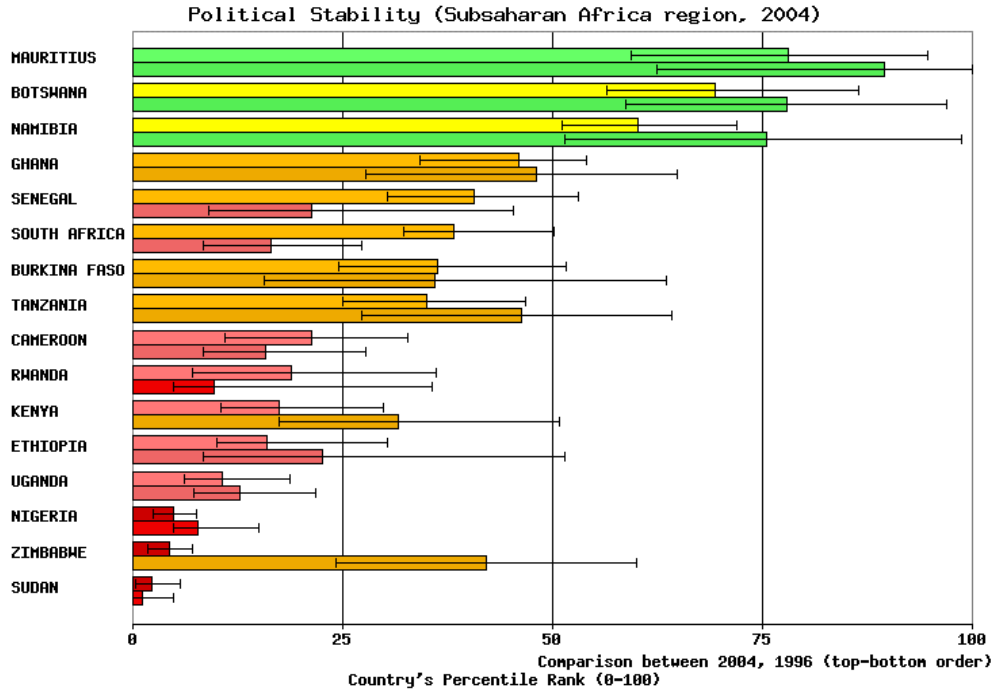
Source: DAAD (internal)

Table A4: Humboldt scholarship/grant holders by country of origin 1953-2004

Benin	3
Burkina Faso	1
Cameroon	**22**
Congo, DR	15
Congo	2
Côte d'Ivoire	4
Eritrea	3
Ethiopia	**13**
Gambia	1
Ghana	**16**
Guinea	1
Kenya	**12**
Madagascar	3
Mali	1
Mauritius	2
Namibia	2
Niger	1
Nigeria	**137**
Rwanda	2
Senegal	5
Sierra Leone	4
Somalia	1
South Africa	**215**
Sudan	**24**
Tanzania	7
Togo	3
Uganda	1
Zimbabwe	5

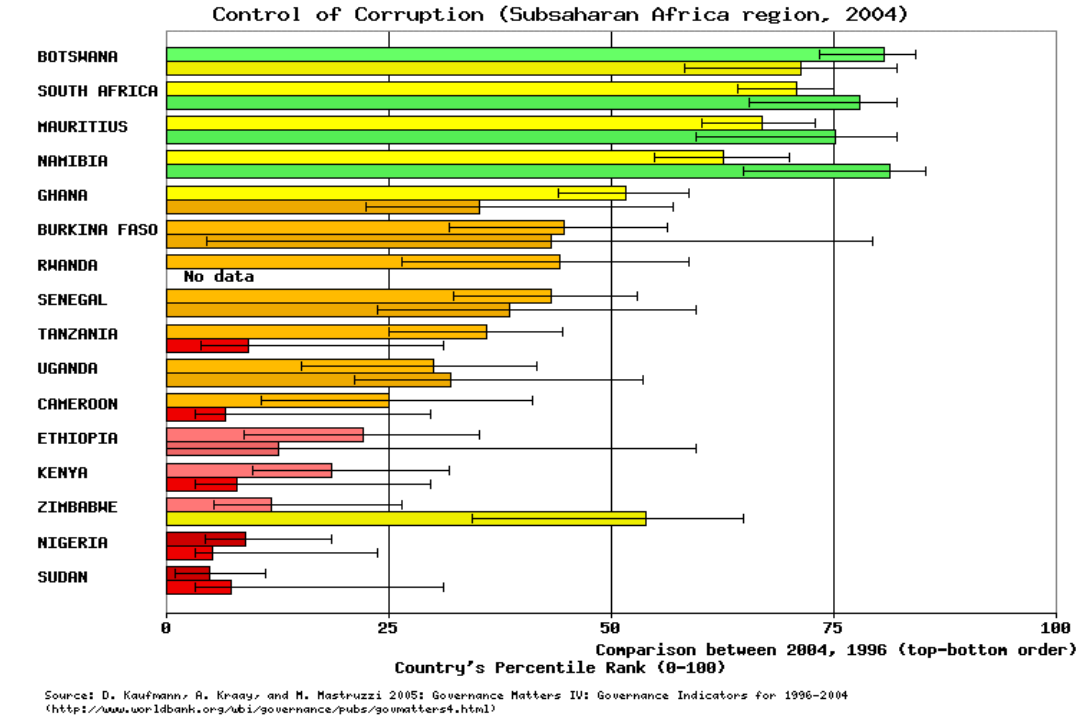
Source: AvH (internal)

Figure A1: Political stability and domestic security in selected countries in 2004, compared with 1996



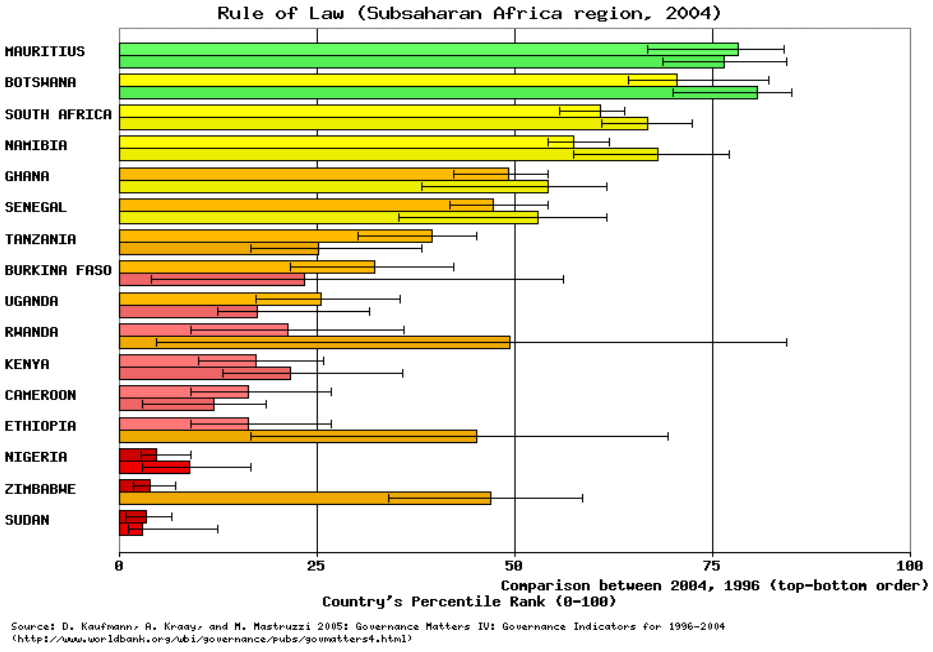
Source Kaufmann / Kraay / Mastruzzi (2005)

Figure A2: Control of corruption in selected countries in 2004, compared with 1996



Source: Kaufmann / Kraay / Mastruzzi (2005)

Figure A3: Rule of law for selected countries in 2004, compared with 1996



Source: Kaufmann / Kraay / Mastruzzi (2005)

Table A5: Economic data for 2000 and 2004 for selected countries

	BIP (In million US$ at present value)		GDP growth per year (%)		GNI per capita in US$		GNI (in million US$ at present value)	
	2000	2004	2000	2004	2000	2004	2000	2004
Botswana	5251	8659	7,65	4,58	3010	4340	5037	7490
Cameroon	**8879**	**14733**	**4,20**	**4,80**	**570**	**800**	**8639**	**13138**
Cote d'Ivoire	**10599**	**15286**	**-2,27**	**-2,30**	**690**	**770**	**10968**	**13263**
Ethiopia	6528	8077	5,95	13,37	110	110	6798	7747
Gabun	4932	7228	2,00	2,00	3120	3940	3928	5415
Ghana	4978	8620	3,70	5,21	330	380	6459	8090
Kenya	**10454**	**15600**	**-0,16**	**2,10**	**360**	**460**	**10686**	**14987**
Madagaskar	3878	4364	4,76	5,25	250	300	3870	5181
Mauritius	4424	6056	4,00	4,20	3690	4640	4385	5730
Namibia	3414	5456	3,49	4,20	1870	2370	3538	4813
Nigeria	**42078**	**72106**	**4,20**	**3,60**	**260**	**390**	**33127**	**53983**
Rwanda	1811	1845	5,97	3,66	260	220	2002	1875
Senegal	4373	7665	5,58	5,96	490	670	4710	6967
South Africa	**132878**	**212777**	**4,15**	**3,71**	**3050**	**3630**	**134408**	**165326**
Sudan	**12192**	**19559**	**6,50**	**6,00**	**330**	**530**	**10290**	**18152**
Tanzania	9079	10851	-0,78	3,00	280	330	8943	11560
Uganda	5889	6833	5,38	5,73	270	270	6299	6911

Source: World Bank (2005a)

Table A6: Literacy rates

	Literacy rate (%) 2000-2004			Literacy rate for youths (15-24) (%) 2000-2004
	Total	Men	Women	Total
Angola	**66,8**	82,1	53,8	71,4
Benin	**33,6**	46,4	22,6	44,4
Botswana	**78,9**	76,1	81,5	89,1
Burkina Faso	**12,8**	18,5	8,1	19,4
Burundi	**58,9**	66,8	51,9	72,3
Cameroon	**67,9**	77,0	59,8	..
Cape Verde	**75,7**	85,4	68,0	89,1
Central African Republic	**48,6**	64,8	33,5	58,5
Chad	**25,5**	40,6	12,7	37,3
Comoros	**56,2**	63,5	49,1	59,0
Congo, DR	**65,3**	79,8	51,9	68,7
Congo	**82,8**	88,9	77,1	97,8
Côte d'Ivoire	**48,1**	60,1	38,2	59,8
Equatorial Guinea	**84,2**	92,1	76,4	93,8
Ethiopia	**41,5**	49,2	33,8	57,4
Ghana	**54,1**	62,9	45,7	..
Kenya	**73,6**	77,7	70,2	80,3
Lesotho	**81,4**	73,7	90,3	..
Liberia	**55,9**	72,3	39,3	70,8
Madagascar	**70,6**	76,4	65,2	70,1
Malawi	**64,1**	74,9	54,0	76,3
Mali	**19,0**	26,7	11,9	24,2
Mauritania	**51,2**	59,5	43,4	61,3
Mauritius	**84,3**	88,2	80,5	94,5
Mozambique	**46,5**	62,3	31,4	62,8
Namibia	**81,3**	81,4	81,2	89,5
Niger	**14,4**	19,6	9,4	19,8
Nigeria	**66,8**	74,4	59,4	88,6
Rwanda	**64,0**	70,5	58,8	76,5
Senegal	**39,3**	51,1	29,2	49,1
Seychelles	**91,9**	91,4	92,3	99,1
Sierra Leone	**29,6**	39,8	20,5	38,2
South Africa	**82,4**	84,1	80,9	93,9
Sudan	**59,0**	69,2	49,9	74,6
Swaziland	**79,2**	80,4	78,1	88,1
Tanzania	**69,4**	77,5	62,2	78,4
Togo	**53,0**	68,5	38,3	74,0
Uganda	**68,9**	78,8	59,2	80,2
Zambia	**67,9**	76,1	59,7	69,4
Zimbabwe	**90,0**	93,8	86,3	97,6

Source: UNESCO Institute for Statistics 2005

Table A7: School and university enrollment rates

	School enrollment rate (primary) (%)	School enrollment rate (secondary) (%)	University enrollment rate (%)	Students enrolled in mathematical-science disciplines (% of all students)
	2002/2003	2002/2003	2002	1998-2003
Angola	61	..	1,02	18
Benin	58	20	..	25
Botswana	81	54	4,69	19
Burkina Faso	36	9	1,43	..
Burundi	57	9	2,03	10
Cameroon	..	..	5,46	..
Cape Verde	99	58	4,55	..
Central African Rep.	..	..	..	15
Chad	63	10	..	..
Comoros	55	..	2,3	11
Congo, Dem. Rep. of	..	..	..	..
Congo	54	..	4,13	11
Côte d'Ivoire	61	21	..	..
Djibouti	36	21	1,21	22
Equatorial Guinea	85	26	..	..
Eritrea	45	22	..	17
Ethiopia	51	18	2,43	19
Gabon	78	..	..	..
Gambia	79	33	..	..
Ghana	59	36	3,31	26
Guinea	66	21	..	..
Guinea-Bissau	45	9	..	..
Kenya	67	25	..	29
Lesotho	86	23	2,99	6
Liberia	..	..	..	..
Madagascar	79	12	2,11	20
Malawi	..	29	..	33
Mali	45	..	2,46	..
Mauritania	68	16	3,33	10
Mauritius	97	74	15,17	25
Mozambique	55	12	..	..
Namibia	78	44	..	8
Niger	38	6	..	..
Nigeria	67	29	8,2	..
Rwanda	87	..	2,5	..
São Tomé and Principe	97	29	..	..
Senegal	58	..	..	..
Seychelles	100	100	..	..
Sierra Leone	..	..		8
Somalia	..	..	..	
South Africa	89	66	15,05	17

Source: UNDP (2005, 258 ff.

Table A8: Important centers of excellence, research and university networks in Subsaharan Africa, and headquarters country

Association of African Universities (AAU)	Ghana
Inter-University Council of East African Universities (IUCEA)	Uganda
African Network of Science and Technology Institutions (ANSTI)	Kenia
Network of African Science Academies (NASAC)	Kenya
Natural Products Research Network for Eastern and Central Africa (NAPRECA)	Tanzania
Council for the Development of Social Science Research (CODESRIA)	Senegal
Centre for Peace and Conflict Studies /University of Ibadan	Nigeria
International Institute of Tropical Agriculture (IITA)	Nigeria
African Economics Research Consortium (AERC)	Kenya
African Virtual University	Kenya
International Livestock Research Institute (ILRI)	Kenya
International Council for Research in Agroforestry (IGAF)	Kenya
Kenya Industrial Research and Development Institute (KIDRI)	Kenya
Kenya Medical Research Institute (KEMRI)	Kenya
International Centre of Insect Physiology and Ecology (ICIPE)	Kenya
International Council for Research in Agroforestry (ICRAF)	Kenya
Kenya Agricultural Research Institute (KARI)	Kenya
International Livestock Centre for Africa (ILCA)	Ethiopia
International Watermanagement Institute (IWMI)	Ghana, Ethiopia, South Africa
National Institute of Medical Research	Tanzania
Council for Scientific and Industrial Research (CSIR)	Ghana
Ghana-India Kofi Annan Centre of Excellence in ICT	Ghana
Kwame Nkrumah University of Science and Technology	Ghana
Mbara University for Science and Technology	Uganda
Botswana Technology Centre (BOTEC)	Botswana
Ecole Inter Etats d'Ingénieurs de l'Equipement Rural (EIER)	Burkina Faso
Kigali Institute of Science, Technology and Management (KIST)	Rwanda
Centre d'Etudes Régional pour l'Amélioration de l'Adaptation à la Sécheresse (CERAAS)	Senegal

Source: TWNSO (2003); TWNSO / TWAS (2003)

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