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Regional and Interregional Cooperation to Strengthen Basic Sciences in Developing Countries

Addis Ababa, 1 – 4 September 2009

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in association with
The Swedish International Development Cooperation Agency (Sida)
and
Addis Ababa University (AAU), Ethiopia,
and under the auspices of
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The front cover illustration was made by Peter Sundin and Hossein Aminaey at the International Science Programme and indicates the complexity of regional collaboration accounted for in this volume. Colours are arbitrary.

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Preface

Kerstin Sahlin

The International Science Programme (ISP) is an important and unique feature on Uppsala University's international agenda. By providing long-term support for the development of active and sustainable research environments, ISP aims at assisting developing countries in Africa, Asia, and Latin America in order to strengthen their domestic research capacity within the basic sciences, focusing on physics (since 1961), chemistry (since 1970) and mathematics (since 2002). The support is directed to research groups as well as to scientific networks. To meet the demands, ISP cooperates with all Swedish institions of higher education as well as with universities in other countries. In addition to Uppsala University, the Swedish International Development Cooperation Agency (Sida) is a long-valued major financial contributor to the ISP operation.

Scientific networking is a natural part of research activities in industrialized countries, and many successful research efforts are based on interactions between intellectually resourceful and technologically advanced research groups. In most developing countries, however, where support for developing research and training in basic sciences is usually very limited, technical resources may be scarce also in those cases when good intellectual resources are at hand. Under these conditions, scientific networking is crucial in forming a critical mass of researchers and students in a given field as well as providing opportunities for sharing and combining technical resources. This may result in complementary activities in scientific research and higher education which give access to advanced equipment and increase the human capital needed to conduct MSc and PhD programmes of a good standard.

The International Conference on Regional and Interregional Cooperation to Strengthen Basic Sciences in Developing Countries held 1 – 4 September 2009 in Addis Ababa, Ethiopia, gave the opportunity for scientific networks supported by ISP and other organizations to showcase and highlight the importance of regional and interregional cooperation to promote basic sciences in developing countries. The event attracted more than 130 participants from almost 40 countries, representing different fields of basic sciences from close to 40 universities world wide, as well as organisations such as the African Development Bank, the European Commission, IAEA, ICTP, Sida, TWAS and UNESCO. More than 20 networks, most of them wholly or partly supported by ISP, accounted for their activities. Other important aspects of networking and cooperation were added by several additional well-renowned plenary speakers. The present volume covers the majority of presentations as well as the concluding discussions.

Sida and the African Union Commission (AUC) provided financial support for the conference, organized by ISP with Addis Ababa University as co-organizer and under the auspices of AUC. These organizations are gratefully acknowledged, as are kind contributions by the Swedish Embassy in Addis Ababa and the excellent practical organization by Shebelle Ethiopia Conference Services.

Kerstin Sahlin is Deputy Vice-Chancellor at Uppsala University since July 1, 2006, and Professor of Public Management in the Department of Business Studies at Uppsala. Professor Sahlin has published widely in the fields of organizational reform, public management, project management, as well as on the development of global standards and regulations.

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Dedication

Joseph Nordgren

Collaboration and networking are key factors in the world society. They make development a mutual process in which we all take part, to which we all can contribute and from which we all may benefit. This is in particular true for research. Although a research field is sometimes seen as a competitive arena where a privileged elite is singled out and rewarded, it is mainly to be seen as an open dialogue where the very interaction is a most important characteristic. Science is a mutual exchange, a systematic give-and-take activity, with no borders.

Yet, efficient collaboration and networking requires individuals who give priority to the common efforts and results, and not to their own interests, neither to the short-term perspectives of their surroundings. To build lasting relations across borders needs patience, planning, and perspectives, and to fill them with valuable contents needs wisdom, creativity and sincerity. The three words just mentioned are used extensively today, yes indeed to such an extent that there are good reasons to believe that they are often misused. Sometimes, however, they are not only adequate but necessary. When the contribution by Professor Lennart Hasselgren is to be characterized, they are absolutely needed.

Professor Hasselgren has served the International Science Programme (ISP) from 1975 until his retirement 30 June 2007, first as assistant director and from 1982 as director of the International Program in Physical Sciences, and since 1998 as the head of ISP. In his work he has been continuously active in building up contacts and networks between different institutions and research groups in the developing countries, as well as between such institutions and research groups in the North. His efforts have, more than anything else, contributed to the success of the ISP. This has been of value to the hundreds of scientists in the developing countries that have been given possibilities to develop their skills and interests this way and thus contribute to their domestic environments, as well as to the groups and institutions in the North that thus have established contacts and perspectives beyond the narrow perspectives of the European – North American world view. Moreover, Professor Hasselgren has set an example of science and science collaboration as a human endeavour that can inspire long beyond the world of science.

We wish to dedicate the present volume on *Regional and Interregional Collaboration to Strengthen Basic Sciences in Developing Countries* to Lennart Hasselgren.

Joseph Nordgren is chairman of the Board of the International Science Program (ISP), Vice-Rector of Uppsala University, and Dean of Science and Technology. He was appointed professor in soft X-ray physics in 1988, and has published some 260 papers in international journals concerning problems in molecular and solid state physics. He has received several scientific awards, among them the Göran Gustafsson Award and the Alexander von Humboldt Award. He has served on a number of international boards and scientific advisory committees. He is a member of the Royal Swedish Academy of Sciences since 1996 and served as a member of its Nobel Committee for Physics 2001−2009, during the last two years as chair.

A word of welcome

Peter Sundin

H. E. Dr. Zerihun Kebede, State Minister, Ministry of Science and Technology,
Honourable Invited Guests,
Representatives of International Organizations,
Distinguished Scholars,
Conference Participants, Ladies and Gentlemen:

It is a great pleasure and honour to bid you welcome to the opening ceremony of this first International Conference of Regional and Interregional Cooperation to Strengthen Basic Sciences in Developing Countries.

Interdisciplinary research is most important in solving a number of challenges facing the world today. Without a base for science, however, it is hardly possible to attempt to develop interdisciplinary and multidisciplinary research of more direct, applicable importance. Since the basic sciences are important and essential components of the knowledge base, they play a crucial role in this respect. Mathematics, physics, chemistry and biology form the pillars on which applied sciences and engineering are built, and it is most important that these fields of basic sciences be strengthened. Without a proper scientific base it is not possible to initiate research of more immediate importance to developing countries.

Funding to developing countries for developing research and training in basic sciences is, however, usually very limited, both from governments and other funding organizations. Furthermore, in many cases the researchers in these countries experience isolation from the scientific community due to several limiting factors such as lack of human and instrumental resources, small means for external collaboration, and limited access to literature. Regional and interregional cooperation is one way to help overcome these limitations, and the International Science Programme, ISP, has for such reasons long been supporting networking and resource sharing.

The initiative to this meeting was actually seeded back in October 2007, when the scientific reference group of the ISP chemistry program had its yearly meeting to evaluate proposals. At this occasion a rather large number of proposals from regional and interregional networks and resource groups were to be evaluated. The reference group found that the scientific network activities proposed in many cases needed further definition with regard to thematic choice, objectives, goals, timeframes, budgets, and so on. Consequently, the reference group proposed that a workshop be held to strengthen the organization of regional collaboration.

The concept of this workshop for chemistry networks has now developed to this full-fledged international conference with representation from several sciences and gathering collaboration partners and initiatives also outside the ISP sphere.

With these words it is, again, a great pleasure and honour to bid you welcome to this meeting.

Peter Sundin has his scientific background in Ecology and Environmental Analytical Chemistry. He graduated in 1990 from Lund University, Sweden, in the field of Chemical Ecology. From 1991 to 2001 he was a researcher at the Swedish University of Agricultural Sciences. In 1997 he was promoted to Associate Professor in Environmental Assessment. In the years 1990 to 2000 he contributed to a Swedish Government Commission on the implementation of a new chemicals policy. In the years 2002 to 2006 he worked as unit head at the Swedish Chemicals Agency, with an intermission 2005 at the Swedish Veterinary Institute. In 2006 he was employed as Director of the International Programme in the Chemical Sciences (IPICS) at the International Science Programme (ISP), Uppsala University, and since 2007 he is the head of ISP.

Peter Sundin has also been the rapporteur for Theme 4, page 405, and authored the *Concluding remarks*, page 409.

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Welcoming speech

Tsige Gebre-Mariam

H. E. Dr. Zerihun Kebede, State Minister, Ministry of Science and Technology,
Honourable Invited Guests,
Representatives of International Organizations,
Distinguished Scholars,
Conference Participants, Ladies and Gentlemen:

On behalf of the International Organization and Local Organizing Committees and on my own behalf I am honoured and privileged to welcome you all to this *Regional and Interregional Cooperation to Strengthen Basic Sciences in Developing Countries*; a conference organized by the International Science Programme (ISP) of Uppsala University, Swedish International Development Cooperation Agency (Sida), and Addis Ababa University.

A number of regional and international organizations, agencies, universities, and research centres have immensely contributed in organizing this timely conference in order to foster basic science, education and research, aiming at forming South-South and North-South networking, collaboration and partnerships among universities and research centres, thereby strengthening capacity building in science education and research in developing countries.

In this regard, I would like to acknowledge the support of UNESCO, the International Atomic Agency, the European Commission, the African Union Commission, The Academy of Sciences for the Developing World (TWAS), the Swedish Embassy in Ethiopia, and all other organizations and universities that are taking part in this Conference.

In the coming four days a number of plenary sessions, parallel sessions addressing pertinent issues on basic and applied sciences as well as networking experiences will be presented and discussed.

Ideas generated, experiences shared, lessons learnt from this exercise would be of paramount importance in order to achieve the set goal, fostering basic science education and research in developing countries to ultimately promote science and technology and improve the quality of life in developing countries.

The organizing committees would value your active participation, your inputs as suggestions, comments and your overall wisdom to set the Way Forward!

According to the programme, the first speaker would have been Professor Andreas Eshete, President of Addis Ababa University (AAU). Although he had planned to take part in this opening ceremony, due to a compelling situation, he cannot be with us this morning. At this moment he is attending the official Launching of the Country Self-Assessment Report of Ethiopia under the African Peer Review Mechanism, representing all the 22 Universities of Ethiopia. He has asked me to convey his best wishes to the success of the Conference and to express the commitment of AAU to proactively engage in the endeavour of promoting Basic Science Education and Research together with all stakeholders.

H. E. Mr. Jean Ping, Chairperson of the African Union Commission will not be with us, again due to another commitment: he is currently attending the African Union Summit in Libya. He is represented by Professor Jean-Pierre Ezin, Commissioner for Human Resources, Science and Technology.

His Excellency Mr. Jens Odlander, the Swedish Ambassador to Ethiopia also could not make it, as he is also attending the African Union Summit in Libya. He is represented by Mr. Berth Abrahamsson, Chargé d'Affaires of the Swedish Embassy.

The next speaker is Mr. Tomas Kjellqvist, Head of Sida Secretariat for Research Cooperation, who has been instrumental in supporting this conference.

Finally, I would like to invite H. E. Dr. Zerihun Kebede, State Minister of the Ministry of Science and Technology of the Federal Government of Ethiopia, who is a chemist and apparently former beneficiary of ISP to deliver his opening speech and officially launch the Conference.

Thank you!

Tsige Gebre-Mariam Wolde-Mariam holds a PhD from the University of Wales, Cardiff, UK (1988) and is a professor at the Department of Pharmaceutics, Addis Ababa University, since 1999. He was Dean of the School of Pharmacy, AAU (2003−2004), and Vice President for Graduate Studies and Research, AAU (2004−2009). He is a Humbolt Ambassador Scientist since 2009 and has published about 100 papers in peer-reviewed national and international journals as well as two books (in Amharic and English) on Graduate Studies and Research at AAU.

Professor Tsige Gebre-Mariam served as a member of the International Organizing Committee of this conference and was the Chairperson of the Opening Ceremony.

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Keynote address

Jean-Pierre Ezin

H. E. Dr. Zerihun Kebede, State Minister, Ministry of Science and Technology,
Honourable Invited Guests,
Representatives of International Organizations,
Distinguished Scholars,
Conference Participants,
Ladies and Gentlemen:

I am pleased to welcome you and address you on this meeting on behalf of the His Excellency Dr. Jean Ping, the Chairperson of the African Union Commission. I would like to congratulate our co-organizers of this meeting, particularly the Swedish International Development Cooperation Agency (Sida), Uppsala University and Addis Ababa University.

The importance of science and technology in addressing socio-economic problems in Africa such as diseases, water sanitation, infrastructure development, etc. has long been recognized, even at the inception of the Organization of African Unity (OAU) in 1964. The transformation of the OAU into the African Union was accompanied by the setting up of a commission with specific departments charged with responsibilities for driving development in specific sectors. The Department of Human Resources, Science and Technology was established with the mandate to drive programmes of education and science and technology among others. A Conference of Ministers of Science and Technology (AMCOST), was also created as a platform to allow Ministers to periodically deliberate on matters relating to science and technology.

Ladies and Gentlemen:

The African Union Commission remains steadfast and committed to advocating scientific development of the continent. The Commission articulates Africa's continental vision. Its programmes are drawn from Africa's priority areas and common objectives. The Department Human Resources, Science and Technology has developed strategic policy documents through the AU system of conference of ministers responsible for education and science respectively to guide the continent on common priority programmes. These strategies, namely the Plan of Action for the Second Decade of Education for Africa and Africa's Science and Technology Consolidated Plan of Action (CPA), adequately respond to Africa's challenges and development needs. I am pleased to inform you that the discussions of this meeting are well aligned to these policy documents.

In our conceptualization of the Pan African University Initiative, the Commission took cognizance of the need to revitalized, rehabilitated and strengthened higher education and research in Africa. Among the proposed networks of differentiated Pan African Universities (PAU), is a University dedicated to Basic Sciences and Technology

Following the declaration by the AU Heads of State and Government to proclaim 2007 as the launching year for building constituencies and champions for science, technology and innovation in Africa, the AU Commission, with the support of its development partners, is running a programme on Scientific Awards targeting young researchers at Member State level, women at regional level and open to all outstanding scientists at continental level. One of the sectors for this programme is basic sciences. For the first time, on 9 September 2009 (African Union Day), the AU Commission will celebrate the achievements of African Women Scientists. I am therefore kindly inviting you to join the African Union in this ceremony.

Ladies and Gentlemen:

The theme of this meeting, *Regional and Interregional Cooperation to Strengthen Basic Sciences in Developing Countries*, is very pertinent to the developing of Africa, as we host the majority of developing countries. What are the basic ingredients for getting African science working? What are some of the key policies and programmes that we need to introduce to promote and strengthen basic science? How do we propose to cooperate regionally and interregionally to strengthen basic science so that we can harness it for our development? How do you propose to align the cooperation with the various AU strategies such as the PAU and the CPA? These are some of the issues we need to address in this meeting. The outcome of this meeting should outline a roadmap towards strengthening basic sciences through regional and interregional cooperation.

Ladies and Gentlemen:

In conclusion, I would like to reiterate that the African Union Commission supports the use of science as a development tool, and initiatives such as this meeting are welcome. Let me wish you fruitful deliberations and a successful meeting. Together we can shape Africa through science!

Thank you.

Jean-Pierre Ezin, born in Benin, is professor at the Institut de Mathématiques et de Sciences Physiques de l'Université d'Abomey-Calavi, Benin. He was appointed on 1 May 2008 Commissioner for Human Resources, Science and Technology of the African Union. He obtained his *Doctorat de troisième cycle* and his *Doctorat d'État* at Université des Sciences et Technologies de Lille, Flandres (France). He served in various academic and public administration positions. His specialty fields include partial differential equations, differential geometry, Riemannian geometry, and pseudo-Riemannian geometry.

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A word of welcome from the Embassy of Sweden

Berth Abrahamsson

Ladies and Gentlemen,
Delegates and Participants to this Conference,
Esteemed Guest of Honour, the State Minister for Science and Technology,
H. E. Mr. Zerihun Zebede.

As a man of only basic academic merits and degrees it is a great honour and pride for me to address such a distinguished audience in terms of academic and scientific achievement. I regret that the Ambassador of Sweden was not able to be here to address you, as he is not yet back from an important mission to the AU Summit in Sirte, Libya. But for me as his replacement I consider myself fortunate to be given this opportunity.

First of all I would like, on behalf of the Embassy of Sweden here in Addis Ababa, to welcome all of you to this ISP Conference at the United Nations Conference Centre, both those who have travelled long distances to reach here, as well as the delegates representing Addis Ababa University.

The theme of the Conference is *Regional and Interregional Cooperation to Strengthen Basic Sciences in Developing Countries*. It reflects a major objective of the International Science Programme (ISP) within the Faculty of Science and Technology of Uppsala University. The programme started with Physics in 1961 and has added Chemistry and Mathematics since then. It plays the essential function of building the basic scientific skills needed to create a sustainable research environment, and it also contributes to developing other dimensions of such an environment. To put it very shortly, a shortage of such skills means great handicaps for research!

The academic results alone of ISP are impressive, among them over 100 PhD theses, 500 MSc theses, and well over 1,000 academic publications only in the last five-year period. It has all along been receiving most of its funding from the Swedish Government, from 1978 from SAREC, and since the reorganization of Swedish development cooperation in the last couple of years, from Sida. As a representative of the Swedish Ministry for Foreign Affairs and the Swedish Embassy in Ethiopia, it is with pride that I associate the support of Swedish aid to the achievement of these academic and scientific outputs.

Now I have been asked to say a few introductory words about the profile of Swedish aid here in Ethiopia. This country was among the very first of

Sweden's cooperating partners from the 1950s, and Sweden's association with Ethiopia goes even longer back in history to the beginning of the 20th Century. Our Embassy here is an important relay both for Swedish support directly to Ethiopia, and for Swedish so-called "regional support" which is destined to regional organizations across the continent.

Our bilateral programme with Ethiopia has been focused for a long time on education and health, as well as on supporting national NGOs. The field of research cooperation with Ethiopian universities has also been a prominent part of this relation. One of our main partners has been of course the University of Addis Ababa, which is a co-organizer of this Conference, and I am most pleased today to be able to greet Professor Tsige Gebre-Mariam, Vice President for Graduate Studies and Research at Addis Ababa University, as co-chair of this important collaborative event.

Our regional support also contains a research component, involving support to enable faculties of African universities to collaborate together on research activities with a dimension which stretches across country borders. Otherwise, it is more and more being directed towards the principal African regional players, at their top figuring the African Union and its Commission, as well as several of the Regional Economic Communities, such as IGAD, ECOWAS, SADC and EAC. Addis in some ways plays the role of an African Brussels, a kind of capital of Africa, and we are honoured also to be able to give support to and work alongside the United Nations Economic Commission for Africa, which is also located here.

As you see, the African Union is a leading proponent of this Conference. This reflects the growing role of the Union in African affairs since its creation a few short years ago. The continent is seeking to solve its problems of poverty, conflict and disease, to build peace and security, to increase its economic integration, to raise its standards of education and research, and increasingly its countries are placing the AU in a leading role for guiding this work. Africa is steadily building up its own structures to take responsibility for the successful human development of the continent. I take pleasure in welcoming here today, the AU Commissioner for Human Resources, Science Technology, Professor Jean-Pierre Ezin, the Delegate of the AU, under whose auspices this conference is being held.

Now I might also add that over the past couple of years, the African and the European Unions have been developing their cooperation in a large number of fields, under the umbrella of the Joint African-European Strategy (JAES). At the moment, as most of you will be aware, Sweden is occupying the Presidency of the European Union, and we are working hard to ensure that the Strategy gets clothed in concrete activities with concrete and mutually beneficial results. One of the eight principal areas of AU–EU collaboration that have been agreed on is that of Science, Technology and Space, and it is my feeling that this conference will help demonstrate what can be done by serious cooperation between the two continents in these areas.

Now I believe I have sufficiently taken up the time and opportunity availed to me today, and I would like to conclude by extending the warm wishes of our Embassy and our Government for a successful and rewarding ISP Conference in Addis Ababa 2009. We hope it will produce not only useful ideas and useful conclusions for the future but also help in building the personal networks which are so important to making ambitious concepts and broad programmes real and alive. I hope you will all enjoy the conference, and I am also looking forward to be your host this evening at the Embassy of Sweden premises.

With best regards, I now hand the microphone back to the Chair.

Thank you!

Berth Abrahamsson is Councellor at the Embassy of Sweden in Ethiopia; at the time of the conference he was Acting Head of Mission.

Berth Abrahamsson has been working as a Human Resource Manager during most of his career and mainly in the field of organizational development. He joined Sida in 1999 and headed a project for development of the salary system. He has been working as a diplomat since 2005, first in Asia and since 2008 in Ethiopia.

Regional research cooperation in the basic sciences in Africa

Tomas Kjellqvist

I am extremly proud and honoured to be one of the people that welcome you to this conference. I am proud because Sweden has contributed to the establishment of a number of well-performing and productive scientific networks, to have been part of a process that created a foundation for science and technology in Africa and also in other developing regions. I am convinced that we during the coming days will have a chance to explore both the work of the networks and the factors behind their success.

The growth of science in Africa has very much been a silent revolution. Very few people have had the opportunity to undertake training in the sciences, very few governments have recognized the need to increase the number of scientists and engineers, and only a handful of development partners and research funders have listened to the proposals for research and research training coming from Africa. Still, a number of people have been able to get scholarships to go abroad for advanced scientific studies. A somewhat smaller number of people have returned to universities in their home country to teach. Even fewer have found resources to continue doing research. Over the years, several small contributions have resulted in a slow but worthwhile growth of scientific competence at this continent.

Very recently, African governments became aware of the need to invest in Higher Education, Research and Innovation. The pressure to invest in higher education increases as larger cohorts leave primary and secondary school. The youngsters leaving school and their parents start to demand the possibilities to pursue higher studies within their own country. Several parliaments have furthered this demand to their governments. The governments have furthered the message to the aid community in the Poverty Reduction Strategy papers by formulating strategy goals on the need to invest in human resources, science, technology and innovation.

Africa's intergovernmental organizations have taken on the same challenge. The New Partnership for Africa's Development (NEPAD), established the Office of Science and Technology, and the African Union Commission put a Directorate for Human Resources, Science and Technology in their organizational set-up. The African Development Bank elaborated their way of working with loans and contributions to higher education, research and innovation. African ministers of science and technology, the AMCOST, adopted the Consolidate Plan of Action for Science and Technology in Africa, and this Plan was also endorsed by the 8th summit of the African Union in 2007, together with a promise from African Heads of State to raise the national funding levels for science and technology.

The realization that higher education, research and innovation are important is also growing in multilateral organizations like the World Bank and the UN. In 2005 Kofi Annan proclaimed that Science and Technology should become one of seven important areas for the UN to work on. The UN Millennium Task Force produced a report on Science and Technology showing the importance of the area in our efforts to achieve the millennium goal. The World Bank, finally, abandoned the standpoint taken during the structural adjustment programmes in the 1980s, that higher education is a luxury that could only be prioritized once the needs for basic education has been filled. A number of G8-meetings have addressed the situation in Africa and the need to invest in Science and Technology, and so has the World Economic Forum. This year, at the beginning of July, the World Conference on Higher Education had a special session on the need to increase Higher Education in Africa. A number of nations volunteered to assist, China, India, the Republic of Korea, Brazil, USA, France, Sweden and also the EU.

The European Union has made an agreement on collaboration with the African Union that includes Item Number 8, *Collaboration on Science and Technology*. This item includes collaboration on improvement on the infrastructures for ICT to make it easier for African scientists and university teacher to access scientific materials and communicate with the global scientific community. The item also includes collaboration on space science, and on capacity building. Some of the networks in the European Research Area are opening up for collaboration outside Europe and particularly looks at Africa with great interest. The 7th Framework Programme for research in Europe has a number of mechanisms for collaboration with so called third countries, and a particular international cooperation network called CAAST-NET has been set up to explore how these mechanisms could be used in cooperation between European and African researchers. I understand that Item Number 8 in the EU/AU cooperation will be presented to you during this conference.

So, during the last five-year period we have seen a veritable boost in the interest for the pursuit of scienctific research and for the fruits it could bring to society, also in Africa. This interest is a ubiquity in the rest of the world. None of the countries that have grown rich during the last 50, 20, 10 or five years would question the fundamental role that science and technology have played in this creation of wealth and well-being. It is manifest both in policy statements and in budget lines, recruitment strategies and evaluations. Yet, there are a number of common concerns spreading around the countries that have built up advanced systems for science, technology and innovation:

• There is recognition of risks to humans and the natural environment that comes out of progress in science and technology. The "time-to-market" factor often forces scientific findings to be engineered to commercial products before the consequences of launching these products are understood. Hence, more science is needed to assess the risks and consequences of science.

• Despite the recognition of policy makers for the need of science, there is distrust and indifference to science among the public. Science may be taken for granted and there is little recognition for efforts made. Particularly this is reflected in the lack of interest among students to enroll at university programs for science and engineering, which often are much more laborious than other programs.

• The working conditions for researchers and university teachers have deteriorated. Massification of higher education without a proportional raise of budgets puts university teachers in stress. Research have to become entrepreneurs and find their own funding, often justifying their proposals with political or commercial arguments rather than with scientific value. As a result, choosing a career as an academic becomes less attractive, at least as long as labour markets can offer jobs with better pay.

• Most of the countries with advanced scientific systems have difficulties in maintaining them with the existing and potential staff. The EU calculates that Europe will need to import 700,000 researchers to keep up its competitive edge against USA and Asia. USA finds itself in a similar condition and it is probable that the major Asian economies will not find all the skills needed in their growing industry and academic communities just from homecoming PhDs.

• Calculations also show that Africa would need at least 1 million researchers to get the systems for higher education, research and innovation up and running. I think it is extremely important to recognize that Africa is competing with the needs of other nations. All external assistance in building African science and technology has the potential to become vehicles for brain drain, even though the assistance schemes might be set up with good intentions.

• There is a need for African researchers and policy makers to organize themselves in a way to focus the efforts to build up and maintain the African scienctifc capacity. Doing this they need to increase their capability of negotiating schemes with international funding bodies and academic communities to avoid the risks and encourage the benefits of international cooperation.

• There is a need for researchers and policy makers among Africas international partners to ensure that all collaboration efforts aims at building up mechanisms for sustainable scientific cooperation, instead of a tempting "grab and go" approach.

• The financial crisis is a threat to such efforts for sustainable cooperation as it forces short-term solutions to substitute for long-term approaches. There is an immediate risk that the proud words of prioritizing investments in science and technology will vaporize water in an arid area.

The intention of painting this gloomy picture as a background to this conference is not to diminish the importance of the past efforts or the potential that I can see in the participants and presentations of the conference. The background picture should be viewed as a challenge for us all – all development partners, whether we are in an industrial or developing country, whether we are scientists or science-policy makers. I painted it to emphasise that science and technology is a global concern, also that science and technology in Africa is a global concern.

Regional cooperation is probably one of the answers to the challenges. Regional cooperation creates a room for comparing notes and sharing scarce resources. Not only on scientific methods and findings, but also ways of collaboration within and beyond Africa and how to employ successful negotiation procedures when trying to engage external researchers and funding bodies to take part in the networks. Networks also contribute to create the enabling environments for research, needed to attract both researchers from elsewhere but also retain those that are already there. I believe that this conference will show us a number of different possibilities to do networking, approaches that has grown in different situations, with different purposes and for meeting needs of different disciplines. We will probably also find a number of generic factors in networking. Sharing and comparing are two key concepts that I think will be recognized in most presentations. I hope that we will have a listing of such key concepts during the conference.

It is my hope that we make the most of the opportunity that we have given ourselves coming to this meeting in Addis Ababa at the very beginning of September 2009. I learned that we will end this conference just a week before the celebration of the Ethiopian New Year. I hope that we, at the end of this conference, will celebrate that we have contributed to a new era for science and technology, in Africa and elsewhere.

Thank you!

Tomas Kjellqvist is a research and innovation policy specialist. He has been working in the management of Swedish aid-funded Research Cooperation since the year 2000 in different positions. Since 2008 he is director of the Secretariat for Research Cooperation at the Swedish International Development Cooperation Agency, Sida.

From 1992 to 2000 he was Research Officer at the Department for Research Cooperation of Sida, responsible for different areas like bilateral research cooperation with Tanzania, Bolivia, and the University Library support programme, for thematic research programmes in social sciences and for research inputs to the Swedish National Commission for the preparations of the United Nations International Conference on Population and Development.

Opening Speech

Zerihun Kebede

The Representative of the African Union Commission,
The Representative of the Swedish Ambassador to Ethiopia,
Mrs. Ana María Cetto, Deputy Director General of the IAEA,
Distinguished guests and participants of the event, Ladies and Gentlemen:

I would like to welcome you all, and I am happy to be with you and honoured and privileged to make an opening speech on this important conference on *Regional and Interregional Cooperation to Strengthen Basic Sciences in Developing Countries.*

Ladies and Gentlemen:

First of all, I would like to express my gratitude to the International Science Programme (ISP) of Uppsala University and the Swedish International Development Cooperation Agency (Sida) for organizing this gathering. With their long-standing experience in the fields of physical, chemical and mathematical sciences, as well as their long-term cooperation with many developing countries, these two institutions represent reliable and dependable partnerships. They have been supporting a number of research activities and offering scholarships to support the Ethiopian Government efforts in capacity building in the areas of science and technology at tertiary educational institutions, namely Addis Ababa and Haramaya Universities. This conference is very timely, particularly for Ethiopia, because it is being held at a time when the country is heavily investing in higher education by opening several new universities and strengthening the already existing ones. In the universities, the Government of Ethiopia is expanding postgraduate programmes both at Masters and PhD levels, which requires large number of qualified human resources and material inputs. The programme involves strengthening the existing programmes as well as introducing new areas of training programmes. For the success of the training programmes and to achieve qualified science and technology personnel for the economy, building research capacity is compulsory. Obviously such Government endeavour could be supported by international partners.

Mr. Chairperson:

The African Union Commission is committed to promoting the role of Science and Technology (S & T) for sustainable development through its many flagship programmes and the NEPAD. A very good example for this effort is Africa's Science and Technology Consolidated Plan of Action which articulates Africa's common objectives and commitment to collective actions to develop and use S & T for the socio-economic transformation of the continent and its integration into the world economy. Africa has the opportunity in this regard to leap-frog into new and emerging technologies just like the Far East Asians did. In this respect, Africa's reliable potential, i.e., enough population size of which about 40 % are less than 15 years old and that can be mobilized into careers in various S & T areas, as well as abundant resources are assets for the continent.

This potential of the continent can be utilized for the development of African nations provided that the S & T activities become the top priority in the national agenda. Because technology as a human-made resource is a key means for transformation of available natural resources to desirable products and services at affordable prices, it converts input to marketable output which enhances, improvement of agricultural productivity, nutrition, health, environmental protection, construction, energy and activities leading toward competitiveness and high value-added new products. In line with this, research and development (R & D) play key roles to practically address the socio-economic problems of the nations. For poor countries, already developed and well established applicable technologies are the top priority and important to hasten the response towards improvement of living standards of the mass.

Technology importation, however, does not mean to simply use and to throw it but to assimilate technology developed elsewhere, and continuously to move up the technology ladder if developing countries are to achieve continued growth and development. This is a very important step for the accumulation of technological capability of the developing countries. Rather than developing new technologies as developed countries do, accumulation can take place through assimilation of foreign technologies for developing countries.

Nationally, to get use of developed technologies, it becomes necessary to formulate a national situation and priority based on a contextual Science, Technology and Innovation Policy, which is to be followed by meticulous national planning for critical mass production of S & T researchers in applied and adaptive research areas, S & T teaching and service personnel in line with a retention mechanism to minimize brain drain, research infrastructure and development of technological capability through technology transfer and assimilation.

With regard to this, there is a general consensus that in developing countries, in order to catch up with the developed ones and to ensure their sustainable development, the highest proportion of resources should be given to adaptive and applied research in contrast to basic research. Bases of adaptive research are mainly imported technologies from developed countries. In this context the importance of basic research is not denied, rather we fully agree that it is a foundation for overall development. But by considering our poverty against time, we need to catch up with fast moving competition and develop our competitiveness in global market in order to ensure our existence since we cannot be isolated from a globalized situation.

Moreover, national economic change and sustainable development are to a large extent accounted for by investments in science, technology and innovation. It is not the mere accumulation of physical capital (the so called Technoware) and natural endowment that transform economies of nations, but also the ability of countries to produce, harness and wisely use scientific knowledge and related technological innovations are critical ones. Even those countries with rich natural resources need science and technology in order to exploit their respective resources. The economic history of the industrialized and newly industrializing countries vividly shows that economic improvement in these countries has been a result of the application of knowledge in productive activities. The gap between poor and rich countries in terms of real income is, therefore, largely because of the differences in the accumulation and utilization capacity of science and technology of the nations. This is evidently disclosed by an explicitly correlated country's scientific and technological capabilities with its economic performance.

Therefore, technology can play this vital role upon continuous introduction and use of technological innovations in every sector. In this regard, enterprises are key role players and can introduce technological innovation through acquisition (i.e., technology transfer) or self-generation (i.e., technology development) to enhance their market competitiveness. However, with regard to self-generation of technologies, the developing countries are not in a position to carry out this task. As experiences of many countries show as well as S & T development history reveals, to alleviate poverty, as technologically backward nations, technology transfer from developed countries may pave a way towards economic growth and development. To achieve all these of course we need well-educated and trained personnel (so called Humanware) in science and technology at all levels. This on the other hand requires education and training which demands a great commitment and meticulous planning of countries. In the planning of research activities for alleviation of poverty and improvement of living standards, we believe, the general framework of different research sectors have to take the following into account:

(a) research priorities with actual technological issues confronting the production system;
(b) addressing performance of the research and development system with techno-economic impact of nations;
(c) resource budgeting of the research and development system must consider economic pay-offs at the end of the technology delivery process.

Ladies and Gentlemen:

As mentioned earlier, the government of Ethiopia is committed to applying science and technology as a means for socio-economic development of the country. Following the education and training policy of the country very important achievements have been met in the education sector in last 15 years. Before expanding university education, primary and secondary education systems are expanded. Similarly, technical and vocational education and training were expanded for both agricultural and non-agricultural sectors in order to produce middle level human resources. Since the economy is growing, high-level professionals are also required for the economy, which also requires the expansion of university education and training programme. All these are foundations for science and technology. Based on this ground work the Government is working on national technology capacity building to support the production system and poverty alleviation strategy of the country. In this endeavour developed countries hopefully will support us in overcoming challenges that we are facing. Today's gathering is of course a practical indication of the support and commitment of our partners, for which I would like to thank the Swedish Government for its exemplary initiatives.

In line with this, international cooperation in terms of technical assistance, human resource capacity building, exchange of researchers and R & D results, as well as collaborative research programmes with technologically advanced countries would be of great importance. Thus, preparation of research and development projects on national or regional development priorities is mandatory. And I believe our supporters and partners will continue their assistance to strengthen the existing as well as introducing new areas of R & D activities for the benefit of our economy through development of basic science education and training.

Having said this, again, I would like to thank the people and Government of Sweden for supporting us. And I hope the conference will come out with important conclusions and outcomes.

Finally, I wish you to have fruitful deliberations in the coming few days; and with this remark, I now declare the Conference officially open, thanking you for your attention.

Zerihun Kebede holds a PhD in chemistry from Warsaw University (1994). At the time of the conference he was State Minister, Ministry of Science and Technology, Ethiopia. As of October 18, 2010, he is Labor and Social Affairs State Minister.

Regional and international cooperation: Putting science to the service of development

Ana María Cetto

Chairman, distinguished delegates and colleagues:

I am honoured to have the opportunity to speak to you today.

The topic which this conference addresses – strengthening basic sciences in developing countries – is very important to the International Atomic Energy Agency (IAEA), and one that is particularly close to my heart. Throughout my career as a scientist and researcher, I have been deeply involved in international scientific cooperation, seeing it as a means to further the development of scientific capacity across the world. Since joining the IAEA I have come to value the role of technical cooperation in building this capacity, and have had the opportunity to see first hand what access to nuclear science and technology can mean for the development of a country. In addition, I have also seen how international and, in particular, regional support can strengthen the abilities of our Member States in a way that is efficient, cohesive and sustainable, and in a manner that puts country ownership of the process front and centre.

Before I enter into much detail, I feel obliged to tell you something about the organization for which I work. Probably to most of you – though not to all, because I recognize among this audience a number of IAEA counterparts – the Agency is best known for its role in ensuring that nuclear technology is not misused – in fact it is frequently referred to as the UN's nuclear watchdog. It is also well known, together with its former Director General Dr. ElBaradei, as the recipient of the 2005 Nobel Prize in recognition of its work in the maintenance of world peace. What the Agency is less well known for, however, is its development work. This work, coupled with the scientific focus of the Agency, makes our technical cooperation activities particularly relevant to the theme of the Conference. We regard technical cooperation as the bridge between the theoretical and the practical, building capacities in high level science that will ultimately be used for the most practical ends – helping to heal illnesses, increase food security, manage environmental resources – a host of concrete applications that improve daily life for hundreds of thousands of people.

Development activities in the form of technical cooperation (TC) have always been part of the IAEA's work. Since the Agency was established in

Vienna in 1957, it has worked to carry out the development mandate set out in its Statute: "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world."

In its early days the organization focused on technical assistance to support the introduction of nuclear technology in a safe and effective manner. Some ten years ago, we shifted focus from assistance to cooperation for sustainable socioeconomic development, building on the skills and infrastructure that Member States have acquired over the past five decades. Member States are full partners in the TC process, guiding the IAEA's technical cooperation activities, setting national and regional priorities, and offering training opportunities and technical support to other Member States.

This shift from assistance to cooperation is significant in the context of the discussion that this international conference sets out to facilitate. It shows how support in a specialized scientific field at the national and regional level, successfully applied over decades, has resulted in a body of countries with rather solid, institutionalized capacities in nuclear science and technology. These capacities have been created to meet specific development objectives at the national level. The assistance-to-cooperation shift also illustrates how an organization such as the IAEA remains relevant by responding to achievements in its Member States, recognizing their changing role, and taking advantage of their strengthened capacities for the benefit of all.

Mentioning the evolving role of Member States leads me to the topic of country ownership. As the scientific capacities of countries increase, so too does their ability to take the lead in defining their needs, conceptualising their national technical cooperation programme, and shouldering the responsibility for the long-term impact of the TC activities they had requested. This transformation from recipient of assistance to programme owner is essential if TC projects are to respond accurately to identified needs, and if their results are to be sustainable in the long run. If international and regional initiatives to support science at the country level are to have appropriate direction and long-term sustainability, country ownership of science programmes and activities is crucial. Adequate research and education capacities are national necessities, but it is also essential that such research and education activities, no matter in what field or at what level of complexity, be used to meet national needs.

How can a multilateral science and technology organization address development priorities, and how can such priorities be identified in a structured and workable way? Our Member States define their priority areas for technical cooperation through the Country Programme Framework, or CPF. CPFs are developed by Member States in close collaboration with the Agency's Secretariat, and are intended to ensure alignment between their needs and available IAEA support. It is true that sometimes, our main counterpart at the national level is too firmly embedded in his or her specialization, and this may mean that accurate alignment with national development priorities does not occur. This weakness arises because no proper bridge has been built between what nuclear science can do, and what it should do within specific country contexts. For this reason, we are working to build closer links with national United Nations Development Assistance Frameworks. These frameworks are expected to provide a comprehensive structure within which the IAEA can more correctly direct its technical cooperation efforts.

This conference examines how basic science can be strengthened in developing countries, and we must consider not only how it may be strengthened, but also where it may best be applied. Science just for the sake of science in a context of persistent hunger and malnutrition, sickness and environmental depletion is science inappropriately directed. Science that fails to take account of context also risks overlooking the wealth of natural resources available to it, and narrows its horizons by failing to harness local and traditional knowledge already accumulated.

Science-based organizations like the IAEA have not only the capacity but also the responsibility to support developing countries in their use of science. The mission of international science programmes and academies reflects consensus on this responsibility. Take for example the International Centre for Theoretical Physics in Trieste, which operates under a tripartite agreement between the Italian Government, UNESCO and IAEA. Its mission is to foster advanced studies and research, focusing on developing countries. The Stockholm-based International Foundation for Science (IFS) aims to strengthen the capacity of developing countries, particularly the less developed ones, to conduct relevant and high-quality research on the sustainable management of biological resources. Then there is Uppsala University's International Science Programme, which aims to assist developing countries in Africa, Asia, and Latin America in strengthening their domestic research capacity within the chemical, physical and mathematical sciences, with a focus on least developed countries. And look at TWAS, the Academy of Sciences for the Developing World, which promotes scientific excellence and capacity in the South for science-based sustainable development. Through their respective programmes, these and other organizations are making extremely valuable contributions to the promotion of science for development.

Calls by the regions for support from international organizations, such as that contained in the 2007 African Union Declaration on Science Technology and Scientific Research for Development, also reflect a recognition by less advanced countries that science does not flourish in isolation. The Declaration recognizes that it is necessary to build and strengthen African institutions to enable them to conduct more scientific research, so that the outputs of this research can be used to solve social and environmental problems, and to contribute to economic development. This is a call for action to link scientific research and socioeconomic needs, and is being answered through joint action plans with, for example, UNESCO and the EU.

For the IAEA, technical cooperation among developing countries (TCDC) is one of the most effective means by which the diverse science and technology needs of countries can be addressed. TCDC draws on regionally available skills and facilities, and strengthens links between institutions in a region. Through their participation in regional TC projects, IAEA Member States with more developed nuclear sectors share their knowledge and facilities with other countries with less advanced nuclear sectors. This is facilitated and supported through cooperative agreements signed by the Member States of a region. Such Regional Agreements are in place in Africa, AFRA,[1] Asia and the Pacific, RCA,[2] and ARASIA,[3] and Latin America, ARCAL.[4] The agreements build national and regional ownership and encourage economies of scale and the efficient use of limited resources; they also provide a basis for intensified collaboration among Member States through programmes and projects focused on their specific shared needs.

The Regional Agreements have developed strategic frameworks for cooperative planning, which set out priorities, strengthen regional programmes and optimize horizontal coordination, including the use of institutional resources and exchanges of expertise. These frameworks allow for the identification of the region's most pressing needs that can be addressed with available nuclear technology and with the support of the IAEA or other international sources of cooperation.

Of course we also support initiatives in the nuclear field that have been taken by our Member States outside the aegis of the IAEA. A noteworthy example is SESAME, the large synchrotron facility for the Middle East being established near Amman, in Jordan, with continued support from UNESCO through its Basic Sciences Programme. SESAME aims to become a major centre for basic and applied research, based on the use of synchrotron radiation in several fields that have relevant applications to everyday life. The IAEA is supporting this important initiative through an interregional technical cooperation project – since countries from both the Asian and the African continents are involved – aimed at helping future SESAME users and operators prepare

[1]African Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology.

[2]Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology for Asia and the Pacific.

[3]Co-operative Agreement for Arab States in Asia for Research, Development and Training Related to Nuclear Science and Technology.

[4]Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean.

for the safe and secure commissioning and operation of the experimental facility by means of fellowships, scientific visits and expert missions.

Human resources are, in most cases, the main target of our TC programme; to give you an idea, just over the last 20 years, we have trained some 16,500 fellows and facilitated over 7,300 scientific visits. Fellowships are available to university graduates or their equivalent and to individuals at technician level in the requested field, mainly through project-oriented on-the-job training. TC has also initiated an IAEA fellowship programme for young professional women that aims to increase the proportion of female staff employed in nuclear institutions. Scientific visits, on the other hand, are intended to broaden the scientific or managerial qualifications of specialists in developing countries: they are awarded to senior staff to allow them to study the development of nuclear science and technology, as well as training programmes and schools in nuclear science.

Ladies and Gentlemen:

Introducing science is one thing, creating and maintaining scientific knowledge is another. This is why in Africa, for example, our Member States are currently implementing a regional strategy for Human Resource Development and Nuclear Knowledge Management through AFRA-NEST, the AFRA Network for Education in Nuclear Science and Technology. A harmonized curriculum for the Masters Degree in Nuclear Science and Technology has been adopted as a minimum standard for awarding such a degree in the region. A process to identify Regional Designated Centres in Professional and Higher Education, that can cater for the needs of countries which do not yet have the capacity to present the curriculum, has been initiated. Such initiatives recognize the importance for the region as a whole to develop a critical mass of specialists and research facilities in a number of areas of nuclear sciences and applications that a single country is not in a position to develop and maintain on its own.

Let me mention in this context, just by way of example, the case of one country, Ghana, which accords human resource capacity building a high priority. The Agency is supporting the PhD training of several fellows from the Ghana Atomic Energy Commission under sandwich programmes. Many of them will become lecturers in the School of Nuclear and Allied Sciences recently established in the University of Ghana. The School began in August 2006 with over 40 postgraduate students including 16 PhDs; several curricula have been accredited and the IAEA has provided inputs to most of these.

The International Nuclear Information System (INIS) is another tool that the IAEA offers to foster the exchange of scientific and technical information on peaceful uses of atomic energy. For decades already, we have supported the establishment of INIS centres around the world, creating a reservoir of nuclear information for current and future generations, providing quality nuclear information services to Member States, and assisting with the development of a culture of information and knowledge sharing. Just recently, a fully operational centre was established in Burkina Faso. In addition, joint training of fellows in Burkina Faso and Niger has resulted in strong cooperation between the institutions involved, who exchange information to support the effective functioning of their respective national INIS centres. In Africa we also assist Member States in establishing capabilities for the use of Information and Communications Technologies (ICT) for training and education in fields of nuclear science and technology relating to agriculture, human health, environmental monitoring, water resource management, nuclear instrumentation and other nuclear and related fields. This effort has recently been strengthened through the provision of ICT telecentres in several countries, including Botswana, Côte d'Ivoire, Nigeria, Senegal, Uganda, and South Africa. We also played a major role in the first Conference on ICT in training and learning in nuclear science and technology in Africa, which took place in Niger in 2007 and attracted a large audience of African ICT experts as well as decision-makers.

All of the above is carried out under the IAEA's technical cooperation programme. Before I conclude, I should also say a word about the IAEA's Coordinated Research Activities, a sound vehicle for strengthening the research capacity of institutes in developing countries, and for creating an enabling environment for the exchange of scientific information and technical knowledge transfer. Coordinated Research Projects complement the role of the TC programme. They provide researchers from developing and industrialized countries with an opportunity to unite their efforts to tackle problems of regional or global concern. A Technical Document summarizing the work and main conclusions of the project, published by the Agency, is a common output. Currently, the Agency is sponsoring over 125 coordinated research projects through 1,900 contracts and agreements awarded to institutes in our Member States.

Ladies and Gentlemen:

Nuclear science is regarded as a highly specialized field, but the IAEA's technical cooperation experience demonstrates how long-term support, careful capacity building, and the instilling of a strong safety culture through legislation and human resource development can bring even such a specialized science to bear on practical development problems, while at the same time placing ownership and programme direction firmly in the hands of Member States. How much more, then, will this be true for the institutionalization of basic science capabilities? All international and regional activities at the national level must keep in mind the point of their intervention – not science for science's sake, but science for people's sake. It is this IAEA experience in bridging the gap between basic sciences and their applications that I wanted to bring to this conference, as it is this bridging that can ensure that science is indeed put to the service of development.

Thank you.

Ana María Cetto is Deputy Director General of the International Atomic Energy Agency and Head of its Department of Technical Cooperation. She holds a degree in Physics from the Universidad Nacional Autónoma de México (UNAM), a Masters Degree in Biophysics from Harvard University, and a Masters and PhD in Physics from UNAM. She has been a research professor for over 35 years and is the author of 90 research articles in physics and more than 100 articles on science education, understanding and policy.

Ms. Cetto is former Dean of the Faculty of Sciences and Head of the Department of Theoretical Physics at UNAM. She has served as Secretary-General of ICSU and chairs the Board of Trustees of IFS. She was a member of the Board of UNU, a member of the Board and President of the Executive Committee of the Pugwash Conferences (Nobel Peace Prize 1995), and a consultant for the World Conference on Science (UNESCO-ICSU, 1999). She is founding Vice-President of TWOWS and an elected fellow of TWAS. She was the Coordinator of the project Museum on Light in Mexico City (1996) and is the founding president of LATINDEX, a comprehensive on-line information system for Iberoamerican and Caribbean scientific periodicals.

Ms. Cetto received the Golden Award of the International League of Humanists in 1998, the Prize for the Development of Physics in Mexico in 2000, and the Reconocimiento Sor Juana Inés de la Cruz in 2006. In 2003 she was appointed Woman of the Year in Mexico.

The contribution of UNESCO to regional and interregional cooperation to strengthen basic sciences in developing countries

Julia Hasler[1]

Since wars begin in the minds of men, it is in the minds of men that the defences of peace must be constructed.
From UNESCO's Constitution

Introduction

As a specialized agency of the United Nations, UNESCO contributes to the building of peace, the eradication of poverty, sustainable development and intercultural dialogue through education, the sciences, culture, communication and information. Established in 1945, UNESCO is the sole agency in the UN System having a unique mandate for the basic sciences and the promotion of cooperation in this field constitutes one of the principal elements of its action under its "S".

Although the basic sciences have become an indispensable science lever for development, their benefits are still unevenly distributed, and many countries find themselves excluded from the endeavour to create, and consequently, profit from scientific knowledge. The divide in the basic sciences cannot but deepen the divide in science education, technology, agriculture, health care, information technologies and, ultimately, between developed and developing countries. Although adequate national capacity in the basic sciences constitutes a major prerequisite for harnessing science in the service to society, there is a lack of support for the basic sciences in many countries, including in developed ones. Yet, a strategy of investment exclusively in favour of applied research, which seeks immediate short-term returns, has an adverse long-term effect on national science and development, and requires determined remedial action.

In a historical context, over the years and in cooperation with many partners, UNESCO has provided training within basic sciences for roughly

[1]On behalf of UNESCO Natural Sciences Sector, Division of Basic and Engineering Sciences.

500,000 researchers and university teachers – the majority of them young scientists from developing countries. It has also established and/or promoted many regional and international science centres of excellence and networks, and a number of non-governmental scientific organizations that cooperate with national institutions all over the world. Examples are the European Organization for Nuclear Research (CERN) in Geneva (Switzerland), the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste (Italy), the International Center for Pure and Applied Mathematics (CIMPA) in Nice (France), the International Centre for Membrane Science and Technology in Kensington (Australia), the International Institute for Molecular and Cell Biology in Warsaw (Poland), the Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME) Centre in Allan (Jordan), the International Biosciences Networks (IBNs), the Microbial Resources Centres Network (MIRCENs), the International Brain Research Organization (IBRO), and other bodies promoting North-South, South-South and West-East cooperation in the physical and biological sciences.

Based on the experiences gained within UNESCO's science programme and prompted by the needs of national science and technology, UNESCO's Member States decided to further develop intergovernmental cooperation for the strengthening of national capacities in science and science education. They did so through the launching of the International Basic Sciences Programme (IBSP), which has become a new operational platform to fulfill UNESCO's mandate in the basic sciences and science education.

The International Basic Sciences Programme (IBSP)

Continued cooperation and dialogue within UNESCO's programme led Member States and partner organizations to reach consensus on the principal objectives to be embraced by the IBSP, namely:

- building national capacities for basic research, training, science education and popularisation of science through international and regional cooperation in development-oriented areas of national priority;
- transfer and sharing of scientific information and excellence in science through North-South and South-South cooperation; and
- provision of scientific expertise for, and advice to, policy- and decision-makers, and increasing public awareness of ethical issues that progress in science entails.

To attain these objectives, the IBSP seeks to build major region-specific actions in cooperation with partner organizations and networks of national, regional and international centres of excellence or benchmark centres already in existence or to be created in the basic sciences. Such a strategy of action strives to foster wide participation in the programme of national and regional institutions, ensure a high scientific standard of activities, and make efficient use of UNESCO's experience in harnessing partnerships for responding to the needs and expectations of Member States.

Examples of collaborative initiatives currently undertaken within the IBSP are as follows:

- IBSP / TWAS / ICGEB programme on capacity building in molecular biology;
- IBRO / IBSP African Neuroscience Collaboration – Building brain sciences in Africa;
- CERN / IBSP initative on the Establishment and Networking of Electronic Libraries and repositaries for African Universities and Scientific Institutes;
- CERN / IBSP project on Training of Science Education Trainers from developing countries at the CERN High School Teachers' Programme and the CERN Summer Student Training Programme;
- Creation of UNESCO Regional Bioinformatics, Genomics and Proteomics (RBGP) Centre in Israel in cooperation with Weizman Institute of Science (Rehovot, Israel); and
- IUBMB / IBSP advanced schools in molecular and cell biology.

The IBSP remains open for any further consultations on joint actions with any interested national, regional or international institutions or organizations.

Areas of focus for IBSP

Compared with other intergovernmental/international science programmes of UNESCO, such as the International Hydrological Programme (IHP), the International Geosciences Programme, or the Man and Biosphere Programme (MAB), the IBSP is but a young programme. It became operational in 2005, and has only just completed its initial phase. Following proposals received from Member States, some 40 IBSP projects were carried out in the period 2005–2007. These projects received support from UNESCO and focused on capacity-building through regional or international cooperation and the pooling intellectual, material, and financial resources of participating institutions in two or more countries.

More recently IBSP has focused its activities on a smaller number of important priority projects. One of these projects is the intergovernmental SESAME Centre that was established under the auspices of UNESCO in Allan

(Jordan) and provides a new synchrotron radiation facility in the Middle East. The project seeks to foster scientific cooperation and solidarity in the Middle East, and to use the promising opportunities that synchrotron light offers for research in the physical, biological and chemical sciences, as well as in health care, high technology, the environment and the cultural heritage.

Another project of note is that aimed at the establishment and networking of electronic libraries and repositories for African universities and scientific institutes. This project, which opens a new vista for cooperation between CERN and UNESCO, is designed to create opportunities for training students in the physical sciences and includes activities in information and communication technology (ICT), such as grid computing, accelerator and detector technologies, in particular with applications to medicine, and other important fields of societal concern.

Rooted in UNESCO's longstanding activity in the basic sciences, the IBSP has a multidisciplinary profile that principally encompasses the mathematical, physical, chemical and biological sciences, while also focusing on science education and cross-disciplinary areas. However the programme is not designed to necessarily cover all the numerous areas of the basic sciences. Instead, the IBSP seeks to identify and address those selected areas of the basic sciences that play a key role for capacity-building in science, science education, the advancement of scientific knowledge, and the use of this knowledge to meet societal needs.

For this reason, UNESCO is, for example, fostering partnerships in cell and molecular biology, biotechnology, genetics, microbiology, neurobiology, biomedical sciences, bioinformatics, biochemistry and biophysics. It is doing this in view of the profound impact that contemporary biological sciences and their alliance with physics and chemistry have on the quality of life and sustainable development. Similarly, special priority is given to projects in chemistry of natural products, green chemistry, nanotechnology and solid state physics, as well as to some areas of theoretical physics and pure and applied mathematics. In science education, the IBSP aims to promote education at university and post-university levels, as well as the linkage between university education and other levels of education.

An example of a project in science education is the Global Microscience Experiments Project for science education in the basic sciences. This initiative builds on activities undertaken by UNESCO earlier within partnerships with RADMASTE Centre at Witwatersrand University, IUPAC, and IOCD. The project promotes hands-on experimentation through use of microscience kits for teaching different basic science disciplines in schools and higher education institutions. Many countries will be able to increase the quality of science teaching in experimental sciences through the use of this affordable, environmentally friendly and safe methodology.

The areas of focus for IBSP are dynamic and are modified and extended in response to the national needs expressed by member states. Moreover, the IBSP is developing cross-disciplinary actions relating to advocacy for science and the provision of science expertise to policy- and decision-makers. On the other hand, activities related to the earth sciences, oceanography and the environmental sciences are not covered by the terms of reference of the IBSP. Instead, they are being dealt with within other international/intergovernmental programmes of UNESCO's Natural Sciences Sector.

Centres of excellence and benchmark centres

The cooperation that IBSP is developing with centres of excellence is motivated by the fact that, in UNESCO's experience, national, regional and international centres of excellence or benchmark centres and their networks have proved to be among the major actors in promoting national research capacities and the use of scientific knowledge for societal needs. By relying on the services of many existing centres, as well as those to be established, the IBSP fosters excellence in national, regional and international institutions, and involves them in international cooperation for strengthening national capacities in science.

Interpretation of the definition of centres of excellence or benchmark centres may be sufficiently broad to embrace the specific criteria of excellence in the regions. Hence, in general, reference to a centre of excellence or benchmark centre could embrace a variety of national, regional or international institutions able to provide services at a standard sought by Member States of UNESCO or regions. A centre, therefore, could be a research or training institution, a university or one of its departments, a laboratory, science museum, library, etc.

A centre that has successfully participated in the implementation of an IBSP project may eventually be granted the status of IBSP centre of excellence or affiliated UNESCO centre in the basic sciences. This status is granted in order to stimulate further support to the centre from UNESCO's partners and other stakeholders in science, and to incorporate the centre into a network that provides viable scientific services to the Organization's Member States through international cooperation.

Major priority actions

In the framework of UNESCO's Medium-Term Strategy for 2008–2013, the IBSP seeks to consolidate and streamline its activities, and focus them on five Major Priority Actions (MPAs) in the basic sciences, namely:

(I) Institutional capacity-building;
(II) Human resources development in research and advanced training;
(III) Promotion of science education;
(IV) Leverage and transfer of scientific knowledge; and
(V) International science expertise and advocacy for science.

Each MPA provides a strategic guideline for shaping IBSP projects, and fostering the concentration of the programme. In this framework, an IBSP project is a set of concerted activities designed to make a tangible contribution to one or more MPAs through international or regional cooperation based on the pooling of intellectual resources, research facilities and funds available at national, regional and international levels.

Criteria for projects

The International Scientific Board of IBSP set up within UNESCO, advises on, and monitors the programme activities. Members of the Board, who hail from all regions and major partner organizations, are scientists actively engaged, in their countries, regions or organizations, in activities that relate to the objectives of the IBSP in the basic sciences, science education, science management and the promotion of international cooperation.

Member States of UNESCO and the IBSP Scientific Board have identified a number of optimum criteria to be applied for the design, evaluation and selection of priority projects. These criteria suggest that a project

- demonstrates scientific excellence;
- may have a real impact on national capacity-building, brings added value and results in lasting benefits;
- is endorsed by the National Commission for UNESCO of the countries involved and/or by pertinent authorities of the partner organizations;
- is relevant to regional development goals and/or Millennium Development Goals (MDGs);
- involves national institutions, science networks, centres of excellence or benchmark centres and partner organizations;

- entails and encourages the participation of at least two countries, one of which must necessarily be a developing one (the greater the number of countries involved in a project the higher is the priority it is likely to be given);
- encourages more particularly the participation of least developed countries;
- effectively uses the IBSP umbrella for catalyzing partnerships and extra-budgetary support from national, regional or international institutions or sponsors; and
- has potential for growth and for raising funds for further self-sustained action.

A proposal for a long-term project embracing more than one of UNESCO's biennial planning and budgeting exercises is to be divided into biennial phases. (A UNESCO biennium starts in an even year).

An IBSP project may use various modalities of action necessary to attain its objectives. Examples are the following.

- Setting-up centres of excellence or networks and development of their activity;
- Regional or international research collaboration within a network of national research institutions/universities;
- Research training at centres of excellence or benchmark centres;
- Advanced training courses, workshops, and seminars organized in cooperation with regional/international non-governmental scientific organizations;
- Activities of regional or international teams promoting science education and public awareness of science;
- Visiting professorships;
- Fellowships for young scientists;
- Activities against brain drain and the isolation of researchers in southern countries, in particular through support for research at home institutions, and South-South and North-South cooperative initiatives;
- Provision of scientific expertise for decision- and policy-makers; and
- Promotion of internet access to electronic scientific journals, and databases.

Since these modalities of action are not exhaustive, when selecting those best suited to attain the objectives of a project, other modalities for regional or international cooperation may also be proposed if more effective.

Participation in IBSP

Since 2008, the programme maintains a continuous dialogue with National Commissions for UNESCO, partner organizations, national institutions, science networks and research and training centres interested in the programme. In this framework, there will be no set deadline for the submission to UNESCO of proposals for the initiation of new IBSP projects or activities, or for the participation in, or development of, existing projects. When national institutions wish to propose a new initiative, they should first consult the relevant National Commission for UNESCO to identify the priority given to it by the governmental authorities, and their commitment to providing national support for it.

Initially, it is the outline of a proposal that is to be submitted and information for this can be obtained from the Executive Secretary of IBSP whose address is given at the end of this document. The outline of proposals are examined by the IBSP Scientific Board and those for which it gives priority will then be subject of consultation between the proposing bodies and the IBSP Secretariat so that an optimum, elaborate project proposal may be prepared. The Scientific Board examines the elaborate proposals and makes recommendations to the Director-General of UNESCO in order that she can take a decision on a project.

Support for projects within the IBSP

A network of institutions participating in an IBSP project constitutes a considerable pool of institutional, intellectual and material resources.

As a rule, the budget of an IBSP project consists of funds from UNESCO's budget, and extra-budgetary resources from the participating institutions, governmental establishments and sponsoring bodies. As Member States of UNESCO are well aware, the Organization is not a funding agency and its budgetary resources are limited. By virtue of its mandate, it therefore acts principally as a promoter of intellectual cooperation and as a provider of seed resources that help catalyze collaborative action and funds from national and other sources. This is why in any IBSP project proposal there is a need for evidence of the participation of Member States and/or international partners on a cost-sharing basis. This evidence is essential for assessing the feasibility of a project and identifying the contribution that may be made from UNESCO's budget. Moreover, this evidence serves as an important indicator of Member States' real commitment to the project and the practical use of its outcome.

The IBSP strategy to develop regional and international cooperation as an instrument for capacity-building in science implies *inter alia* that UNESCO's contribution to an IBSP project should preferably be used to promote collaboration between scientists in research, training, scientific expertise and science education, while the acquisition of equipment, chemicals, and scientific literature could be obtained from the extra-budgetary resources allocated to the project, and possibly the Participation Programme of UNESCO, which is designed to respond to specific needs of national and regional institutions, particularly those of the least developed and developing countries, post-conflict and post-disaster countries, small island developing states and countries in transition. All requests for support from the Participation Programme are to be submitted to UNESCO by National Commissions for UNESCO.

Other forms of support that IBSP may provide for projects embrace:

- Assistance for widening participation in the project of Member States, non-governmental scientific organizations and networks involved in the IBSP;
- Help, in cooperation with the IBSP Scientific Board, in obtaining external scientific expertise that may be required in the project from world-leading scientists or institutions;
- Provision of information concerning UNESCO's programme activities and other IBSP projects that can be used for project implementation;
- Granting, to a research centre or science education centre participating in the IBSP, the status of an IBSP centre of excellence recognized by UNESCO, or an affiliated UNESCO centre in the basic sciences;
- Assistance to integrate institutions participating in the project into regional or international networks cooperating with UNESCO;
- Support for fund-raising efforts to obtain funds for the project from governmental authorities, donor agencies or individual benefactors, non-governmental scientific organizations, research and educational institutions, fellowships committees, and world-renowned science leaders;
- Increasing awareness of the returns of the project, its findings and recommendations, in particular as regards bringing this information to the attention of governmental authorities and international organizations; and
- Assistance to promote follow-up to the project and the use of its results in developing countries.

Accomplishments resulting from IBSP projects are regularly reported to governments at the General Conference of UNESCO. Institutions having successfully participated in the IBSP and having been granted the status of UNESCO associated centre of excellence in the basic sciences will be able to develop their activity within an IBSP network of centres of excellence whose services to Member States will be promoted through intergovernmental cooperation in the framework of UNESCO.

Further information

Requests for further information, and inquiries and proposals concerning the IBSP should be addressed to Mr. Nalecz, Executive Secretary of the IBSP, Director, Division of Basic and Engineering Sciences at UNESCO.
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For further details see:
http://portal.unesco.org/science/en/ev.php-URL_ID=6293&URL_DO=DO_TOPIC&URL_SECTION=201.html

Julia Hasler, born in Zimbabwe and a graduate of the University of Cape Town (BSc Honours in Biochemistry, and PhD), had post-doctoral positions at the University of Cape Town Medical School and Arizona State University and visiting scientist positions at Massachusetts Institute of Technology and University of Arizona. She worked at the University of Zimbabwe for 22 years, rising from Lecturer to Professor of Biochemistry. At the University of Zimbabwe, she established a productive research group with funding from Sweden, and supervised many research students at Honours, Masters and PhD level in the area of biochemical pharmacology. Julia has been active in promoting regional cooperation in Africa and has a strong interest and commitment to building scientific capacity in Africa. In October 2003, she joined UNESCO in Paris as a Programme Specialist and is now involved in programmes to promote and support international collaboration in the life sciences and chemistry.

Regional and international cooperation to strengthen science, technology and innovation in Africa

Mohamed Hassan

Contents

A. Problems and challenges

1. Experience has shown that no country has achieved sustained economic and industrial development without the support of a minimum core of motivated, highly skilled and innovative scientists.

2. The continuous failure of the majority of governments in sub-Saharan Africa to increase and sustain investment in R & D has resulted in a gradual erosion of the competent research and education institutions and the subsequent loss of the most able scientific minds in the region to industrialized and oil-rich countries.

3. Measured by the number of research articles published in international peer-reviewed journals, sub-Saharan African countries contributed only 0.9 % during the five-year period 2003–2007 (see Tables 1 and 2, Annex 1). Out of this total, one country, South Africa, contributed 0.37 %.

4. During the same period the region produced a much smaller percentage of patents amounting to less than 0.07 % of world's total patents filed in the USA (see Annex 1, Table 3).

5. The fundamental challenge facing sub-Saharan Africa, in our view, is to successfully introduce radical measures to improve the quality of education and research, especially in schools and universities.

6. The second equally critical challenge is how to improve the quality and method of science education in schools and universities in order to train and retain a new generation of problem-solving scientists and technologists. The world-class scientists that Africa should hope to produce must know how to direct their talent to solving Africa's problems. The challenge therefore is to link cutting-edge science produced in Africa to critical real-life problems: achieving food security, providing safe drinking water, improving sanitation, improving accessibility to low-cost renewable energies and combating diseases. These critical needs are all part of the UN Millennium Development Goals which Africa is striving to achieve within the next five years.

7. In summary, the challenge that sub-Saharan Africa faces is how to nurture and sustain home-grown scientific talents to conduct problem-solving scientific research. The growing sustainability problem in the continent will never be solved by outside experts in spite of their good intentions.

B. Action by governments

8. The sustainable growth of science, technology and innovation (STI) and their utilization for developmental needs of African societies is, in the final analysis, mainly the responsibility of governments.

9. While it appears that the majority of the African leaders are convinced that only through science-driven development can their nations overcome poverty and achieve the MDGs, there is an urgent need for single-minded political leadership to translate this conviction into an articulated plan of action and a strong government commitment to implement it.

10. There are three levels of action that require the attention of governments. Firstly, it is essential that a national science policy based on the technological and industrial needs of the society be appropriately designed in collaboration with the local scientific leadership. For a country to have a clear and effective

science policy it is imperative that an efficient science policy organ be formed involving knowledgeable and capable science managers and advisers with sufficient responsibility and power to enable it to design and execute the national science plan and to coordinate all the scientific and technological activities in the country.

11. The number of African countries with science policy organs have, fortunately, substantially increased in recent years, particularly at the ministerial level. There are currently over 40 ministries responsible for national science and technology policies in the region. Nevertheless a number of critical problems have to be resolved before these bodies become effective and be in a position to render the services expected from them. These problems are largely caused by the shortage of funds and the inefficiency in management and organization.

12. Secondly, it is essential that the science policy be fully integrated into the nation's development plan. This will ensure that the scientific and technological knowledge generated by various research institutions is linked to the socio-economic and industrial needs of the country. Furthermore a close relationship between the national development plan and the national science and technology policy will on the one hand expand the involvement of industry and the productive sectors of the nation in research and development activities and on the other hand will promote mission-oriented scientific and technological research activities in support of the economic sectors. This is well illustrated by the case of South Korea (see Annex 2.1), where a concerted action by Government and private sector has helped the country to achieve remarkable progress in Science and Technology capacity and in industrial development.

13. Thirdly, the Government must ensure that adequate and stable funding is provided for the implementation of the national science and technology. As indicated earlier, without a firm commitment by the majority of African Governments to increase the level of funding for research and development from its current level of less than 0.3 % of the GNP to at least 1 %, no science policy will be effective enough in generating and sustaining indigenous scientific and technological capacity. The average proportion of GNP allocated to research and development in Africa is the lowest compared to other regions in the developing world and is about one tenth of the proportion in industrialized countries. This is in stark contrast to the large percentage of GNP spent in the military (see Annex 1, Table 4).

14. In recent years, Africa has witnessed a series of well-meaning promises, pledges and resolutions issued by Heads of State in Africa and around the world. Important among them are those issued by the G8 Summit in 2005 and the African Union Summit in 2007.

15. In 2005 the G8 leaders at their meeting in Scotland unanimously pledged to support the recommendations of the Commission for Africa, including the provision of 5 GUSD to help rebuild Africa's universities and 3 GUSD to help establish centres of scientific excellence in Africa. The following year a decision was taken by the G8 to authorize an initial 160 GUSD to support the creation of networks of centres of excellence proposed by the New Partnership for Africa's Development (NEPAD). Yet, to date, little of this amount has actually been transferred to Africa.

16. At the African Union (AU) Summit, held in 2007 in Addis Ababa, Ethiopia, 53 African leaders discussed regional strategies for the promotion of science and technology. They announced that 2007 would be the year of "African scientific innovation". African leaders have expressed support for science and technology in the past. But the meetings were followed by meagre results and disappointment. This time the level of commitment – and enthusiasm – was different.

17. The AU Summit recommended that each African country should spend at least 1 percent of its GDP on science and technology. Such a recommendation had been made several times before. This time, however, it may actually be fulfilled by some countries. In fact, several African countries, most notably those that have also embraced democracy and good governance, have substantially increased their investments in science and technology. These countries include Ghana, Kenya, Mozambique, Nigeria, Rwanda, Senegal, South Africa, Tanzania, Uganda and Zambia.

18. At the AU Summit, Paul Kagame, president of Rwanda, for example, announced that his country has dramatically boosted expenditures on science and technology from less than 0.5 % of GDP a few years ago to 1.6 % today. He also said his country would increase investments in science and technology to 3 % of GDP over the next five years. That would make Rwanda's investment in science and technology, percentage-wise, comparable to that of South Korea and higher than that of most developed countries. A country teetering on collapse less than a decade ago and still living in the shadow of genocide has embarked on a path that could lead to science-based sustainable development (see Annex 2.2).

19. South Africa is the second country in sub-Saharan Africa that is about to reach the level of 1 % of GDP expenditures in S & T. Their target is to achieve this by the year 2012.

20. In 2006, Uganda has received a 25 MUSD loan from the World Bank to support science and technology within the country, including the creation of centres of scientific excellence that will not only serve Uganda but also the entire region. The grant was given, in part, because of Uganda's successful

efforts to build its own scientific and technological capacities, particularly in the fields of public health and agricultural science.

21. In 2008, Zambia received a loan of 30 MUSD from the African Development Bank to support teaching and research at the University of Zambia and to provide postgraduate fellowships to some 300 students majoring in science and engineering. At the AU Summit, the president of Zambia, Levy Patrick Mwanawasa, proclaimed that building capacity in "science and technology is the only means to develop the country."

22. The president of Malawi, Bingu wa Mutharika, who heads one of the region's poorest countries, acknowledged at the AU Summit that building scientific and technological capacity provides the only sure way to break the longstanding cycle of extreme poverty that has gripped the African continent for decades. "We have depended on donor countries for scientific development for so long," he noted. "It is time we commit more resources in our national budget to advance science and technology." He urged his minister of finance to make science and technology a budget priority and to provide additional funds for this effort on a sustained basis. He also pledged to create international centres of excellence in the fields of hydrology and biotechnology.

23. In 2004 the Kenyan government decided to invest 12 MUSD to build the country's capacity in biotechnology, biosafety and genetically modified (GM) crops, making it the second sub-Saharan country (after South Africa) to conduct GM experiments that conform to international biosafety standards.

24. In 2008 the Kenyan president decided to establish a new science ministry by merging the former ministry of science and technology with the department of higher education. The new ministry of higher education, science and technology aims at strengthening the linkages between higher education and research. One of the successful accomplishments of the new ministry is the approval by the Kenyan parliament of a national policy in biotechnology.

25. In a similar move, Uganda's cabinet approved in 2008 the country's first national biotechnology and biosafety policy. The policy provides objectives and guidelines for the promotion and regulation of biotechnology use in the country.

C. Fostering the next generation of leaders in STI

26. Any national science policy must have as its first priority the development of human resources beyond the critical mass. The sub-critical number of highly qualified scientists and technologists in most African countries is hampering the development and applications of STI to the socio-economic needs

of the region. This, in fact, is a key factor for the presence of a large number of foreign technical consultants in Africa. Compared to other regions of the World, Africa has the lowest number of scientists and engineers per million inhabitants.

27. Training the next generation of STI leaders is therefore essential and has to be pursued both at the national and regional levels. This requires promoting science and technology learning mechanisms in both schools and universities. Although in recent years there has been a substantial expansion in the education systems in a large number of African countries, the shortage of qualified teachers, laboratory equipment and library facilities has inhibited the efficient training of scientists and technologists. As a result the quality of graduates in Mathematics, Science and Engineering in many African countries has fallen sharply.

28. Thus there is an urgent need in many African countries for improving the quality of secondary and higher education, especially in Mathematics, Science and Technology. This will require adequate funding for equipment and scientific literature in the majority of African schools and Universities. The availability of adequate scientific infrastructure will assist Africa to develop its own scientific talent and provide alternative and attractive opportunities for outstanding students to pursue higher education within the continent.

29. Graduate and postgraduate training within African institutions is essential to the vitality and credibility of these institutions. It has several advantages including enhancing the indigenous generation and application of knowledge, diminishing the possibility of brain drain and easing the pressure on governments to pay for large numbers of students studying abroad.

30. Within the process of manpower development special attention should be paid to the discovery and development of talent from the early stages of education. Gifted children need to be nurtured in a special environment conclusive to the exploitation of their talent and the development of their professional careers. This is well illustrated in countries such as Cuba and South Korea, where the governments have established specialized science high schools for the purpose of training gifted children, and advanced institutes of technology for university undergraduate education for talented students. The establishment of a similar system of elite schools and colleges in science and technology should be encouraged in Africa both at the national and regional level. This will provide a fast track for the supply of highly qualified and talented leadership in science and technology. The essential role of these indigenous world-class experts in the national development plans of the region cannot be overemphasized.

D. World-class universities and centres of scientific excellence

31. Following independence a major effort was made by African Governments to develop their universities and to establish within them scientific institutions of international standing. Those universities and institutions attracted some of the best young students in the continent and produced some of Africa's most eminent scientists. Unfortunately maintaining the scientific infrastructure in universities became a low priority at the advent of the financial crisis in the mid-seventies. As a result many highly qualified African scientists and engineers had left the continent in search for better jobs and research opportunities.

32. A recent statement on "Brain Drain in Africa" submitted by the Network of African Science Academies (NASAC) to the G8+5 Summit in July 2009 indicates that at least one third of African scientists and technologists live and work in developed countries. The statement calls upon African leaders and leaders of G8+5 countries to invest in rebuilding universities and centres of excellence in Africa and to honour previous commitments made by G8 Governments to support quality education in Africa (see Annex 2.3).

33. The current higher education system in the majority of African countries is not adequate enough to foster scientific excellence. If African universities and scientific institutions are to attract once again young talents into a scientific career, their teaching staff must include scientists of international calibre and their laboratories and libraries must be provided with adequate and up-to-date facilities.

34. Each African country must strive to build at least one world-class university to attract and nurture talented students and to provide quality research and training facilities.

35. It is also critical to establish research units and centres of excellence within universities to strengthen links between education and research.

36. Furthermore to counteract the brain-drain and to ensure that a critical mass of highly qualified experts in science and technology is always available, a number of world-class research and training national and regional institutes in areas of science and technology critical to Africa's development must be established in African countries where these do not exist. In particular it is vital for the credibility and competitiveness of African countries that world-class research institutions in critical areas related to health, natural resources and agricultural production be located within the continent. The presence of these world-class centres of excellence in the continent will also attract

eminent African scientists and technologists to return to their home country and help in a new science-centred development process.

37. Universities must also re-orientate part of their curriculum towards addressing real-life problems. They must link up with other problem-solving research institutions and provide the latter with young researchers they badly need.

E. Regional networks and international partnerships

38. The three major inter-governmental organizations in Africa promoting cooperation in science and technology are the African Union (AU), the United Nations Economic Commission for Africa (ECA) and the African Development Bank (AfDB). Under the aegis of these three organizations and other specialized agencies of the United Nations such as UNDP and UNESCO, a number of successful regional networks and centres have been set up to promote greater cooperation among African states in science and technology. A good example is the African Network of Scientific and Technological Institutions (ANSTI) set-up by UNESCO (see Annex 2.4).

39. This modality of regional cooperation proved to be very effective in pooling together the scarce resources for promoting communication and collaboration between African scientists and technologists. Such regional networks and centres should therefore be strengthened and the establishment of similar ones in other areas of science and technology should be encouraged.

40. The most viable non-governmental scientific organization promoting regional cooperation in science and technology is the African Academy of Sciences (AAS). Established in 1985 under the leadership of one of Africa's most prominent scientists, Professor T. R. Odhiambo, AAS has united the most eminent African scientists and has quickly gained world-wide recognition for its work in mobilizing the scientific community in Africa and for its efforts to promote science-driven development in the Continent (see Annex 2.5).

41. Cooperation between Africa and other regions of the South is very beneficial to the continent, especially with countries such as China, India, Brazil and Mexico, which have in recent years made remarkable progress in the development of their science and technology capacity and have established research institutions comparable in excellence with those of industrialized countries. These institutions are in a much better position to help other less developed countries of the South. A recent example of successful South-South cooperation is the development of biofuels in Sudan in cooperation with Brazil (see Annex 2.6).

42. TWAS has recently established an extensive programme of fellowships to facilitate the training of students and young scientists in the most scientifically advanced countries of the South. These fellowships, which are strongly supported by a number of governments in the South, can be of great benefit to young African scientists (see Annex 2.7).

43. A joint effort by African states and intergovernmental organizations of the UN system is urgently needed to establish in the region research and training centres of excellence in various fields of frontier science and technology which are most likely to have a strong impact upon the economic and social development of Africa. It is essential for these centres to be operated by African scientists of international standing and to be closely linked with African industries and other productive sectors.

44. Existing international centres in Africa such as the International Centre of Insect Physiology and Ecology (ICIPE) (see Annex 2.8) with stable funding and outstanding scientific leadership have recorded great success, which has been recognized world-wide. Centres such as ICIPE or the International Institute for Tropical Agriculture (IITA) are excellent examples for the new centres to be modelled on.

F. Strengthening the relationships between academia, governments and industry

45. For a national science policy to have a strong impact on the overall development plan, it is necessary that it succeeds in establishing strong collaboration between research institutions and local industry in areas of science and technology relevant to the industrial development of the nation. Academic and research institutions in Africa should be encouraged to orient their research and training activities towards the needs of industry. The industrial sector should on the other hand expand its involvement in the activities of the research and higher education institutes engaged in science and technology. The most successful newly industrialized countries of the South are those which have been able to form a strong alliance between science, technology and industry.

46. In most African countries there is very little interaction between universities and industry and very few universities in the region conduct research and training programmes pertinent to the industrial needs. To bridge the existing gap between scientists, technologists and industrialists, African governments should encourage and support the establishment within the universities of interdisciplinary research and training centres in areas of science and technology most relevant to the development of local industry.

47. In particular greater importance should be given to the development of strong linkages between engineering institutions, small-scale industries and the agricultural sector with the principal aim of producing simple and modern tools and equipment required by farmers to increase their productivity and efficiency.

48. Small research and training units should also be formed and strengthened in areas of cutting-edge technologies relevant to industry such as lasers, fibre optics, composite materials, pharmaceuticals, fine chemicals and biotechnology. These centres should operate as a joint venture between universities and industry and should be run by a common board involving high-level indigenous industrialists and academics.

49. Furthermore, to strengthen the linkages between research institutions and industry, qualified staff and postgraduate students in these institutions should be encouraged to undertake specific development projects in industry.

G. Summary and priority actions

50. Africa is entering the second decade of the 21st century with a monumental challenge to its survival and long-term development. At the base of this challenge is Africa's ability to participate in and benefit from the rapidly advancing frontier of scientific and technological knowledge.

51. In the Industrialized countries of the North and in a growing number of developing countries development is becoming increasingly dominated by the new forces of modern science, technology and innovation. These forces, if harnessed properly, offer immense possibilities for solving many of the complicated problems which are currently impeding economic and social development in Africa.

52. Recent advances in information and communication technologies, biotechnologies and nanotechnologies, for example, can be instrumental in helping African countries to eradicate poverty and achieve the Millennium Development Goals (MDG).

53. The challenge is, therefore, for African countries to master modern science and new technologies and to apply them to their own development requirements.

54. To meet this challenge, radical measures are needed by the African Governments. These will include substantially more investment in research and development and full integration of science and technology into national development plans, building national and regional capacities in science and tech-

nology, intensifying regional cooperation and establishing strong national and regional alliances between industry and research institutions.

55. For science and technology to make an effective contribution to development, a critical minimum of investment in research and development must be devoted by African Governments. At present very few African Governments allocate more than 0.3 % of their GNP to R & D, as compared to the allocation of over 3 % in the majority of industrialized countries. Thus a meaningful commitment by Governments in Africa should at least require a tripling of the existing resources to bring them close to the level of 1 % of the GNP as recommended by UNESCO and more recently by the African Union 2007 Summit.

56. Furthermore, Science and Technology policy need to be integrated fully into the national development plan of every country in Africa. This will ensure that the scientific and technological knowledge generated by various research institutions is linked to the socio-economic and industrial needs of the country.

57. Building indigenous capacities calls for strengthening research institutions, as well as developing the human resources beyond the critical mass. This will require adequate funding for equipment and scientific literature and more investment in mathematics, science and technical training.

58. There is also an urgent need for restructuring the systems of secondary and higher education to make science more interesting and attractive to young people. This means devising a more hands-on approach to scientific study in the classroom, emphasizing learning by doing rather than the rote memorization that has historically characterised scientific learning, especially in biology. "La main à la pâte" initiative launched by the French Academy of Sciences a few years ago, has become a much-emulated strategy for educational reform in science. The results have been encouraging, outlining a blueprint for success that can be emulated by others.

59. African countries must also support programmes to increase scientific literacy among both children and adults. Rapid advances in science mean that science education must be a lifelong endeavour. As science gains prominence among African countries, it is important to create and support institutions for life-long learning that enable people to understand what science-based development means for them and the role that science can play in poverty alleviation and sustainable growth.

60. Science centres and science museums are important institutions for bringing science to the public and promoting scientific awareness and public understanding of science. Of the 2,400 science centres worldwide, just 23 are in Africa, and they are concentrated in five countries: Egypt, Tunisia, Botswana, Mauritius and, most notably, South Africa, which has 17 such centres. There is an urgent need to establish at least one science centre in every African country.

61. Furthermore, to counteract the brain-drain and to ensure that a critical mass of highly qualified experts in Science and Technology is always available, a number of world-class research and training institutions in critical areas such as food security, energy supply, tropical diseases, soil erosion, water quality, deforestation and desertification must be established and sustained within the continent.

62. In addition, collective action by African states and donor organizations is required to establish high-level research and training centres in key areas of frontier science and technology such as molecular biology, biotechnology, informatics, nanotechnology and new materials.

63. Regarding human resource development, the plan should be to reach the level of at least one thousand scientists per million population in every African country before 2025. To achieve this aim, African universities and research institutions should be provided with sufficient infrastructure to enable them to offer attractive opportunities for outstanding science students to pursue higher education within the Continent.

64. Postgraduate training within the African institutions will enhance the indigenous generation and application for knowledge, diminish and possibly reverse the brain-drain, and ease the pressure on Governments to pay for large numbers of students studying in the industrialized countries. To further facilitate this, African Governments and donor organizations should sponsor a major programme of scholarships to enable African students to pursue postgraduate education in high-level scientific institutions within the Continent and in other scientifically advanced developing countries. Such programme can be implemented in collaboration with TWAS, the Academy of Sciences for the Developing World.

65. Throughout the process of human resource development, special attention should be paid to the discovery and development of talent. Achieving the desired goal of science-led and sustainable development depends very crucially on engaging fully Africa's most able and talented young minds. Special programmes, such as the Olympiads aimed at identifying young talented students with exceptional scientific abilities, should be supported at the national, subregional and regional levels. Gifted students selected through these programmes need to be nurtured in a special environment to accelerate the development of their talent. This can be achieved through the establishment of national or regional elite schools and colleges for gifted students or through designing intensive and challenging additional school and university courses in basic Sciences and Mathematics.

66. Given the scarcity of resources, regional cooperation in some critical areas of science and technology is essential. A charter on scientific cooperation between African States is urgently needed to facilitate links between research institutions and to allow full freedom of movement of researchers and students within the continent.

67. Priority should be given to setting up jointly funded regional research and training centres of excellence in key areas of frontier science and technology relevant to the economic and social development of African societies. The African Academy of Science (AAS), which has brought together eminent scientists from all parts of Africa and has facilitated the establishment of a Network of African Science Academies (NASAC), is in a unique position to play a key role in developing regional programmes in science and technology. The Academy and the Network deserve strong support from the African Governments.

68. For research institutions in Africa to have a strong impact on economic development, it is necessary that they establish strong links with local industries to facilitate the utilization of scientific results by the production sectors. In addition, the scientific and technological needs of industry should also be clearly identified to universities and research institutions to enable them to orient their research and training plans to meet these needs.

69. Furthermore, African policy makers should initiate regional or subregional projects aimed at forging new partnerships between industry and research institutions in which research teams from both sides are encouraged to work together on technological and environmental projects of great benefit to the continent.

Annex 1. Tables

Table 1. Production of S & T knowledge (2003–2007).

Part of the world	*Percentage*
Sub-Saharan Africa	0.9
Rest of the developing world	19.4
Rest of the world	79.7
Total	100.0 %

Table 2. Sub-Saharan Africa's share of scientific publications 2003–2007.

Country	*Percentage*
South Africa	0.37
Nigeria	0.09
Algeria	0.07
Kenya	0.05
Cameroon	0.03
Tanzania	0.03
Ethiopia	0.03
Uganda	0.02
Ghana	0.02
Senegal	0.02
Zimbabwe	0.02
Rest of Africa (39 countries)	0.16
Total	0.91 %

Table 3. Patents for inventions by US Patent Office.

Country	*US Patents (average 2003–2007)*	*Percent of world total*
South Africa	98.0	0.06063
Kenya	4.8	0.00297
Zimbabwe	1.0	0.00062
Nigeria	1.0	0.00062
Seychelles	0.4	0.00025
Gabon	0.2	0.00012
Benin	0.2	0.00012
Côte d'Ivoire	0.2	0.00012
Ghana	0.2	0.00012
Ethiopia	0.2	0.00012
Tanzania	0.2	0.00012
Cameroon	0.2	0.00012
Total (12 countries)	106.6	0.06593 %

Table 4. Public investments in African countries.
Sources: World Military and Social Expenditure 1989, Ruth Leger Sivard, World Priorities, Inc., Washington D.C. (these figures refer to 1986 and GNP/capita is expressed in 1986 USD) and Statistics and Technology (Extracts from UNESCO Statistical Yearbook 1989).

Country	*Population in thousands*	*GNP/Capita* USD	*Defence % of GNP*	*Health % of GNP*	*Education % of GNP*	*Science and Technology % of GNP*	MUSD	*1% of GNP* MUSD
Algeria	22,386	2,654	1.9	2.2	6.1	0.3	178.24	594
Angola	8,983	1,095	12.0	1.0	3.4	n/a	n/a	98
Benin	4,177	275	2.3	0.8	3.5	n/a	n/a	11
Botswana	1,117	983	2.3	2.9	9.1	0.2	2.20	11
Burkina Faso	8,090	151	3.0	0.9	2.5	0.5	6.12	12
Burundi	4,860	238	3.5	0.7	2.8	0.4	3.40	12
Cameroon	10,136	935	1.7	0.7	2.8	0.8	75.84	95
Central Afr. Rep.	2,638	297	1.7	1.2	5.3	0.2	1.56	8
Chad	5,141	131	6.0	0.6	2.0	0.3	2.02	7
Congo	1,787	975	4.6	2.0	5.0	0.0	0.06	17
Egypt	48,857	749	8.9	1.0	4.8	0.2	57.68	366
Ethiopia	43,037	120	8.6	1.0	4.2	n/a	n/a	52
Gabon	1,021	3,161	3.8	2.0	4.8	n/a	n/a	32
Gambia	767	265	0.8	2.3	4.0	n/a	n/a	2
Ghana	13,267	496	0.9	0.3	3.5	0.9	59.26	66
Guinea	6,225	305	3.0	1.0	3.0	n/a	n/a	19
Guinea Bissau	n/a	n/a	n/a	n/a	n/a	n/a	n/a	19
Ivory Coast	10,688	673	1.2	1.1	5.0	0.3	21.59	72
Kenya	21,224	324	2.4	1.9	6.0	0.8	55.10	69
Lesotho	1,583	395	2.4	1.6	3.5	n/a	n/a	6
Liberia	2,249	450	2.2	1.5	5.0	n/a	n/a	10
Libya	3,935	5,290	12.0	3.0	10.1	0.2	72.28	208
Madagascar	10,547	256	2.4	1.8	3.5	0.2	6.58	27
Malawi	7,379	178	2.3	2.4	3.7	0.2	2.63	13
Mali	8,322	152	2.5	0.7	3.2	n/a	n/a	13
Mauritania	1,814	444	4.9	1.9	6.0	n/a	n/a	8
Mauritius	1,050	1,256	0.2	1.8	3.3	0.6	9.72	13
Morocco	22,709	604	5.1	1.0	5.9	n/a	n/a	137
Mozambique	14,079	272	7.0	1.8	n/a	n/a	n/a	38
Niger	6,298	266	0.7	0.8	4.0	0.1	1.67	17
Nigeria	98,483	731	1.0	0.4	1.4	0.3	215.94	720
Rwanda	6,312	265	1.9	0.6	3.2	0.5	9.07	17
Senegal	6,613	446	2.3	1.1	4.6	1.0	29.49	29
Sierra Leone	3,755	341	1.2	0.7	3.0	n/a	n/a	13
Somalia	6,627	235	4.4	0.2	6.0	n/a	n/a	16
Sudan	22,470	393	5.9	0.2	4.0	0.2	17.66	88
Swaziland	688	551	1.6	2.4	6.2	n/a	n/a	4
Tanzania	23,607	284	3.3	1.2	4.2	n/a	n/a	67
Togo	3,052	256	3.2	1.6	5.5	1.4	10.95	8
Tunisia	7,443	1,121	6.2	2.7	5.0	n/a	n/a	83
Uganda	16,033	461	4.2	0.2	1.1	n/a	n/a	74
Zaire	31,684	160	3.0	0.8	0.4	n/a	n/a	51
Zambia	7,283	359	3.2	2.1	4.4	0.5	13.09	26
Zimbabwe	8,567	682	5.0	2.3	7.9	n/a	n/a	58

Annex 2

Annex 2.1. South Korea and Nigeria

In the late 1960s, South Korea and Nigeria were relatively comparable to each other when it came to broad statistical indicators that are often used to define a country's position within the global community – for better or worse. South Korea's gross domestic product (GDP) stood at nearly 7.5 GUSD, 32nd in the world. Nigeria's GDP was 6.6 GUSD, 36th in the world. In terms of scientific publications in international peer-reviewed journals and number of patents, it's fair to say that neither South Korea nor Nigeria had any significant contributions to report.

What a difference a few decades can make – at least for some countries. In 2007, South Korea's GDP stood at 1.2 TUSD, 14th in the world. Its scientists were responsible for 2.7 percent of scientific publications worldwide (that's 10th in the world and nearly twice the percentage of all of Africa). According to the World Intellectual Property Organization (WIPO), in 2007, South Korea overtook France to become the fourth country of origin for Patent Cooperation Treaty filings, behind the United States, Japan and Germany.

Nigeria, meanwhile, has remained stagnant in its rankings. Its GDP was 295 GUSD in 2007, 38th in the world. The number of peer-reviewed scientific publications by Nigerian scientists was less than 0.12 percent of the world's total; and the number of patents was still too small to show up as a percentage of the world total (1 application in 2007 according to WIPO). South Korea, by the way, has a landmass of about 98,000 square kilometres and a population of 49 million. Nigeria has a landmass of about 910,000 square kilometres and a population of 148 million.

Annex 2.2. STI-based development strategy of Rwanda

Rwanda's new development strategy, as elaborated in reports like Vision 2020 and National Investment Strategy, shows the country's determination to adopt science and technology as a fundamental tool to achieve economic development. Government's major measures in the field of STI include the improvement of the country's scientific and technological infrastructure through public investment and South-South cooperation, the promotion of a knowledge-based economy through information technology and the application of science, as well as the development of a small number of world-class institutions of higher education, including the National University of Rwanda and the Kigali Institute of Science, Technology and Management.

Annex 2.3. Brain drain in Africa

The Network of African Science Academies (NASAC) has recently submitted a Statement on "Brain Drain in Africa" to the G8+5 Summit held in Aquila (Italy) in July 2009, in an attempt to tackle the longstanding loss of human resources affecting Africa and severely hampering its development efforts.

Following the 1960s and 1970s, during which period Africa boasted some of the developing world's finest universities, a steep decline in funding, political indifference and widespread conflict created the premises for an increase in brain drain as native scientists were increasingly confronted with a dramatic deterioration of career opportunities in their home countries. It is estimated that currently one third of all African scientists live and work in developed countries.

While acknowledging past efforts to tackle brain drain by individual African countries, Pan-African organizations, developed nations and international banks and inter-governmental agencies, and at the same time reckoning that the solution lies primarily with Africa, NASAC leaders propose a new approach to meeting the challenge. This approach recognizes the opportunities that may be provided by the diaspora of African scientists residing abroad and calls for devising new policies to draw on their knowledge and expertise to the advantage of Africa's scientific and economic progress.

Based on the new approach, the phenomenon long perceived as a one-way flow of African scientists is turned into a two-way flow interaction through joint projects between Africa's emigrant researchers and home-based scientific communities. Developed countries are asked to contribute by helping improve Africa's S & T infrastructure, fostering North-South scientific cooperation and promoting policies allowing an increased mobility of scientists across borders.

The statement suggests in particular five measures to tackle brain drain:

- Invest in the rebuilding of universities and research centres in Africa to enable African scientists to engage in world-class research without having to emigrate;
- Extend financial support to young African scientists to pursue postgraduate and postdoctoral training in universities in Africa and other developing countries;
- Launch regional and international centres of excellence in Africa in areas of study of critical importance to Africa's development, especially with regard to the MDGs. These centres should promote international collaboration in solving global problems relevant to Africa;
- Broaden efforts to encourage Africa's diaspora to participate in initiatives to address critical science-based issues on the continents and to engage African scientists in joint projects. To these purposes, policies may

be devised to encourage short-terms visits and collaborative projects involving Africa's scientific diaspora and scientists who have remained in their home countries; expanding North-South scientific exchange; development of a database of highly qualified Africans in the diaspora;
- Honour the commitment made by G8+5 countries at the 2005 G8 Summit and based on the recommendations of the Commission for Africa's publication, *Our Common Interest*, which called on its members to provide 5 GUSD to help rebuild universities and 3 GUSD to help establish centres of scientific excellence in Africa.

Annex 2.4. The African Network of Scientific and Technological Institutions (ANSTI)

The African Network of Scientific and Technological Institutions (ANSTI; www.ansti.org) is a body of cooperation that includes African institutions engaged in university-level training and research in science and technology. Created in 1980, through the financial support of the United Nations Development Programme (UNDP), United Nations Educational, Scientific and Cultural Organization (UNESCO) and Germany, the network has grown over the years to become an effective institution for the development of human resource capacity in the fields of basic and engineering sciences. To date it has 109 member institutions in 35 countries in sub-Saharan Africa.

Annex 2.5. The African Academy of Sciences (AAS)

The African Academy of Sciences's mission is to serve, first, as an honorific society with the primary function of honouring African science and technology achievers and, second, as a development-oriented mobilizer of the entire African science and technology community with the fundamental role of facilitating the development of scientific and technological capacity for science-led development in Africa, promoting excellence and relevance in doing so. The African Academy of Sciences primarily focuses on:

- Capacity building in science and technology;
- Mobilization and training of the African scientific community;
- Publication and dissemination of scientific materials;
- Research, development and public advocacy.

The functioning of the Academy as a Pan-African honorific society, together with its organizational structure, programme impact and track record, has contributed to its success in the last 20 years. Indeed, AAS has through its activities succeeded in building networks and partnerships within Africa and throughout the world. With its Pan-African outlook, the Academy has been able to influence issues of global concern on the continent, coordinated the activities of several national scientific organisations for the benefit of the whole continent, and gained credibility as a rallying point for the overall development of science and technology in the continent.

The fact that AAS fellows are drawn from all over the continent has created a large pool of highly motivated expertise in a wide range of scientific, technological and social science disciplines working together in a trans-disciplinary manner to tackle many of Africa's developmental problems.

Annex 2.6. South-South cooperation on biofuels: the case of Sudan

In June 2009, Sudan inaugurated its first biofuel plant that is expected to produce in the next two years 200 million litres of ethanol from sugar cane. The plant was built in cooperation with the Brazilian company Dedini drawing on the long-standing experience of Brazil in the field of biofuels.

Another major project, worth 150 MUSD, for the development of biofuels in the country is being carried out in collaboration with Egypt and focuses on the production of biofuels from non-edible crops, including agricultural waste such as rice straw, crops stalks and leaves. Development of biofuels using agricultural waste is proving a successful strategy for its positive impacts both on the environment and food security. In fact, diverting agricultural waste to producing ethanol can decrease the polluting effects of burning agricultural waste preventing at the same time the sacrifice of food supplies to produce biofuels, with positive impacts on the country's food security.

Annex 2.7. TWAS South-South Fellowships

The TWAS South-South Fellowships programme provides over 280 fellowships annually tenable in developing countries such as Brazil, China, India, Malaysia, Mexico and Pakistan for scientists from developing countries.

The fellowships, for various lengths of time, are available for postgraduate, postdoctoral and advanced research and are awarded in collaboration with partner organizations, including the National Council for Scientific and Technological Development (CNPq), Brazil; the Chinese Academy of Sciences (CAS), China; the Council for Scientific and Industrial Research (CSIR) and Department of Biotechnology (DBT) of the Government of India, and the S. N. Bose National Centre for Basic Sciences and the Indian Association for the Cultivation of Science (IACS), India; the Universiti Sains Malaysia (USM), Malaysia; the National Council on Science and Technology (CONACYT), Mexico; and the National Centre of Excellence in Molecular Biology (CEMB) and the International Centre for Chemical and Biological Sciences (ICCBS) in Pakistan.

Annex 2.8. ICIPE: A case study of an international centre of excellence in Africa

ICIPE (www.icipe.org) was created in Nairobi in 1970 with the aims of developing methods for managing crop pests and disease vectors and enhancing the use of beneficial insects. These activities are rigorously carried in ways that are environmentally friendly and sustainable.

In recent years, ICIPE has developed, for instance, a system of growing molasses grass between rows of maize to repel stemborer pests from the crop and introduced new varieties of honeybees and silkworm moths. The results of ICIPE's research work have been widely adopted by thousands of African farmers with positive impacts on income generation.

Mohamed Hag Ali Hassan was born on 21 November 1947 in Elgetina, Sudan. He is Executive Director of TWAS, President of the African Academy of Sciences (AAS) and chairman of the Honorary Presidential Advisory Council for Science and Technology in Nigeria. After obtaining his DPhil (University of Oxford, 1974), he returned to Sudan as professor and dean of the School of Mathematical Sciences at the University of Khartoum.

He received the Comendator (1996), and Grand Cross (2005), National Order of Scientific Merit, Brazil; and Officer, Order of Merit of the Italian Republic, 2003.

His membership includes: TWAS fellow (mathematical sciences), 1985; Founding Fellow, AAS, 1985; fellow, Islamic World Academy of Sciences, 1992; honorary member, Academia Colombiana de Ciencias Exactas, Físicas y Naturales, 1996; corresponding member, Académie Royale des Sciences d'Outre-Mer, Belgium, 2001; and foreign fellow, Pakistan Academy of Sciences, 2002.

Support for mathematics in developing countries

John M. Ball

Introduction

In this short article I will address some issues related to the support of mathematics in developing countries. Of course many of these issues are similar to those facing other scientific subjects, but there are some difficulties special to mathematics. Mathematics underpins all the sciences, both as a language and a way of thinking. It is impossible to adequately address science-related problems facing countries without a solid science and mathematics base. Many of the key challenges facing the planet, for example the prediction and control of the climate, have key mathematical components; these challenges are global, and require global intellectual cooperation. Such cooperation has the important corollary of contributing to peace and understanding between nations independent of their political relations.

Mathematics is highly incremental – you need to master more elementary concepts before learning more advanced ones – and to reach higher levels requires many years of training. Encountering a poor teacher may have a very damaging effect on a student's mathematical education and enthusiasm for the subject. Thus the quality and inspiration of teaching is critical; in particular the training of teachers is a vital component in improving mathematical standards. This is one reason why sequential strategies based on first improving primary, then secondary mathematics, etc. will not succeed; well-qualified people are needed to train teachers and develop educational strategy. All levels from primary education to research in universities need to be tackled simultaneously in order that mathematics contributes to society in an effective manner.

Developing countries initiatives of the International Mathematical Union (IMU)

IMU is the scientific union for mathematics (responsible, for example, for awarding the Fields Medals). The members of IMU are countries; there are currently 68 members, representing a majority of the world's population but a minority of the 193 countries in the world. This is typical of scientific unions, and reflects both the lack of scientific organization in some less developed countries and a feeling (which I do not share) that member countries should have a track-record of mathematical research. A subcommission is the International Commission on Mathematical Instruction (ICMI), with an additional 17 members who are not members of IMU, another the Commission for Developing Countries. A new class of Associate Membership was introduced in 2006 especially designed for developing countries (with no dues and no vote); so far 4 countries, Ecuador, Kenya, Kyrgyzstan, and Thailand have joined in this category and more applications are under consideration or are being prepared.

Since the IMU income is primarily from the dues of members, the budget for support of developing countries is very small compared to need, about 170,000 USD annually, including a generous contribution of 45,000 USD from the Abel Fund. The budget is used to fund a small grant scheme for conferences and research visits, to make a small number of strategic grants, to fund (in conjunction with contributions from national mathematical societies) travel for young and senior mathematicians from developing countries to attend the four yearly International Congress of Mathematicians (in Hyderabad, India, 2010), and to support the Ramanujan Prize for young mathematicians from developing countries (jointly with the Abel Fund and ICTP, Trieste). A recent initiative is the writing of the report, sponsored by the John Templeton Foundation, *Mathematics in Africa: Challenges and Opportunities* (see www.mathunion.org/publications/reports-recommendations).

A mentoring scheme for Africa

This is a joint initiative of the IMU, the London Mathematical Society (LMS) and the African Mathematics Millennium Science Initiative (AMMSI – see the contribution by Wandera Ogana, page 113), funded by grants from the Nuffield Foundation and Leverhulme Trust. The imprimatur of IMU/LMS/AMMSI was essential for convincing the funders that their money would be well spent.

Under the scheme, research groups in Africa are paired with individuals and groups in the UK and elsewhere who act as mentors. The pairing is done following calls for proposals by AMMSI and for mentors by the LMS (on websites, in the LMS newsletter and the IMU electronic newsletter IMU-Net). A key aim is to improve morale and research capability in African Mathematics Departments. African faculty and research students may make short visits to the institutions of mentors, but the idea is to support research groups *in situ* without contributing to a brain drain. So far nine mentoring partnerships have been set up, with three new ones soon to be initiated. (Details of the partnerships can be found on the LMS website at www.lms.ac.uk/grants/MARM_projects.html.) As examples, one partnership is between Frank Neumann, of the University of Leicester, UK, and the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana. The aims and objectives of this partnership are: coordination of research interests for mentoring and collaboration, selection of suitable postgraduate students and researchers, improvement of the local research environment, improvement of postgraduate education, dissemination and exchange of knowledge, and the establishment of permanent national and international research links. A notable outcome of this partnership has been its influence in the selection of KNUST as the location for the new National Institute of Mathematical Sciences (NIMS).

Another partnership is between Nigel Cutland, of the University of York, UK, and the Bahir Dar University, Ethiopia, an aspiration being the launching of an MPhil/PhD programme in order to upgrade staff. The department at Bahir Dar University suffers from problems typical of universities in the developing world, such as minimal library resources, with many texts photocopied, very poor internet, large teaching loads (more than 12 hours per week), and a lack of research leadership.

Developing mathematics in Tibet

I have visited the Department of Mathematics at the University of Tibet in Lhasa three times, in 2002, 2005 and 2009, and am currently supervising a research student from the department in Oxford. With help from the Chinese Mathematical Society and the China Association for Science and Technology, I have tried to help the Department develop a plan of action to improve the research and teaching quality. Tibet University faces many difficult issues, including geographical isolation and a harsh physical environment (the altitude of Lhasa is 3650 m). Despite an attractive new campus the facilities are poor in comparison with many universities in mainland China. There is no significant research tradition and it is difficult to attract well-qualified faculty even with enhanced salaries. About half the undergraduate students are Tibetan and half from mainland China, with corresponding differences in background and native language, but working harmoniously together. The undergraduate degree is designed exclusively for the training of school teachers. Funding for research training and travel to conferences, etc. is negligible.

Some of these problems are not unique to less developed parts of the world and not quick to solve; we all know how difficult it is to introduce a research culture into a department that does not have one. One possible way to accelerate the process could be to establish a link with a stronger department in mainland China which can act in a mentoring capacity and help train young faculty. Another is to take advantage of video-conferencing technology to access courses and seminars and conduct remote research supervision, thus mitigating the effects of geographical isolation, a possibility made all the more practical since China has a single time-zone. Of course all this requires appropriate funding. The undergraduate course could be broadened so that it trains mathematicians who will be useful to society in different ways, not just as school teachers.

Citations and impact factors

There is a worrying trend throughout the world for university administrators, government funders, etc. to rank the research of departments and individual researchers by seemingly objective metrics such as numbers of citations and the impact factors of journals where their papers are published. It seems that this trend is accentuated in some developing countries, where its effects can be more serious due to the smaller size of the research base. In some countries salary is affected by such metrics, while I have heard of one university in a relatively prosperous though underdeveloped country that seeks to improve its research rating by hiring to part-time posts highly-cited researchers, by this means acquiring their own share of the citations of these researchers. Numbers of citations, impact factors, etc. are statistics, perhaps valuable if intelligently used in the evaluation of large units, such as universities or large departments, but dangerous when applied to individuals (see the 2008 *Citation Statistics* report of IMU/ICIAM/IMS; www.mathunion.org/fileadmin/IMU/Report/CitationStatistics.pdf). It is what you write, and what top researchers think of it, that really counts, not where your paper appeared or its general popularity; deep work may be unappreciated for some years except by a few experts capable of understanding it.

Concluding remarks

Mathematical talent does not respect geographical or political boundaries, but the opportunities to develop it vary widely depending on where you live. Schemes to nurture such talent should involve cooperative planning with subject leaders in the developing country concerned (thus respecting local culture and conditions), and should avoid externally imposed solutions. Talented individuals should be identified, supported and rewarded through long-term programmes. An important resource comprises (especially young) academics in the developed world, who should be encouraged to regard it as part of their duty to share knowledge and experience with those who have less access to facilities and advice. As discussed at this conference, thematic networks are an excellent way to increase critical mass and morale. The internet has essentially removed the problem of access to information, given a suitably fast connection (however, being trained to use this information is a different matter). As internet connections improve, live video-conferencing becomes an increasingly attractive possibility for sharing courses and seminars between regions on similar time-zones, in particular increasing the effectiveness of thematic networks.

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Importance of collaboration and networking in capacity building in basic sciences in the developing countries

Mohammed Mosihuzzaman

Basic science in LDCs and developing countries

Physics, Chemistry, Mathematics and Biology are the basic science subjects which form the foundation of all professional and applied sciences. However, these basic science subjects are chosen by fewer students worldwide, even in the developed nations. The primary reason is limited job availability. The other reason is lower income prospect. The situation for choosing science subjects by students is very similar for LDCs and developing countries. This is particularly so as the politicians and administrators, who are usually not from science background, do not have any concept regarding the necessity of basic science as the foundation of national development. South Korea and Malaysia are examples of having such concepts and they could assemble a large number of scientists (and also engineers) by attracting expatriates with much higher salaries to create the scientific base for national development. Something similar can be done for most the LDCs if they want to develop quickly. Clear political vision and will are prerequisite for achieving such results—and are lacking in most cases.

Lack of minimum number of scientists

Lack of interest in taking up basic science subjects at the university level starts with a low level of teaching and learning in the secondary and higher secondary level. This is primarily due to lack of adequate number of science teachers in schools and the absence of proper laboratory facilities. The situation is very similar in research organizations and government-run standards and testing laboratories. A minimum critical number of scientists are required to develop a particular field of science. That critical number is not present in most of the laboratories in developing countries and thus scientific development is seriously impaired. Whatever is done is usually based on isolated personal efforts.

Lack of instrumental facilities

Personal efforts often generate frustration due to lack of research facilities. For experimental sciences, lack of instruments is the major hurdle. It is often seen in developing countries that a young bright science graduate after returning from abroad with a PhD degree joins as a faculty in a university or as a scientific officer in a research organization and gets totally frustrated within a short time. Only a few dedicated patriotic persons survive these frustrations and try to contribute to society within limited resources. Others either find their way out of the country or just pass their time with routine job assignments, e.g., taking the assigned classes in the universities. Interest to stay back can be created by giving them incentive, both monetary as well as providing better facilities for research.

Formation of Groups or Clusters within a department or within several departments can help in procuring some instruments through the university. A determined worker may find some funds locally and, in very few cases from international sources. Several people working together mean collaborating with each other. At the present stage of scientific development, collaboration between persons working in the same field has widened significantly to include persons working in related fields. For example chemists, biologists and medical professionals must collaborate closely if they want to develop a drug or unravel the mystery of a disease. Collaboration is also an absolute necessity for securing services of sophisticated instruments, especially for those working in developing countries. The existing collaborations are usually North-South, but in some limited areas Regional or South-South collaboration is developing.

Spirit of Cooperation within the country or in the region is at low level

Unfortunately, in my personal experience, the spirit of cooperation is very much lacking in the South. Even in a particular department, one faculty member is hardly collaborating with another faculty working in similar fields. Interdepartmental or multidisciplinary collaboration is a necessity realized by many but practiced by very few in the South. Regional South-South or in some cases South-North collaboration has contributed in the development of basic science in some areas. Much more is needed to be done to stimulate spirit of cooperation among scientists in the South.

True patriotism or concern for humanity may induce such spirit.

Preference for North-South collaboration

Most of the scientists working in the universities and research organizations in the less-developed countries in the South did receive their higher degrees in the North. Many of them are naturally inclined to North-South collaboration. In many cases this leads to working in the North, publishing some papers and securing promotion in the home institution. This does not help development of research at home.

A reverse type of collaboration, which may be termed as South-North collaboration, can be more beneficial. In this type of collaboration scientists and postgraduate students work in the South for some time, which can help build research in the South in two ways: (a) Knowledge and skill can be better transferred if a scientist from an advanced laboratory spends some time in the South as the experienced scientist from the North can guide the collaborating scientist as to how to work in a difficult situation with limited facilities. (b) Postgraduate students from the North can do a part of their work in the south and can directly help the postgraduate students in the host laboratory with their better knowledge base and skill.

Collaboration leads to Networking

Collaboration at the National and Regional levels leads to Networking. Networks give some formal and structural basis for continued collaboration. Exchange of scientists and young postgraduate students within the Networks facilitate transfer of knowledge and skill among the collaborating institutions. Networks are better placed to organize scientific seminars, symposia and conferences by exposing larger number of research workers from within and outside the networking institutions to the latest scientific activities. International scientists are drawn to the conferences usually leading to expansion of collaboration.

Networks are in a better position to draw attention of development partners and donor agencies than individual scientists. Administrative problems sometimes create hurdle in running the networks towards achieving their goal. However, these hurdles can be overcome by better understanding and spirit of cooperation among networking institutions or persons.

National, Regional and International Networking

Networks can be at the national level. For example NITUB (Network of Instrument Technical personnel and User scientists of Bangladesh) is a national network. However, in recent time it is expanding its activities by helping other developing nations in organizing similar networks or training programmes.

There are a good number of Regional networks specifically in the chemical sciences. Examples are many like NAPRECA, ANRAP, LANBIO, etc.

AFASSA (Africa, Asia, South America) is an example of an international network involved in coordinating natural product research in the three continents.

Funding for networks in basic sciences

Except for some specific sources like ISP, networks involved in Basic Science do not find an easy way to get funded. Scientists involved in networking will have to work hard to draw attention of development partners and donor agencies for funding. National Governments of the countries involved in networking are usually not interested as they hardly understand the value of scientific collaboration. Again scientists of the respective countries are to lobby their governments to get grants for networks.

Networks supported by ISP

ISP is unique in encouraging formation of networks and giving continuous support to them. IFS supports network activities but they are limited to their Grantees only. UNESCO and OPCW have supported networks in a limited way.

ISP networks are primarily in the Chemical Sciences; some with a touch of biology. Africa hosts most of the ISP-supported networks. Only two are in Asia, one in South America and one includes all these three continents: AFASSA. AFASSA is not truly a network in itself, it is rather a network of networks.

The two networks in Asia are a little different than all others. ANRAP is a disease-targeted (diabetes) natural product research network. NITUB is also a very special network dedicated to keeping scientific instruments working and thus directly contributing to basic science.

Positive effects of networks supported by ISP

ISP started its activities by inviting physicists to Sweden in the 1960s and later in the 1970s chemists were also invited to Sweden to develop collaboration with Swedish scientists. In the 1980s ISP started giving long term follow-up support to the scientists who continued their pursuit of research at their home laboratories. This follow-up support started creating research groups centering ISP Fellow and some successful Research Groups emerged.

These success stories led to the formation of networks centering around the successful research groups. So, the focal points of networks usually started with successful research groups.

Most of the networks have contributed significantly in bringing scientists together and transferring knowledge and skill to the less-privileged laboratories. A good number of young scientist, especially postgraduate students, have been trained in laboratories with relatively better facilities. Many seminars, symposia and conferences have been continuously organized by the networks at the national, regional and international levels. These scientific meetings have not only benefited local scientists and students but also created opportunities for new collaborations.

Capacity building through ISP support

By supporting research groups, ISP has contributed significantly in developing instrumental facilities for research. Much of the instruments in the laboratories of ISP-supported research groups came through ISP grants. The capacity building has been, in many cases, augmented by IFS Grants to individual scientists in a group. OPCW has contributed in donating some costly instruments to successful Research Groups supported by ISP.

Capacity building also means human resource development. Training of young scientists and postgraduate students has contributed to building up research capability in the ISP-supported countries. Many senior scientists also have been exposed to advanced laboratories in Sweden and elsewhere in Europe and updated their knowledge and skill.

Development of Basic Sciences by ISP support

ISP may be identified as a single agency which has contributed significantly, and without strings, in developing basic sciences in developing and least-developed countries. It will be difficult to quantify such developments.

The improvement in instrumental facilities in a particular research group in a department has contributed in the overall development of research activities in the department. Some faculty members from the department and from other departments have used the facilities. Competitive research efforts have improved quality of research for others outside the ISP-supported group. Of course jealousy has also been created, impeding certain activities in the group.

The overall impact is improvement of research activities in the basic science areas of physics, chemistry and biology and, in recent times, also in mathematics.

What more can be done?

Networks may be given more importance in developing basic sciences in the South. Laboratories with leading roles in network activities may be given due prominence in considering funding so that they may become Centers of Excellence capable to provide better service to the networking institutions.

Other funding agencies, like IFS, OPCW, UNESCO, TWAS, etc., may note the above two points. Networks and participating laboratories should seek fund from other agencies, directly or through respective governments to improve the activities of the networks. Successful laboratory leaders have a better chance of getting funds from sources other than ISP.

Responsibility of scientists in the South

In the ultimate analysis, it can be said that it is the responsibility of the scientists in the South who has to shoulder more burden with hard work to improve basic science in their respective countries. The scientists have to note that without improving science education at the pre-university and undergraduate levels, basic science will not improve as may be expected.

Lobbying is required everywhere and at all levels. Basic science also requires strong lobbying by the scientists at the ministerial level as well as at the highest level of the government. Although in many cases ministers are simply decorative, they should be invited to opening/closing ceremonies of seminars/symposia/conferences. This is just an important part of the lobbying.

Outlook and policy decisions by the North

Swedish support in general and ISP funding in particular are practically without strings. Grants once made, ISP does not interfere in the final budgeting of the allotted money. The fellow has to give a detailed report on the expenditure every year. For any change in diverting money from one head to another, the fellow is supposed to discuss with ISP. In case of most other donor agencies and development partner countries strings are attached with a grant or soft loan. This may be in terms of appointing consultants from the country concerned or buying instruments from their own manufacturers.

Swedish support to ISP is now limited to certain designated countries. Government outlook and policy decisions taken by the donor countries are their inherent internal matter and we cannot do anything about it. We can only urge the development partner countries to broaden their outlook and take policy decisions in such a way that Basic Science is developed in the South, as development of Basic Science is a primary requirement for overall national development.. The consequences of most countries in Africa, Asia and South America, remaining under-developed with poverty, pollution and disease will affect the developed nations equally.

Change of vision in the country concerned

Unfortunately, the governments in the poor countries in the south do not realize the above fact. We, scientists must try hard to convince the policy makers in our respective countries to have a different mind-set. We, through our universities or Academies of Sciences should put forward visions for the future which governments may pick up. Without changing the vision and the will of the politicians (or non-political rulers), science will not develop in the South and we will remain LDCs or at the bottom of the developing nations. We have to shake up the bureaucratic machinery and the governments to make them realize that basic science has to develop without which national development cannot be geared up. The alternative is to get into the government and take proper policy decisions.

Knowledge-based society and survival with dignity

Twentieth century was primarily dominated by industry-based societies. In contrast, the twenty-first century is visualized to be driven by knowledge-based society. To expand our knowledge base we must excel in Basic Science. Therefore, we must endeavor to improve Basic Science in whatever way we can. For surviving in this competitive world there is no alternative.

We must strive to be at a high level of knowledge in Basic Science, paving the way for its application in this digital age and create a future for our next generation to live in dignity.

Mohammed Mosihuzzaman (born 6 August 1940) got his MSc in Organic Chemistry from the Department of Chemistry, University of Dhaka, in 1963 and his PhD from the University of Birmingham, UK, in 1968. He spent two years at the Ohio State University, USA, as a Post-Doctoral Fellow. He spent all his life teaching various topics of Organic Chemistry at the University of Dhaka and retired in 2006. He organized a big research group in Dhaka with support from ISP and IFS and produced over 100 MSc degrees, 5 MPhil degrees, and 19 PhD degrees, and published more than 110 research publications in national and international journals. His research interests started with carbohydrate chemistry; then he concentrated on medicinal plants, especially those having anti-diabetic and anti-cancer activities. Lately he also worked on organic pollutants and established the Organic Pollutants Research Centre at his department. After retirement he spent time at the International Centre for Chemical and Biological Sciences at the University of Karachi, Pakistan. Recently he has taken a bold step to establish the International Centre for Natural Product Research (ICNPR) with scientific support of a host of reputed scientists from around the globe.

Professor Mosihuzzaman is the Founder Chairman of the ISP-supported Asian Network of Research on Anti-Diabetic Plants (ANRAP). He is also the initiator and coordinator of another very successful network, the Network of Instrument Technical Personnel and User Scientists of Bangladesh (NITUB) which has been widely acclaimed both inside and outside Bangladesh—see the article by Altaf Hussain on page 321.

Mohammed Mosihuzzaman has also written the report on the Asian Network of Research on Anti-Diabetic Plants, page 299.

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Regional and international cooperation to strengthen basic science in Africa

Aderemi Kuku

1. Introduction

For the purpose of this article, *basic sciences* will mean Mathematics (including Statistics and Computer Science), Physics, Chemistry, and Biology (including Basic Medical Sciences). It is well known that basic sciences are at the foundation of all areas of science and technology for socio-economic development.

Basic sciences have in fact flourished in Africa over the years through international cooperation and collaboration. For one thing, the initial African contacts with modern-day mathematics, physics, chemistry and biology came through colonial education – British, French, Portuguese, etc. – which came from Europe, and the earliest African specialists in these areas were trained in Europe or the USA through one international cooperation or another or at universities in Africa intimately linked with top universities in the UK or continental Europe. Indeed, research and education in the basic sciences flourished at high level during the colonial era and up to the 60s and 70s, when the quality of higher education in many of the African universities compared favourably with the best in Europe and the USA. Unfortunately, the situation of higher education started deteriorating from the mid-seventies, and by now, progress in education and research would have ground to a halt but for the cooperation and collaborations with many African tertiary institutions from many international scientific organizations – e.g. Sida, ISP, IPMS, UNESCO, ICTP, CIMPA, MSI, TWAS, RSC, NUFU, etc. and some foundations such as Ford, Mellon, Carnegie, etc.

Today, the need for regional, interregional and international collaboration to strengthen basic sciences in Africa is even more compelling in view of the fact that there has been undue proliferation of universities all over the continent with inadequate matching funds from the African governments, with the consequences that available expertise in the basic sciences is spread thin, resulting in shortages of staff, facilities, and infrastructures and serious reduction in the quality of tertiary education being received in the sciences by African students.

The general objective of basic scientific education in Africa should include inculcating the cultures associated with scientific training, preparing adequately those who will constitute middle and high-level human power for the continent, and creating a critical mass of basic scientists needed for the overall social, economic, scientific and technological development of Africa.

In this article we examine how far Africa has gone towards achieving this goal through regional and interregional collaboration and how to further strengthen basic science through such collaborations.

First we briefly review in section 2 some reasons for Africa's underdevelopment – some historical reasons, lack of political will, dependent economy, inadequacy of teaching and research facilities, brain drain, environmental problems, and high population growth. In section 3, we discuss the nature of basic sciences relative to other areas of science and technology. We examine the African situation and conclude that Africa has yet to produce a critical mass in all the areas of science and technology. Section 4 is devoted to international cooperation and networking in the basic sciences. Here we showcase some successful ongoing research and networking efforts being made on the continent. In section 5, we briefly discuss a Pan-African AAS/UNESCO capacity-building project in the basic sciences in the hope that this project, which aims at improving teaching and research in the basic sciences in their various ramifications, will be embraced and supported by the international scientific community and funding agencies. In a final section 6, we briefly outline the way forward for Africa – political will of African governments to invest heavily in research and development; radical improvement of teaching and research facilities; radical improvement in funding for science and technology research and development; strengthening existing networks and creating new ones; radically improving the quality and quantity of research output in Africa; attracting good students for careers in the basic sciences; identifying contemporary areas of basic sciences for development in Africa; leapfrogging into modern scientific frontiers and high technologies; strengthening currently identified potential centres of excellence and identifying new ones; and so on.

2. Some reasons for Africa's underdevelopment in science and technology

Even though Africa is a big continent endowed with a lion's share of the world's natural resources, with a large population of about one billion as well as a large area of arable land, Africa remains the least developed continent in the world. Here are some reasons why.

2.1. Some historical reasons

One major reason for this underdevelopment is historical, because Africa was left behind by the radical mathematical, scientific, industrial and technological revolutions of the 18th and 19th centuries when also many basic scientific principles resulting in general theories were discovered. These revolutions resulted in accumulated knowledge with associated scientific tradition and culture in the developed world, as a result of which Africa had little or nothing to show by way of tradition and culture in scientific, technological and industrial knowledge and practice. In fact, most first-generation African basic scientists are still alive.

Nevertheless, during the colonial era, high-level education, intellectual pursuits and creativity flourished in Africa up to the 60s and 70s when many African universities compared favourably with the best in the UK, Europe and the USA. From the mid-70s till now, the situation has deteriorated rather badly. There has been serious decline in enrollment for postgraduate studies resulting in lack of enough university teachers in the basic and other sciences. Moreover, proliferation of universities of dubious quality have further spread thin available expertise on the continent with resultant fall in standards of university education.

2.2. Lack of political will

Many African countries have not made S & T development their priority. Most African countries invest only 0.1 to 0.4 % of their GDP to Research and Development. Only South Africa and Rwanda have invested up to the desired 1 %. Tanzania hopes to attain this level of investment by 2015.

2.3. Dependent economy and debt burden

Many countries in Africa still import manufactured goods at exorbitant prices as well as export raw materials which earn rather little in the world market. It is also well known that the huge external debts of many African countries constitute a serious handicap to their development, since very little foreign exchange is left for development after servicing debts. However, it is gratifying to note that some African countries such as Nigeria have recently received substantial debt-relief packages from their creditors and have been able to settle such debts for good.

2.4. Lack of a critical mass of S & T teachers and researchers

Expertise in Mathematics and S & T is spread thin all over the continent. Many institutions are understaffed with inevitability of large classes and inadequate tutorials. Some basic scientists like mathematicians and physicists are becoming endangered species since it is becoming difficult to find adequate replacements for those retiring.

2.5. Inadequacy of teaching and research facilities

Basic scientific research can only be productive in an atmosphere of adequate journals, books and laboratory facilities. It is well known that teaching and research facilities are less than adequate in most African countries. Most of the good books at tertiary level are imported, and because of the low value of the currencies in many African countries, these books are unaffordable to students, teachers and even libraries. The use of computers for teaching in schools and tertiary institutions are just beginning to catch on but even then computers are in short supply because not enough funds are committed for that purpose.

2.6. Brain drain

Many of the African mathematicians and scientists trained abroad either do not return or even when they do return decide after a while to leave their countries for a career abroad for various reasons ranging from poor remuneration, lack of enough facilities or maltreatment by their home institutions or countries.

2.7. Environmental problems

Environment problems in form of political instability, natural and man-made disasters, dysfunctioning public utilities make it difficult to function efficiently as scientists.

2.8. High population growth

This puts a lot of pressure on existing rather limited resources, facilities and services.

3. Nature of basic sciences vis-à-vis other areas of science and technology

3.1. Nature of mathematics

Mathematics as a discipline has a long history spanning thousands of years with significant contributions to its developments at various periods of history due to various cultures such as Egyptians, Babylonians, Greeks, Arab-Islamic, Indians, Mayans, Chinese, Europeans. Moreover, the subject has come a long way since Archimedes used to find the volume of a sphere through weighing of infinitesimals (into which such a sphere was divided). Methods currently applied have become very profound, sophisticated, rather technical and diversified, and we rightly see mathematics today in its various ramifications:

Number, involving activities such as counting, measurements of length, weight and so on, as well as displaying deep understanding of rational, real, complex, and p-adic numbers;

Shape, leading to studies in geometries, topology, Lie groups with applications like gauge-field theories, fractals, catastrophies, strange attractors, and so on;

Movements, of waves, planets, involving the use of ordinary and partial differential equations, Fourier analysis, calculus of variations;

Chance and randomness, with associated mathematics like probability, statistics, stochastic differential equations, etc. – all with the added exploratory powers of new technologies such as computers.

The subject is now so large with so many sub-disciplines and it is in fact believed that more mathematics has been created in the last one hundred years than in all previous ages put together. Many traditionally applied areas – e.g. engineering and technology, chemistry, physics, economics, biology, etc., now require sophisticated mathematics for their in-depth study. Moreover, problems that have confounded mathematicians for years, including the easily stated Fermat's last theorem could only be solved through highly sophisticated and abstract techniques.

All these considerations raise serious pedagogical issues about how to minimize global illiteracy in contemporary mathematics that has resulted in hostilities towards the subject from parents, funding institutions, and the general public. The fact that the subject continues to grow phenomenally in various directions dictates a crying need to continue to find efficient, economical ways of coordinating and unifying ideas for the purposes of teaching, research and applications.

Mathematics is also interwoven with other sciences. Thus, we have Mathematical Biology (Biometrics), Mathematical (Theoretical) Physics; Mathematical (Theoretical) Chemistry, Mathematical Economics (Econometrics), Mathematical Linguistics, or even Mathematical History (Cliometrics).

3.2. Major components of science and technology

There are essentially four major areas of science and technology as follows:

3.2.1. Basic sciences

These include: (a) Mathematics (including statistics and computer science; (b) Physics; (c) Chemistry; and (d) Biology (including basic medical sciences).

3.2.2. Applied sciences

These include: (a) Medicine and Health; (b) Agriculture (including livestock, fisheries and forestry studies); (c) Energy; and (d) The Earth Sciences (including Meteorology and Oceanography, irrigation and soils, mineral exploitation, many areas of engineering such as civil, mechanical, electrical and so on.

3.2.3. Low or classical technologies

These include areas such as: (a) Iron, steel and other metal goods; (b) Petroleum technologies; (c) Power generation and transmission; (d) Design and fabrication industries; (e) Chemicals.

3.2.4. High technologies

These include (a) Micro-electronics, including development of software, computer-aided design, the fabrication of microchips, and their applications to industries; (b) Space Sciences; (c) New materials (including composite materials and high temperature super-conductors); (d) Pharmaceuticals and fine chemicals; and (e) Biotechnology (including the knowledge of molecular biology, genetics and microbiology, which are very promising for use in agriculture, energy and medicine), nanotechnologies.

3.3. Some remarks on how Afrcia has fared relative to the above classification on S & T

The question now is: How has Africa fared in each of the four areas outlined above? The truth of course is that Africa has yet to produce a critical mass in any of the components, while the developed countries continue to make phenomenal advances. So, it becomes inevitable that Africa find short cuts to develop in all directions and leapfrog into basic scientific frontier as well as high and emerging technologies. So, there is no need for debates on whether Africa should concentrate only on low-level technologies or so-called applied sciences. Obviously, Africa needs to mobilize her youth to cover all terrains and do whatever they can do best.

One important aim of this article is to see how further international cooperation could result in more rapid development of basic sciences and hence S & T on the continent.

4. International cooperation and networking in basic science in Africa

As remarked earlier, research in the basic sciences has flourished in Africa over the years through international cooperation North-South and South-South. There are a lot of ongoing networks in the various disciplines across the continent with cooperation from various scientific agencies, and organizations outside Africa and the deteriorating situation of basic scientific research in the universities have made it imperative that the existing networks be strengthened and new ones initiated. In this section we discuss some of the existing networks and how they could be further strengthened.

4.1. Mathematical sciences

4.1.1. Major areas of mathematical research in Africa

Research in many areas of mathematics is being carried out all over the continent – e.g. Algebra (some), Analysis (numerical, classical, functional, complex, harmonic), Topology (some) (algebraic, differential); Algebraic Geometry (some); Riemannian Geometry (some), Logic and foundations (some), Ordinary differential equations (ODE), Partial differential equations (PDE); Probability and Statistics, Graph theory (some), Computer Science (some), Mathematical modelling, Biomathematics (some), Mathematical physics, Control theory (some), Lie groups and Representation theory (some), Dynamical system (some), Fluid Mechanics, Non-Commutative Geometry (some).

The word *some* attached to some areas of mathematics above indicates that such areas are scantily represented on the continent. In any case, Africa has no critical mass in any of the specialties. Indeed, viable research groups exist in very few universities. Some of the weak areas for the continent include Mathematical Statistics, Mathematical Computer Science, Algebra in a broad sense, Algebraic Topology, Differential Geometry/Topology, Algebraic Geometry (including Arithmetic Algebraic Geometry), Dynamical Systems, Lie Groups, Lie Algebras, Non-Commutative Geometry.

4.1.2. Some mathematical networks in Africa and their international connections

Even though Africa is yet to have critical masses in various areas of the mathematical sciences, there are nevertheless some functioning networks.

(A) EAUMP and PDEMC. There are two networks supported mainly by the Swedish International Programme in the Mathematical Sciences (IPMS), based in Uppsala – one in Eastern Africa (Eastern African Universities Mathematics Programme, EAUMP, and the other, Partial Differential Equations, Modelling and Control, in West Africa including Burkina Faso, Senegal, and Mauritania). The research areas covered by the networks include epidemiological modelling, ecological and hydrodynamical modelling, modelling of pollution of ground water. These two networks are also being supported by CIMPA, Nice (France), and ICTP, Trieste (Italy).

(B) GIRAGA (Group inter-africain de Recherche en Analyse, Géométrie et Applications). This network connects institutions mostly in Francophone West and Central Africa. GIRAGA was founded in 1986 and organizes seminars and advanced courses in Analysis, Geometry and Applications mostly at Yaoundé in Cameroon and Porto-Novo in Benin. This network has obtained substantial support from CIMPA, UNESCO, ICTP, DAAD and the Belgian Government.

(C) RAGAAD (Reseau africain de Géométrie et Algèbre appliquées au Développement). This network is supported also by CIMPA, ICTP, etc.

(D) AMMSI (African Mathematics, Millennium Science Initiative). This network is part of a global network MSI (Millennium Science Initiative) based at the Institute for Advanced Study, Princeton, New Jersey, USA. This network has a task force made up of African mathematicians from all the African subregions and has been involved in awarding grants and scholarships, as well as organizing schools and workshops for the benefit of young mathematicians.

(E) *Two dormant networks*. There were two good networks that have recently become dormant: (1) AMU, Pan African Mathematical Sciences network under the auspices of the African Mathematical Union (aimed at exchanging staff and graduate students South-South and North-South (i.e. between Africa and the developed world) and (2) MUSA (Mathematics and Its Uses in Southern Africa) connecting Botswana, Malawi, Mozambique, Namibia, Zambia and Zimbabwe, Lesotho, and Swaziland under the sponsorship of NUFU (the Norwegian University Committee for Development, Research and Cooperation). It is hoped that these two strategic networks will be revived in the future.

4.1.3. Some mathematical centres

There are also some mathematical centres devoted to the propagation of research and education in the mathematical sciences.

(1) *NMC, National Mathematical Centre*, Abuja, Nigeria. This Centre is supported mainly by the Federal Government of Nigeria and had fruitful collaborations from ICTP, UNESCO, etc.

(2) *IMSP, Institut de Mathématiques et de Sciences Physiques*, Université d'Abomey-Calavi, Porto-Novo, Benin. This institute has received support

as well as enjoyed good collaboration with ICTP, the Belgian Government, TWAS, CIMPA, and the EU.

(3) *AIMS, African Institute of Mathematical Sciences*, Capetown, South Africa. This institute is supported by the South African Government, NEPAD, VODACOM, Gatsby, Mellon, and Ford Foundations.

(4) *IRMA, Institut de Recherche en Mathématiques*, Université de Cocody, Abidjan, Côte d'Ivoire. This centre is supported mainly by the government of Côte d'Ivoire.

(5) *National Centre for Mathematical Sciences*, Accra, Ghana. This Centre is supported by the Government of Ghana as well as some international funding agencies, e.g. IPMS, Sweden.

4.1.4. Some regional and subregional mathematical societies

(A) *AMU, African Mathematical Union*. Founded in 1976, AMU organizes many mathematical research and education activities all over Africa. AMU has four Commissions on (1) Mathematics Education, (2) History of Mathematics in Africa, (3) Pan-African Mathematics Olympiads, and (4) Women in Mathematics in Africa. AMU also publishes the Journal *Afrika Mathematika*.

(B) *SAMSA, Southern Africa Mathematics Association*. SAMSA also organizes various mathematical activities in Southern Africa.

4.2. Research and networking in physics

In most African universities and tertiary institutions, good expertise in various areas of physics, especially theoretical physics is rather thin on the ground. Among the various institutions and societies promoting research and networking on the continent are the following.

4.2.1. *African Physical Societny*

The activities of this society include: (1) promoting science, mathematics, and technology education in Africa; (2) promoting general collaboration and networking among African and other physical societies in and outside Africa; (3) publishing *African Journal of Physics*.

4.2.2. *African Materials Research Society*

This society seeks to promote research and networking in Africa. In particular, it promotes the African Laser Centre funded by the South African Government, NEPAD, etc.

4.2.3. *AMSEN, African Materials Science and Engineering Network*

This network connecting some universities in West, East and Central Africa aims at development of materials science and engineering for the benefit of the continent, especially as regards adding value to the mineral deposits all over the continent.

4.2.4. *National Astrophysics and Space Sciences Programme*

This programme is located in Capetown, South Africa, and spearheads and coordinates a network involving various universities in South Africa which provide training and education as well as host students for research projects.

4.2.5. *National Institute for Theoretical Physics*

This institute aims to provide high quality African graduates in mathematics and physics from within and outside South Africa.

4.2.6. *African Advanced Institute for Information and Computation Sciences*

This institute based in South Africa aims to promote research and networking in computational sciences all over the continent.

4.3. Research and networking in chemistry

4.3.1. *Federation of African Societies of Chemistry*

This federation promotes the advancement of chemical sciences and the advancement of chemistry that will impact on developmental aspirations of Africa. It cooperates with international organizations such as UNESCO, RSC

(Royal Society of Chemistry), IUPAC, EUCHEMS, etc. The Federation, together with UNESCO and the Government of Ethiopia succeeded in getting the year 2011 declared by UN as the International Year of Chemistry.

4.3.2. Pan-African Chemistry Network

This network currently has three hubs: in Kenya (University of Nairobi), Ethiopia (University of Addis Ababa), and South Africa (Johannesburg and Capetown). It organizes research collaborations and networking in and outside Africa as well as provides resource materials for effective teaching and other tertiary institutions. It also organizes workshops/conferences and awards scholarships.

4.3.3. AFNNET, African Natural Products Network

AFNNET aims at propagating research in natural products chemistry and biochemistry as well as related fields of engineering, pharmacology, environmental science, nutrition and economics in order to develop Africa's rich biodiversity into a natural products industry.

4.3.4. SABINA, Southern African Biochemistry and Informatics for Natural Products

This network aims to propagate research in Natural Products Chemistry and biochemistry to exploit its potential for increasing food security and improving public health.

4.4. Research and networking in biology

4.4.1. African biosciences networks

These networks supported by NEPAD aim at building and strengthening capacity in the biosciences through networking and harnessing the indigenous knowledge for sustainable utilization of natural resources and wealth generation of Africans. There are four subregional networks:

(A) *SANBio, South African Network for Biosciences*. This network is based at the Council for Science and Industrial Research (CISR) in South Africa.

(B) *BECA, Biosciences East and Central Africa*, based at the International Livestock Research Institute (ILRI) in Kenya.

(C) *WABNet, West African Biosciences Network*, based at the Institut Sénégalais de Recherches Agricoles (ISRA) in Senegal.

(D) *NABNet, North Africa Biosciences Network*, based at the National Research Centre in Egypt.

4.4.2. *African network for the promotion of conservation biology*

This network is in cooperation with the AAS and the International Society for Conservation Biology.

4.4.3. *African Society for Computational Biology*

This society organizes various activities in Africa and promotes networking in cooperation with the International Society for Computational Biology.

4.4.4. *African Institute for Biomedical Science and Technology*

This institute in Harare, Zimbabwe, is in cooperation with WHO, National Institutes of Health, Centres for Disease Control and Prevention, promotes the Bio-Bank and the Pharmacogenetics database of African populations, which deals with collection and preservation of biological material for biomedical research in Africa.

4.5. Other African regional science initiative

4.5.1. *RISE, Regional Initiative in Science and Education*

This initiative under the auspices of AAS, the African Academy of Sciences, SIG, Science Initiative Group, and the Carnegie Foundation supports five thematic networks involving a number of universities in Africa and provides comprehensive graduate training.

5. African Academy of Sciences (AAS); UNESCO project for capacity building in the basic sciences

(A) *Rationale for the project*

(1) Basic sciences constitute the foundation of all scientific, technological innovation, social and economic development of Africa.

(2) The sorry state of basic sciences all over the continent creates a compelling and urgent need for this project.

(3) AAS is a Pan-African Organization with members who are distinguished specialists in most aspects of science and technology and can thus mobilize its members and secretariat for providing effective solutions to many of the

basic-sciences problems. Many members are also influential politically in their countries and also in their subregions

(4) UNESCO has an international basic sciences programme and so, AAS and UNESCO can effectively collaborate towards the alleviation of the problems. Moreover, some of the AAS Fellows are members of the UNESCO Board for IBSP.

(B) *Pan-African network for research and education in the basic sciences.*

(a) *Aims and objectives of the network*

(1) To produce adequate staff in universities, polytechnics, colleges of education, and research centres.

(2) To accelerate the evolution of some members of the network as centres of excellence for training and research in the basic sciences.

(3) To alleviate brain drain by getting young Africans to register for higher degrees at institutions that are members of the networks with exposures to facilities abroad while working on their theses.

(4) To encourage North-South and South-South cooperation and collaboration in the areas of research and training of graduate students for higher degrees of African universities.

(5) To bridge isolation gaps among African scientists through development of research groups in a number of institutions of the network, eventually leading to the production of critical mass of African scientists so badly needed for developmental purposes.

(b) *Proposed programmes for the network*

(1) Professors from within and outside the network would be invited from time to time to visit members of the network, giving lectures and contributing towards the development of research expertise at the host institutions.

(2) Special efforts will be made to improve the library, laboratory and other facilities of members of the network (both at undergraduate and graduate levels) to facilitate productive research by students and staff as well as effective teaching at both undergraduate and graduate levels.

(3) There will be cooperation as well as exchange of staff and students among members of the network. Moreover, maximising the use of available facilities will be special features of the network.

(4) Some 30 universities and research centres in Africa have been identified as members of the network. Membership of the network has been restricted to those who already have on the ground some facilities and infrastructures that can be improved upon.

(C) *Some other AAS/UNESCO basis sciences capacity building programmes*

(1) Teritiary textbook development projects. Specialists in various areas of the basic sciences will be commissioned to write tertiary level textbooks to be published in Africa at affordable prices. It is well known that comparable texts published by commercial publishers in Europe or USA are too expensive for African students.

(2) Donation programmes for books, journals, and computers to African institutions. AAS/UNESCO will independently and/or join forces with institutions, e.g. ICTP, TWAS, already involved with getting individuals and/or organizations to donate books, journals, and computers to African institutions.

(3) Popularization of science and inculcation of scientific culture. AAS/UNESCO will champion more intense popularization efforts for science through various activities and channels including print and electronic media and through encouraging popular writings to explain various areas of contemporary science in simple language.

(4) Awarding research grants and prizes in the basic sciences. In awarding grants and prizes, special considerations will be given to African women scientists.

6. The way forward – some suggestions

(1) AU, NEPAD, and the international scientific community should embrace and support the AAS/UNESCO project as an effective way of alleviating the problems of developing basic sciences in Africa given the fact that AAS has within its membership distinguished and influential experts in the various aspects of the basic and other sciences. AAS also has a viable secretariat for organizing and overseeing the various activities.

(2) African governments should demonstrate political will for radical increase in funding for basic sciences and other areas of science and technology.

(3) Every effort should be made through funding from within and outside Africa as well as through international scientific collaboration to promote a new generation of promising scientists by increasing the number of postgraduate and postdoctoral fellowships. In this direction, there should be a lot of focus on areas of weakness of the continent in the various areas of science while also trying to produce the much desired critical mass.

(4) Radical improvements in teaching, research infrastructures and facilities should be effected at the universities and research centres all over the continent.

(5) Existing networks in the various areas of basic sciences should be strengthened and new ones created.

(6) Every effort should be made to attract good students and personnel for careers in the basic sciences through special incentives in form of scholarships and fellowships as well as good remuneration for science teachers at all levels.

(7) In each country or subregion, there should be at least one place where infrastructures and facilities for research and training in some aspect of basic sciences are excellent and the use of such facilities should be maximised for the benefit of other nearby institutions.

(8) Some centres already identified as potential centres of excellence should be strengthened and new ones identified.

(9) Brain drain should be stemmed through radical improvement of working environment, facilities and remuneration for scientists. Moreover, brain drain should be turned into brain gain by encouraging African scientists in the diaspora to return or frequently come to Africa to share their expertise with their colleagues working on the continent.

(10) Closer links should be developed between universities, research institutes and industries. African governments should find a way of compelling multinationals based in Africa to contribute a fraction of their profits to an R & D fund. Indeed, every African country should set up an R & D fund (like the National Science Foundation in the USA) from which research grants can be awarded to practising scientists in the country.

(11) Contemporary areas of basic sciences yet to be developed should be identified and definite efforts made to make such areas a priority in the award of scholarships and fellowships for postgraduate studies.

(12) Africa should leapfrog into scientific frontiers and high technologies.

(13) Research output in Africa in the basic sciences and other areas of science and technology should be radically improved in quality and quantity.

(14) There should be heavy investment in tertiary level textbook development in the basic sciences. These books should be published in Africa since imported books are too expensive for most African students.

(15) Popularization of science in all its modes and forms should be intensified all over the continent.

(16) Intensification of international research and network collaborations North-South and South-South (i.e., between African tertiary institutions and those in Brazil, China, India and so on).

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Natural Product networks in Africa and their contribution to cooperation and economic development

Ameenah Gurib-Fakim

1. Introduction

The human race has always relied on Nature for all its basic needs and, not the least – medicines. Plants have formed the basis of sophisticated traditional medicine systems, which have been in existence for thousands of years and continue to provide mankind with new remedies. Although some of the therapeutic properties attributed to plants have proven to be erroneous, medicinal plant therapy is based on the empirical findings of hundreds and thousands of years and the interest in Nature as a source of potential chemotherapeutic agents continues.

Natural products and their derivatives represent more than 50 % of all the drugs in clinical use in the world. Higher plants contribute no less than 25 % of the total. Among the important potent drugs derived from flowering plants are *Dioscorea spp.*, derived diosgenin, from which all anovulatory contraceptive agents have been derived; reserpine and other anti-hypertensive and tranquilizing alkaloids from *Rauwolfia sp.*; pilocarpine to treat glaucoma and dry mouth, derived from a group of South American trees (*Pilocarpus spp.*) in the Citrus family; two powerful anticancer agents from the Rosy Periwinkle (*Catharanthus roseus*); laxative agents from *Cassia sp.* and as a cardiotonic agent to treat heart failure from *Digitalis sp.*.

It has also been reported that approximately half (125,000) of the world's flowering plant species live in the tropical forests. Tropical and subtropical Africa has been reported to harbour between 40,000 and 45,000 higher plant species that potentially hold considerable value. It is also estimated that this number represented at least 25 % of the global pool of plant genetic resources and contributed significantly to the world's trade in genetic materials.

Tropical biodiversity therefore will continue to support a vast reservoir of potentially important drug species. The potential for finding more compounds is enormous as at date only about 1 % of tropical species have been studied for their pharmaceutical potential. This proportion is even lower for species confined to the tropical rain forests. To date about 50 drugs have come from tropical plants and many have been discovered through serendipitous laboratory observations.

To date, there are three anti-cancer drugs on the market or completing clinical trials that have been derived from plants and they are from: the Papaw (*Asimina spp.*); the Western Yew Tree (*Taxus brevifolia*), effective against ovarian cancer, and the Mayapple (*Podophyllum peltatum*) used to combat leukaemia, lymphoma lung and testicular cancer.

The existence of undiscovered pharmaceuticals for modern medicine has often been cited as one of the most important reasons for protecting tropical forests, so the high annual extinction rate is a matter for concern, to say the least. The estimated global rate of extinction is at present calculated at 0.6 % due mostly to deforestation but at the level of the African continent, it is estimated to be around 1 % and this makes Africa to have the highest rate of deforestation in the world.

2. Use of herb since antiquity to date

The World Health Organization has estimated that nearly 80 % of the vast majority of people on this planet still relies on their traditional *material medica* (medicinal plants and other materials) for their everyday health care needs. It is also a fact that people who use traditional remedies may not understand the scientific rationale behind their medicines, but they know from personal experience that some medicinal plants can be highly effective, if used at therapeutic doses. Since we have a better understanding today of how the body functions, we are thus in a better position to understand the healing powers of plants and their potential for their potential as multi-functional chemical entities for treating complicated health conditions.

Medicinal plants typically contain mixtures of different chemical compounds that may act individually, additively or in synergy to improve health. A single plant may, for example, contain bitter substances that stimulate digestion, anti-inflammatory compounds that reduce swellings and pain, phenolic compounds that can act as an antioxidant and venotonics, anti-bacterial and anti-fungal tannins that act as natural antibiotics, diuretic substances that enhance the elimination of waste products and toxins and alkaloids that enhance mood and give a sense of well-being.

Modern allopathic usually aims to develop a patentable single compound or a magic bullet to treat specific conditions. Traditional medicine often aims to restore balance by using chemically complex plants, or by mixing together several different plants in order to maximize a synergistic effect or to improve the likelihood of an interaction with a relevant molecular target. In most societies today, allopathic and traditional systems of medicine occur side by side in a complementary way. The former treats serious acute conditions while the latter is used for chronic illnesses, to reduce symptoms and improve the quality of life in a cost-effective way.

3. African traditional medicine

African traditional medicine is the oldest and perhaps the most diverse of all medicine systems. It is a holistic involving both the body and the mind. The healer typically diagnoses and treats the psychological basis of an illness before prescribing medicines to treat the symptoms. Africa is considered to be the cradle of mankind with a rich biological and cultural diversity, marked by regional difference in healing practices. Unfortunately, the systems of medicines are poorly recorded and remain so to date. Yet the documentation of medicinal uses of African plants is becoming increasingly urgent because of the rapid loss of the natural habitats of some of these plants because of anthropogenic activities. The African continent is reported to have one of the highest rates of deforestation in the world. The paradox is that it is also a continent with a high rate of endemism with the Republic of Madagascar topping the list at 82 %.

Famous African medicinal plants include *Acacia senegal* (Gum Arabic), *Agathosma betulina* (Buchu), *Aloe ferox* (Cape Aloes), *Aloe vera* (North African Origin), *Artemisia afra* (African wormwood), *Aspalanthus linearis* (Rooibos tea), *Boswellia sacra* (Frankincense), *Catha edulis* (Khat), *Commiphora myrrha* (Myrrh), *Harpagophytum procumbens* (Devil's Claw), *Hibiscus sabdariffa* (Hibiscus, Roselle), *Hypoxis hemerocallidea* (African potato), *Prunus africana* (African Cherry). Madagascar by herself has contributed with the *Catharanthus roseus* (Rosy Periwinkle) and has the potential of contributing more in view of the diversity of her flora and fauna.

4. Documentation of traditional knowledge and PROTA

The importance of traditional knowledge is increasingly being recognized and many of these plants and their traditional knowledge are now been documented in the series of publication of the PROTA series. Plant Resources of Tropical Africa is an initiative of the PROTA-Foundation based at the University of Wageningen in the Netherlands (www.prota.org).

PROTA 11(1) (2008), first of a series of 4 volumes describe the wild and cultivated plant species of tropical Africa traditionally used in local medicine. In the first volume, the medicinal plants of several important medicinal plant-containing families are treated. The PROTA series are likely to become important sources of traditional information on medicinal plants from which the search of new drugs can begin.

5. The search of new drugs through ethnomedicine

As mentioned above, plants have formed the basis for traditional medicine systems, which have been used for thousands of years in countries such as China and India. The use of plants in traditional medicine systems of many cultures has been extensively documented. These plant-based systems continue to play an essential role in health care and in the development of new drugs. Of the 119 drugs, 74 % were discovered as a result of chemical studies directed at the isolation of the active substances from plants used in traditional medicine. In addition, the use of so-called complementary or alternative herbal products has expanded in recent decades.

Unfortunately, although Africa has over 5,000 plant species used medicinally, few have been described and studied. The continent is also reported to have contributed only 83 out of the 1,100 leading commercial medicinal plants.

Although the African continent is blessed with a unique and highly diverse flora, the reasons for her absence on the international scene are manifold. This has had a direct impact on business and on the agricultural sectors. It is also being acknowledged that Africa will continue to lag behind unless African countries prepare internationally recognized medicinal plant standards.

6. The need for validation

6.1. Quality and safety: Production, standardization and quality control

Plant drugs, also known as phytomedicines or phytopharmaceuticals, are plant-derived medicines that contain a chemical compound or more usually mixtures of chemical compounds that act individually or in combination on the human body to prevent disorders and to restore or maintain health. Pure compounds or chemical entities are either isolated from natural products or made by synthesis in the laboratory. Herbal teas, decoction, alcoholic extracts are also traditional ways of using medicinal plants. Very often these plant materials are used in a non-standardized manner. However, nowadays more and more emphasis is being put on the use of standardized materials.

6.2. Doses and efficacy

Two questions have confounded the first person who sampled a medicinal plant – *Do herbal remedies work?* and *How much should a patient ingest for an effective and safe cure?* If one goes back and reads about the history of mankind, the battle against diseases in all the cultures of the world, the search for miracle cures for diseases like cancer, malaria and leukaemia, etc., then the answer would be a resounding – *Yes.*

However, in many instances, skepticism about the efficacy of quite a few plants is also justified. This skepticism has been growing as a result of the many unrealistic claims made by producers of herbal products. Scientists have been proceeding in a systematic way in order to validate the claims of several medicinal plants. For some symptoms and ailments, this may be fairly easy to prove but in more complex health conditions, the situation becomes a bit complicated. Nonetheless, medicinal plant extracts are showing a great deal of promise even in instances of complexity of illnesses. In order to proceed with the validation of the efficacy of medicinal plants, there are several levels of evidence that are taken into account (WHO Monographs, 1999, 2002):

1. The ethnobotanical claims;
2. Anecdotes;
3. Pharmacological studies;
4. Observational studies;
5. Clinical studies.

Millions of dollars are spent each year on herbal products that are marketed as food supplements but in reality very few know, chemically, what they are purchasing or using. Very often the dosage varies from the different brands of the same herbal product. In spite of these major shortcomings, there has been a phenomenal increase in the interest towards phytoremedies. The chemistry and efficacy of many of these plants are relatively unknown and there is a chance of toxicity or overdose until the secondary compounds are known and understood.

There is a tendency in the US and in Europe to regulate and license this market and this has led to greater and more effective use of these important medicinal plants. There is also general agreement that chemical standardization is the way forward in order for herbal remedies to be prescribed to patients who seek to be treated with medicinal plants.

6.3. Standardization for plant-derived ingredients in medicinal products

Standardization ensures that a minimum level of active ingredients is present in the extract and is becoming increasingly important as a means of ensuring a consistent supply of high-quality phyto-pharmaceutical products. It can be defined as the establishment of reproducible pharmaceutical quality by comparing a product with established reference substances and by defining minimum amounts of one or several compounds or groups of compounds. Standards for active ingredients to be used in medicinal products may be found in monographs and/or pharmacopoeias.

7. Why is standardization important?

It is accepted that concentration or dosages are very important because herbal medicines (in common with conventional medicines) contain biologically active substances that may produce non-trivial side effects when taken in excessive doses. Very low doses, on the other hand, may have no therapeutic value. In practice, plant material is often highly variable, so that a minimum concentration or a concentration range is often used rather than an exact level. An upper limit is necessary with highly active or potentially harmful ingredients, as most plants have a wide therapeutic window (e.g. a toxic compound is considerably higher than the therapeutic dose).

In the case of compounds with a narrow therapeutic window, chemical entities are favoured, as opposed to extracts. These phyto-drugs when they become registered become a medicine that needs to comply with the basic standards required for all drugs. Standardization also allows comparison of the clinical effectiveness, pharmacological effects and side effects of a series of products (e.g. against a placebo). Standardized products provide more security and increase the level of trust people have in herbal drugs.

At the international level, the World Health Organization has developed a strategy to review traditional medicines and included within this review is a programme to develop monographs for herbal ingredients (see below for the Legal Framework). Additionally, the European Scientific Cooperative on Phytotherapy (ESCOP) was established in 1989 to advance the scientific status of phytomedicine and to assist with the harmonization of their regulatory status at the European level. ESCOP has already published 60 monographs on the medicinal uses of plant drugs that have been submitted to regulatory authorities across Europe and accepted by the Working Party on Herbal Medicinal Products of the European Agency for the Evaluation of Medicinal Products (EMEA) as providing the basis for proposed core-SPCs for European decentralized marketing authorizations.

A Pharmacopoeia is a collection of quality standards for medicines and their components. In order to obtain marketing authorization for a medical product, the ingredients or the medicinal product must generally comply with a Pharmacopoeial standard. Thus Pharmacopoeial standard may provide guidance on acceptable purity criteria for that ingredient.

8. Some of the existing frameworks for plant-derived ingredients with medicinal properties

8.1. The World Health Organization (WHO)

The WHO views herbal medicines as herbs, herbal materials, herbal preparations and finished herbal products that contain active ingredients, parts of plants, and other plant materials, or combinations. The WHO recognizes that the traditional use of herbal medicines refers to the long historical use of these medicines and that they may be accepted by national authorities. As a result of this view, the WHO Traditional Medicines Strategy 2001–2005 was developed to review a framework for action for WHO and its partners aimed at enabling TM/CAM (Traditional Medicine / Complementary and Alternative Medicine) to play a far greater role in reducing excess mortality and morbidity, especially among impoverished populations.

8.2. The European Union (EU)

The EU directives 2001/83/EC on the Community code relating to medicinal products for human use lays down a general framework for pharmaceutical products requiring pre-marketing approval before gaining access to the market and laying down the requirements for the documentation of quality, safety and efficacy, the dossier and expert reports. This framework has effectively been in operation, and additionally the European Agency for the Evaluation of Medicinal Plant Products (EMEA), which acts as a central agency for single European medicines marketing authorizations, operates a Herbal Medicinal Products Working Party (HMPWP).

However, individual Member States (UK, Germany, France, Italy, etc.) have taken different approaches in reviewing herbal medicines.

8.3. The United States (US)

In the US, the Food and Drug Administration (FDA) has responsibility for food and drug products. Drugs are regarded as products that claim to treat, cure, mitigate or prevent a disease. Herbal medicines follow the same procedures as those for a chemical drug. Otherwise natural products are regulated as foods under a requirement for ingredients to be generally recognized as safe (GRAS). Natural products generally have GRAS status, provided that this is supported by expert consensus.

Hence dietary supplements and herbs are considered to be foods, provided that they are generally regarded as safe and do not make medicinal claims. Furthermore, the ingredients and the plants or parts of the plants must be quantized, and where ingredients are listed with a pharmacopoeia reference, they must meet the standard laid down in the pharmacopoeia. There are also specific requirements for food additives that do need a pre-market approval by the authority.

8.4. African Association of Medicinal Plants Standards

During the Medicinal Plants Forum held in Cape Town in 2000, under the aegis of the Commonwealth Secretariat, it became clear as to the reasons why African Medicinal Plants are absent from the international scene. They are:

- Lack of suitable technical specifications and quality control standards. Lack of these standards are considered to be major barriers to regional and international trade and they are also the reasons as to why traditional medicine has not been widely integrated into the African Primary Health care.
- Another important feature which demarcates Africa from other continents like Asia for example, is the lack of official recognition from respective governments and this is generally a major handicap to what can be an important business for the continent.

The above challenges have witnessed the creation of the African Association of Medicinal Plants Standards (AAMPS), which has among its many objectives – the development of the African Herbal Pharmacopoeia. The initial publication will encompass 52 important medicinal plants from the continent.

9. The role of networks in the area of Medicinal Plant studies

Several networks operate on the continent and include NAPRECA, WANPRESS, NUSESA, etc. Among the major funders of these networks are the International Foundation of Science (IFS) and the International Science Programme (ISP). So far, these networks have engaged in sustaining and building capacity as well as creating awareness on this important theme. These networks are also aware that in the field of natural products development, documentation is a very important activity especially if some of these plants give rise to extracts/molecules that are likely to be patentable. Documentation helps in constituting prior art and is recognized by bodies like the World Trade Organization (WTO) and World Intellectual Property Organization (WIPO).

With the adherence of many countries to WTO, one of the areas on which networks should orient some of their activities is to ensure that their respective countries have their legal system WTO/TRIPS-compliant. This will ensure that they derive maximum benefits from their biodiversity, which the CBD has ensured to be their sovereignty.

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Promoting mathematics in Africa through the African Mathematics Millennium Science Initiative (AMMSI)

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Abstract. The African Mathematics Millennium Science Initiative (AMMSI) is a distributed network of mathematics research, training and promotion throughout sub-Saharan Africa. The main objectives of AMMSI include strengthening mathematics teaching, research and applications, and raising general awareness of the importance of mathematics for modern science and modern nations. Since its inception in 2005, AMMSI has made a number of accomplishments in fulfillment of its mandate, namely: awarded annual Research/Visiting Fellowships to enable mathematicians to visit other universities in Africa; awarded annual partial scholarships; supported the organization of regional conferences and workshops in mathematics; and facilitated postgraduate students to attend mathematics conferences. In collaboration with other organizations, AMMSI is also involved in implementing a project called Mentoring African Research in Mathematics (MARM) whose main objective is to promote a mentoring relationship between mathematicians in countries with a strong mathematical infrastructure and their African colleagues, together with their students. To date nine universities in Africa are participating in the MARM project. In this paper we present the objectives, activities and impact of AMMSI, in the context of what sub-Saharan Africa needs to do in order to promote mathematics.

1. Introduction

The Millennium Science Initiative (MSI), administered by the Science Initiative Group (SIG), is designed to accelerate the development of nations by building stronger capacities in science, scientific leadership, and the uses of science (see SIG, 2009). The MSI, in collaboration with the Academy of Sciences for the Developing World (TWAS) and the African Academy of Sciences (AAS), helped to establish the African MSI, in order to support the African scientific leadership to equip more Africans with the tools of modern science, link scientific programmes together as partnerships, and promote the uses of science for the benefit of society.

The African MSI designed a programme of three components: biotechnology, information technology, and mathematics. In order to proceed with the programme in mathematics, the African MSI proposed the establishment of the African Mathematics Millennium Science Initiative (AMMSI). In January 2003, the first steps were taken to make AMMSI a reality by constituting a Writing Group (WG) that would prepare a draft proposal for activities and funding of AMMSI. The Writing Group members were: Professor Wandera Ogana, University of Nairobi, Kenya (Chairman); Professor Edward Lungu, University of Botswana, Botswana; Professor David Bekollé, University of Yaoundé 1, Cameroon; Professor Sunday Iyahen, National Mathematics Centre, Nigeria; Dr. Leif Abrahamsson, Uppsala University, Sweden; and Dr. Alan Anderson, USA, MSI-SIG, Princeton, USA (Grant writer, Secretary).

The Writing Group gathered information from various sources and examined documentation of past MSI meetings and discussions. It also distributed a questionnaire to a wide cross-section of individuals and institutions in Africa and internationally. The views expressed by the respondents to the questionnaire were taken into account while drafting the proposal. The Writing Group held one meeting in Nairobi, Kenya, and another at Uppsala University, Sweden. In between the meetings, the Writing Group interacted via electronic mail and telephone till the final proposal was submitted (AMMSI Writing Group, 2003).

Investigation by the Writing Group yielded a number of observations about the state of mathematics in Africa. It was noted that in some African countries, both Anglophone and Francophone, there is teaching of mathematics at a high level of proficiency through the primary and secondary schools. This proficiency is not appropriately reflected in tertiary institutions and so the continent as a whole remains poorly served in mathematics. The general weakness in mathematics education, particularly at the post-school level, has led a number of African mathematics educators to urge for implementation of proper education in mathematics, if the continent aspires to progress industrially and economically, for instance, Eshiwani (1991). A workshop in Tanzania (Kohi et al. 2000), attended by leading mathematicians, cited the following conditions, among others, that impacted negatively on the practice and teaching of mathematics:

- Small numbers of mathematics faculty and postgraduate students;
- Geographical and professional isolation of mathematics departments and individual mathematicians;
- Inadequacy of facilities for teaching and research;
- Poor working conditions, low salaries and weak infrastructure;
- Lack of access to current journals, relevant software and equipment;
- Low levels of government support for postgraduate training in mathematics.

These conditions were generally found to prevail in most universities in sub-Saharan African countries.

2. Objectives of AMMSI

In order to help address some of the factors that affect the development of mathematics in the continent, the Writing Group came up with a number of objectives for AMMSI, namely:

(i) To strengthen the teaching and learning of mathematics and its applications (*Teaching and Education*);
(ii) To support research in mathematics and mathematics education, including interdisciplinary research in areas involving applications of mathematics (*Research*);
(iii) To enhance capacity in mathematics and its applications through linkages, networks and regional/international collaboration (*Linkages and Networking*);
(iv) To raise general awareness of mathematics and articulate publicly the importance of mathematics to modern nations (*Outreach and Public Education*);
(v) To enhance the use of information and communications technology in the teaching, learning and applications of mathematics (*ICT*).

In fulfillment of each objective, many activities were proposed to be carried out. In this paper, however, we will confine ourselves to those activities that have actually been carried out, as described in subsequent sections.

3. Organizational structure

AMMSI is a distributed network organized through the following five regions in sub-Saharan Africa, each with a Regional Coordinator:

Central Africa: Burundi, Cameroon, Central African Republic, Chad, Congo, Democratic Republic of Congo (DRC), Gabon, Equatorial Guinea, Rwanda. AMMSI Regional Coordinator: Professor Bitjong Ndombol, Faculty of Sciences, University of Yaoundé 1, Yaoundé, Cameroon.
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Eastern Africa: Djibouti, Ethiopia, Eritrea, Kenya, Somalia, Sudan, Uganda, Tanzania. AMMSI Regional Coordinator: Professor Wandera Ogana, School of Mathematics, University of Nairobi, Nairobi, Kenya.
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Southern Africa: Angola, Botswana, Comoros, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Zambia, Zimbabwe. AMMSI Regional Coordinator: Professor Edward Lungu, Department of Mathematics, University of Botswana, Gaborone, Botswana. *E-mail:* lunguem@mopipi.ub.bw

Western Africa (Zone 1): Gambia, Ghana, Liberia, Nigeria, Sierra Leone. AMMSI Regional Coordinator: Professor Samuel Ilori, Department of Mathematics, University of Ibadan, Ibadan, Nigeria.
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Western Africa (Zone 2): Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Guinea Bissau, Guinea Conakry, Mali, Mauritania, Niger, São Tomé and Príncipe, Senegal, Togo. AMMSI Regional Coordinator: Professor Hamidou Touré, LAME, University of Ouagadougou, Ouagadougou, Burkina Faso.
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The regions have been selected to reflect historical ties in the education systems and/or current regional links. The AMMSI networking approach is designed to help improve conditions in mathematics in Africa by attempting to build strong linkages between geographically dispersed centres and thus help to promote personnel exchange, mentoring, modelling and joint meetings.

4. Activities to date

Through the support of a number of organizations, acknowledged at the end of this paper, AMMSI has carried out the activities described hereunder in fulfillment of its objectives.

4.1. Research/Visiting Scientist Fellowships

The fellowships are awarded to academics and researchers in mathematics and its applications. They are intended to facilitate university staff, from sub-Saharan African universities, to travel to other institutions in sub-Saharan Africa for durations ranging from a few weeks to one year. Invitation from the host institution is a mandatory requirement in the application process. Apart from utilizing facilities at the host institutions, awardees are expected to interact with other experts in their areas of research and participate in postgraduate training. The fellowships may also be awarded to university staff from outside Africa for the purpose of contributing to research and postgraduate training in sub-Saharan universities.

Table 1 shows the numbers and percentages of fellowship grantees during 2005–2008 by region and, for each region, the numbers and percentages by gender. During this period, Central Africa and Western Africa Zone 2 got the most grants (26 %), while Southern Africa got the least (14 %). Overall, male staff obtained most of the fellowship grants (83 %) compared to female staff (17 %); this was partly due to the small number of qualified female applicants. The result is consistent with the survey by the Writing Group, which revealed that the percentage of female staff members in many departments of mathematics in African universities is less than 10 %.

Table 1. AMMSI Fellowship awards during 2005–2008. Key: *CA:* Central; *EA:* Eastern; *SA:* Southern; *WA1:* Western, Zone 1; *WA2:* Western, Zone 2.

	CA	*EA*	*SA*	*WA1*	*WA2*	*All*
Females, number	3	0	1	0	0	4
Females, percent	50	0	33	0	0	17
Males, number	3	4	2	4	6	19
Males, percent	50	100	67	100	100	83
Number, total	6	4	3	4	6	23
Percent, total	26	17	14	17	26	100

4.2. Postgraduate scholarships

The scholarships are awarded to students who are sub-Saharan African nationals to enable them to pursue postgraduate studies in mathematics and its applications. They are designed to strengthen mathematics learning and culture by supporting the training of postgraduate students in African institutions and are therefore not for students who wish to pursue studies in universities outside Africa. The grants provide only partial support with the award amount dependent on the level of need.

Table 2. AMMSI Scholarship awards during 2005–2008. Key: *CA:* Central; *EA:* Eastern; *SA:* Southern; *WA1:* Western, Zone 1; *WA2:* Western, Zone 2.

	CA	*EA*	*SA*	*WA1*	*WA2*	*All*
Females, number	6	13	6	11	9	45
Females, percent	18	32	15	20	30	23
Males, number	28	27	34	23	41	123
Males, percent	82	68	85	80	70	77
Number, total	34	40	40	54	30	198
Percent, total	17	20	20	28	15	100

Table 2 shows the numbers and percentages of scholarship grantees during 2005–2008 by region and, for each region, the numbers and percentages by gender. The largest number of scholarships went to Western Africa Zone 1. Since each region had an equal amount of money to distribute, it means that, on the average, Western Africa Zone 1 awarded a smaller amount of money per grantee. Overall, male students obtained the bulk of the awards (77 %) compared to females (23 %).

Table 3 gives the distribution of scholarships by level of study and shows that overall about half of the scholarships were used for doctoral studies, slightly over a third for masters and the rest for postgraduate diploma, DEA and Maîtrise, largely from the Francophone regions of Central Africa and Western Africa Zone 2. The scholarships were used mostly for masters studies in Eastern Africa (62 %) but mostly for doctoral studies in the rest of the regions, namely, Southern Africa (62 %), Western Africa Zone 1 (65 %), and Western Africa Zone 2 (70 %).

Table 3. AMMSI Scholarship awards by level of study during 2005–2008. Key: *CA:* Central; *EA:* Eastern; *SA:* Southern; *WA1:* Western, Zone 1; *WA2:* Western, Zone 2.

Level of study		*CA*	*EA*	*SA*	*WA1*	*WA2*	*All*
PhD	*Number*	5	15	25	35	21	101
	Percent	15	38	62	65	70	61
MSc	*Number*	14	25	14	16	3	72
	Percent	41	62	35	30	10	36
Other	*Number*	15	0	1	3	6	25
	Percent	44	0	3	5	20	13

4.3. Regional conferences

AMMSI has sponsored annual conferences in its different regions, on a rotational basis, with focus on topics relevant to the hosting AMMSI region, but with a requirement that an opportunity must be provided for interaction with researchers and postgraduate students from other AMMSI regions. A conference can be organized by the AMMSI Regional Coordinator or by another mathematician, provided it is approved as a regional event. To date there have been four such conferences held:

Conference in Porto-Novo, Benin: This was held during 10–17 August 2005. The theme was *Representation Theory in Geometry and Physics*. The conference was organized by Professor Jean-Pierre Ezin of IMSP, Porto-Novo, Benin.

Conference in Nairobi, Kenya: This was held during 4–10 December 2006. It was a general Eastern African Mathematics conference, organized by Professor Wandera Ogana, University of Nairobi, Kenya.

SAMSA Conference in Windhoek, Namibia: This was held during 26 November –1 December 2007. It was a general SAMSA Conference, organized by Professor Edward Lungu, University of Botswana, Botswana.

Conference in Yaoundé, Cameroon: This was held during 1 –16 January 2009. The theme was *Topology and Geometry*. The organizer was Professor Bitjong Ndombol, University of Yaoundé I.

4.4. International conferences and workshops

In addition to supporting regional conferences, AMMSI also organizes international conferences and workshops in order to provide a wider opportunity for African mathematicians to interact among themselves and also with mathematicians from other continents. These meetings are expected to reflect significant involvement by postgraduate students as participants or in a training school. These meetings are spaced at longer intervals and to date only two have been held:

Mathematical Biology Workshop. The workshop was held at the Holiday Inn, Nairobi, Kenya, during 6–10 December 2006. It was preceded by a mini-course on mathematical biology for postgraduate students from all over Africa. Lecturers at the mini-course and presenters at the workshop were renowned mathematicians from Africa, USA and Canada. A round-table discussion was also held on the state of mathematical biology in Africa.

Symposium on the African Woman and Mathematics. The symposium was held at Girassol Indy Village, Maputo, Mozambique, during 29–30 November 2008. The symposium had the theme *Mathematics Education and the African Woman* and its main focus was to examine and discuss the factors that influence the appreciation and understanding of mathematics by African girls and women. In addition, participants were to be provided exposure to research contributions by women in mathematics and its applications, and in mathematics education. The first day there were presentations in mathematics education, with emphasis on issues affecting girls and women. Also covered were the contributions and production of mathematical ideas by the African women in cultural practices. In addition, a number of postgraduate students made brief presentations on mathematics education and girls, focusing largely on their own experiences. The morning session of the second day concentrated on the contributions made by African women in mathematics. Lectures were given by established researchers; in addition, a number of female postgraduate students made commendable reports on their on-going theses research in a variety of fields. During the afternoon there was a roundtable discussion which identified factors that influence the mathematics education of the African girl child and woman, and made recommendations on how to address these factors, in order to improve mathematics learning by the African girl child and woman. A more detailed report is available in the Conferences page of the AMMSI website (AMMSI 2009).

4.5. Conference support to postgraduate students

AMMSI has an arrangement with the London Mathematical Society (LMS), through which the latter body provides grants to cover travel expenses by postgraduate students to mathematics meetings held in Africa. The aim is to provide postgraduate students with opportunities to interact with their academic seniors, meet potential mentors and gain experience in making scientific presentations. Request for support is made by the meeting organizers, through AMMSI, but the individuals to be supported are identified by the meeting organizers. This scheme has supported several events every year, since 2005, and so far over 40 postgraduate students have benefited.

4.6. Mentoring African Research in Mathematics (MARM)

Mentoring African Research in Mathematics (MARM) is a cooperative programme designed to support mathematics research and advanced teaching in the countries of sub-Saharan Africa. MARM is jointly run by the London Mathematical Society (LMS), the International Mathematical Union (IMU), the International Centre for Mathematical Sciences (ICMS), Edinburgh, and the African Mathematics Millennium Science Initiative (AMMSI). The MARM programme sponsors research partnerships between mathematicians in the more developed countries and African colleagues and their students. Its goal is to counter the mathematics brain-drain from sub-Saharan Africa by supporting the work of qualified mathematics professionals in situ. Selection for participation in this programme is preceded by a call for expression of interest, to which responding African departments indicate areas in which they most need collaboration. At the same time, individual mathematicians outside Africa have another call for expression of interest to which respondents indicate their areas of expertise. The MARM Board finally matches selected institutions with potential mentors. Thereafter, contact is initiated between selected departments and mentors so that they work out their own plan and schedule of activities. In the past the calls for interest had specific deadlines but this has changed and now the call is open without a defined closing date.

To date the following institutions in Africa participate in MARM: Addis Ababa University, Ethiopia; Bahir Dar University, Ethiopia; Kenyatta University, Kenya; Kwame Nkurumah University of Science and Technology (KNUST), Ghana; Laboratory of Applied Mathematics and Computer Science, Côte d'Ivoire; Makarere University, Uganda; National University of Rwanda, Rwanda; University of Buea, Cameroon; and University of Ilorin, Nigeria. Another five institutions have been identified for participation in MARM. For details of the existing projects, see the website of the London Mathematical Society (2009).

5. Impact and testimonials

Evaluation of the AMMSI programme implementation and reports submitted by participants in AMMSI activities indicate that there have been some positive impacts. A more comprehensive evaluation can only be arrived at after more analysis of the reports and a follow-up survey. Preliminary analysis, however, yields a number of interesting findings.

5.1. Positive impacts

(a) *Publications:* To date individuals have reported a number of publications attributed directly to participation in the AMMSI programme. Some of these have been a result of collaborative research from the fellowship programme or the MARM project. In some cases, postgraduate students have been enabled to publish papers arising from their thesis research.

(b) *Research:* Academic staff and postgraduate students have been provided opportunities for increased involvement in research through the fellowship and MARM programmes. Established researchers have been able to identify new collaborators while some postgraduate students have been absorbed in new research projects as a result of contact with researchers from other institutions. In some instances, the additional support from AMMSI has enabled postgraduate students to conduct research for their theses

(c) *Postgraduate Training:* Established mathematicians have had the opportunity to become involved in postgraduate training outside their home institutions, through the fellowship and MARM programmes. This has enabled the host institutions to conduct some courses which could have been shelved due to lack of manpower or appropriate expertise. In some cases, the established contacts have enabled postgraduate students to proceed to other institutions for further training.

(d) *Postgraduate Studies:* The AMMSI Postgraduate Scholarship programme has enabled a number of recipients to complete their postgraduate studies, sometimes under adverse circumstances. It has also been used by some individuals to proceed to PhD studies after masters, in the absence of other funding alternatives.

(e) *Collaboration and Links:* A significant aspect of the AMMSI programme has been to bring together individuals from diverse regions in Africa, or from different continents, so that they collaborate in research and postgraduate training. In some cases the initial contact, facilitated by AMMSI, has resulted in a wider institutional link than originally anticipated.

(f) *Conference Presentations:* A major drawback in conducting research in Africa is the absence of an avenue to present one's research findings to other researchers for criticism and suitable feedback. The AMMSI conferences and workshops have, to some extent, filled this gap. More importantly, they have also enabled postgraduate students to gain the techniques of formal presentation of research findings before a critical audience.

5.2. Testimonials

Below are extracts from selected reports, indicating the impact of AMMSI:

> I visited the Department of Mathematics in University Cheikh Anta Diop (UCAD) in Dakar, Senegal. I conducted research and also gave four lectures on the theory of nearby points. As a result of this visit I will continue collaboration with Professors Sambou and Solomon. I thank those responsible for AMMSI for allowing me to perform this mission. It was my pleasure to participate in the program of international academic exchanges. (Professor Basille Guy Richard Bossoto, Marien Ngouabi University, Brazzaville, Congo; Fellowship awardee 2005, for visit to University Cheikh Anta Diop (UCAD) in Dakar, Senegal)

> I was awarded the AMMSI scholarship in 2005 and 2006. The funds enabled me to undertake my studies and conduct research for my Master of Applied Mathematics and Computational Finance. My project was on the pricing and hedging of exotic options. A copy of the thesis is attached. After graduation, I am currently pursuing my studies in France at the Université de Paris 1, Panthéon Sorbonne. (Miss Faty Atta Diaw, MSc candidate, Université Gaston Berger de Saint-Louis, Senegal; Scholarship awardee 2005 and 2006)

> I was awarded an AMMSI scholarship which assisted me in doing research and payment of tuition fees for my Master of Science in Biometry. Through the AMMSI scholarship I was able to graduate in time since I had financial constraints which would have otherwise made it impossible for me to realize this. The scholarship has enabled me to attain a higher level of training and it went a long way to help me in my career advancement. (Raymond Ojwang' Omollo, MSc candidate, University of Nairobi, Kenya; Scholarship awardee 2005)

> I was awarded the AMMSI scholarship in 2007 and 2008. The financial assistance I received helped me progress well with my studies and I am about to complete my PhD studies. From my thesis I have extracted a paper entitled "Rational Homotopy of Function Spaces," which I have sent to be considered for publication. (Mrs. Rugare Kwashira, PhD candidate, University of Botswana, Botswana; Scholarship awardee 2007 and 2008)

> I received the AMMSI scholarship in 2006 and 2007. The money enabled me to carry out my research uninterrupted and to supplement living expenses. I am indeed grateful for the award, without which my PhD degree programme would not have ran this smoothly and progressively. I sincerely thank you for the award that has made my PhD degree journey a lot easier than earlier envisaged (particularly in a foreign country). (Tajudeen T. Yusuf, PhD candidate, Federal University of Technology, Akure, Nigeria; Scholarship awardee 2006 and 2007)

> Collaborative research projects were initiated with lecturers and postgraduate students at the University of Botswana. With the help of AMMSI, three research papers have since been published in reputable international journals and the copies are attached. (Dr. (Mrs.) Senelani D. Hove-Musekwa, National University of Science and Technology, Bulawayo, Zimbabwe, Fellowship awardee 2007, for visit to University of Botswana, Botswana)

6. Challenges

Evaluation also reveals that AMMSI faces the following challenges that need to be addressed for the initiative to be more effective.

(a) *Inadequate Funding:* A major constraint in the operations of AMMSI is the inadequate funding available to date. This has hampered efforts to expand the AMMSI activities and place adequate focus on research. It has also meant continued availability of limited fellowship and scholarships amounts. The vast majority of the recipients do not complain about the grants but other individuals have indicated, perhaps with some justification, that the fellowship and scholarship schemes could become more attractive if the amounts were increased.

(b) *Communication Problems:* Communication with mathematicians and institutions of mathematics continues to be a very slow process. This is due to a number of factors, including the absence of a comprehensive database of reliable information about mathematicians and mathematics institutions in Africa. In particular, the absence of reliable e-mail contacts means that communication which could be dealt with in a day takes several weeks, if not months, to resolve. Complicating this situation further is the reluctance of many individuals to respond to mail, advertisements or even conference announcements.

(c) *Transfer of Funds:* The transfer of funds to fellowship and scholarship awardees through suitable bank accounts has been successful in a number of countries but quite problematic in others. This has sometimes resulted in delay in commencement of research, for postgraduate students, or in an adjustment of the period for the fellowship visit to a host institution.

7. Supporting organizations and institutions

The activities of AMMSI have been made possible through the support of organizations and institutions mentioned below.

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8. Concluding remarks

Although the original AMMSI proposal contained many activities, funding constraint has compelled the organization to focus on a few aspects, namely, fellowship and scholarship grants, conferences, collaboration and linkages. If AMMSI were to identify additional funding sources through new initiatives and partners, it could strengthen the current activities, diversify to other areas and introduce a strong element of research. Despite the limited funds available, the activities of AMMSI appear to have made some difference, albeit small, in the lives of African mathematicians.

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- Past AMMSI Regional Coordinators: Professor David Bekollé (Central Afriza); Professor Mary Teuw Niane (Western Africa, Zone 2).

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Difficulties in the regional cooperation in Africa: the case of university cooperation and research

Alfred S. Traore

Abstract. The countries of Africa, more particularly those of sub-Saharan Africa, face many difficulties in the construction of their development. The poverty of the households does not allow a food balanced for the populations nor a sufficient medical hedging to enable them to have a labour force productive of wealth, able to support a high level of higher eduction. As it is recognized nowadays, "Without higher educational and adequate research structures, no country can secure an authentic endogenous and durable development...". It is thus an obligation for the African states to organize their higher educational systems and research from the point of view that they must be at the service of society.

But the difficulties are numerous to arrive at this result. The difficulties related to the harmonization of the academic curricula are preconditions to facilitate academic mobility of the students and of the teachers. For its viability, any cooperation must be supported by financial and human resources. Logistics must be available: communication network, equipment and infrastructure for regional education and research.

Finally, there is no profitable regional cooperation without a firm contract on behalf of the partners and a clear comprehension of the need for the union to act together.

In the article we analyse the situation in West Africa, which suffers from a lack of fabric for a true university cooperation maintained by the recipients themselves, at the moment when universalization creates conditions more favourable to the birth of supranational common lobbies.

Introduction

The universities must play a more significant role in Africa than in any other area of the world because of the scientific and technological delay of the continent. The universities have knowledge, competences, capacities and technical know-how in a great number of fields. They constitute the principal reserve of human resources and are places privileged in the formation of human capital, without which no country can dream of a happy destiny. They ensure the education, indeed on most levels, of trainers (teaching at all levels, from the primary education to the secondary to higher education), of the researchers (intellectual, thinkers, etc.), of politicians and leaders of civil society, in short, of all the actors of development. Their role in research, analysis, evaluation, in information and technology, and consequently in the economic development and the social progress, is crucial. They constitute the centres of production and storage on a large scale of knowledge which can be used as rails for the construction of Africa.

It is thus necessary that special concern be granted to the development of the universities and their correct operation. That necessarily passes by a good collaboration between universities, accepted in regional dynamics. Unfortunately, there are obstacles with such a vision of things as we will now see in the following headings.

1. Difficulties related to the lack of harmonization of the academic curricula;
2. Difficulties related to the lack of qualified human resources in terms of quality and quantity;
3. Difficulties related to the lack of powerful and adapted logistics: equipment and infrastructure of education and research, communication facilities;
4. Difficulties related to the lack of financial resources;
5. Difficulties related to the lack of a legal framework favourable to the university and to regional scientific cooperation.

1. Difficulties related to the lack of harmonization of the academic curricula

Since the accession of the African countries to independence, the regional cooperation South-South has been regarded as a major strategy for development of the higher education in Africa. Indeed, it is enough to recall that each of the seven conferences of the Ministers for education and planning, known under the name of MINEDAF, the first of which goes back to 1961, recommended to give high priority to the reinforcement of regional cooperation, in particular in the fields of exchange of students, teachers, researchers, and the production of teaching equipment. In this line of ideas one can quote the existence, right before and after the first hours of independence of the years 1960, of the regional universities in French-speaking Africa. They educated senior professionals on the basis of the same programmes and university courses for this area of Africa. They were the universities of Dakar (Senegal), of Abidjan (Côte d'Ivoire), Brazzaville (Congo-Brazzaville) and Tananarive (Madagascar).

But for reasons of national sovereignty, as from the years 1970, each country in this region believed it to be good to obtain its own university. It followed from there an atomization of universities with for corollaries a reduction of academic mobility, missed financial means for each country with a view to supporting its teaching, lower quality of education, social explosions of all kinds as strikes of students and teachers, etc. This phenomenon lasts up to now, breaking down the majority of the universities of the area. The lack of harmonization thus does not facilitate the regional cooperation through the mobility of the students, the teaching staff and the researchers, whose system of gradation is still not the same from one country to another.

However, with the favour of certain politico-economic regroupings vis-à-vis the current constraints, the promotion of regional cooperation is facilitated by the processes of political and economic integration in progress in Africa and by the intensive use of communication and information technologies. As we all know, the reinforcement of regional cooperation will not only make it possible to meet more effectively the present needs and future for an African society in exponential change but also to reduce the phenomenon of escape of competences towards other continents more secure in infrastructure of education and research. To mitigate the negative negotiable instruments of the brain drain, to make progress to share knowledge, the worldwide conference on higher education held in October 1998 in Paris affirmed that from now on the cooperation should be conceived as forming an integral part of the institutional missions and the systems of higher education in the world.

In West Africa, the programme of support and development of the regional centres of excellence initiated by the West-African Economic and Monetary Union, UEMOA, is one of the actions which should be greeted. It aims at strengthening the regional cooperation in the area of UEMOA, which gathers eight countries of West Africa (Decision No. 09/2002/CM/UEMOA). This sectoral programme aims at improving the offer of third-cycle education within the union, to strengthen the quality of education, to support the professionalization of the university educations, to support mobility of students, teachers and researchers of the area. It aims in addition at supporting the development of research in the institutions of higher education of the union, to support the setting in network of the institutions of higher education in order to help them to leave their academic insulation. It is thus an effective means to bring all the institutions of education and research to the same level of quality.

With the support of the financial partners, several universities of West Africa, conscious of the need for this regrouping, set up bodies of cooperations regional such as the West-African Society of Chemistry (Société ouest-africaine de Chimie, SOACHIM), the West-African Network of Biotechnologies, Réseau ouest-africain de Biotechnologies (R.A.BIOTECH). These bodies centre their activities on the search of excellence, thanks to the mutualization of financial means and of human resources with a view to leading major projects for the development in several scientific and technical fields. These bodies are essential today like places of junction for students and teachers of several nationalities for the control of the same research and training schemes.

It should be noted that harmonization of programs and courses and support of a solid regional cooperation are induced by undeniable beneficial negotiable instruments. It facilitates the comparison between the diplomas decreed by the universities concerned. It imposes measures of insurance – quality and the introduction of the standards of quality accepted by all. It supports intra-regional and interregional mobilities, thereby imposing pooling of scientific information, of intellectual resources with a view to constituting a network of regional expertise to make Africa participating in the increase of knowledge of humanity. Finally, the harmonization of courses is likely to create more dialogue and of cooperation between the systems of higher education of various linguistic areas while bringing a more coherent and more unified vision of higher education to Africa. At a broader level, the harmonization makes it possible to create a common African area of research and higher education, which is necessary to carry out the vision of the African Union that the African higher-educational establishments become a dynamic force on the international arena.

Finally, one needs to set in motion the continental convention on the recognition of studies and certificates, diplomas, ranks and other bonds of higher education in the states of Africa to make a success of this challenge.

2. Difficulties related to the lack of qualified human resources in terms of quality and quantity

In the field of human resources, it is not easy to build a regional cooperation. In an atomized university system, each one tends to be folded up on itself, approaching by chauvinism the challenges of the development which do not know of any border: diseases, malnutrition and lack of technology are challenges for the universities and the research centres.

The universities of West Africa meet more and more difficulites to renew their teaching staff because of the difficulties related to the profession: bad working conditions (insufficiency of financial resources for better equipment in the laboratories and ensuring a teaching of quality), not very attractive salary conditions, attracting other professions which are more developing for the individual. In this context, the teaching staff, which is growing older, can be mobilized for regional cooperation only with difficulty. Without motivation, this staff is aspired by daily domestic tasks, and student to teacher ratios are very high. By way of illustration, at the University of Ouagadougou one counts in 2008-2009 50,000 students to approximately 400 permanent teachers; that gives an average ratio of 125 students to one teacher.

Moreover universities in this area are young. Scientific fields are still recorded there for which no teacher on a national basis is available or does not have the level of qualification necessary to become a lecturer. It is then necessary to call upon international cooperation for the hedging of lessons in these areas which can imply challenges for the local development. Such a human landscape offers little chance for the setting-up of a viable regional cooperation.

3. Difficulties related to the lack of powerful and adapted logistics: equipment and infrastructure of education and research, communication facilities

Since the birth of the universities of West Africa, very weak attention has been given to the installation of infrastructure. The capacity of reception are largely exceeded by the request. It is the consequence of the impact of under-financing of these universities. Hence there is an inadequacy of the infrastructure compared with educational needs. The techniques of communication are not very powerful, the laboratories badly equipped. In this context, how to organize a regional cooperation worthy of the name? This is why the cooperation South-South is not easy to be structured: it lacks logistics for development. Thus, the African universities hesitate to sign agreements of exchange between the universities, a prerequisite for a consolidated regional cooperation. The cooperation at the time is more directed towards the north than towards the area.

How to arrive then to a sustainable development if the local challenges are not approached by multi-field teams, recruited at the regional level and installed in regional centres of competence, leading to and efficient programme of useful research to favour the needs of the community?

These centres of competence will be able to offer the functionality desired only if they have a suitable infrastructure, the creation of which concerns the responsability of the political decision makers. Even when African teams obtain results interesting for the development of the continent, it misses structures of popularization or publication of these results.

Indeed, the promotion and the publication of scientific reviews in Africa is limited enough. To fill this vacuum, several universities currently try to launch their own reviews or annals of the university to face the deficit of the sharing of knowledge. But such initiatives are quickly confronted with challenges like the quality of research, the availability of the matter to be published in a constant way, the limitation of the financial resources, etc. A good organization on this level could constitute the first link of a regional cooperation, founded on the division of the successful experiments. That would be advantageous with the economy of the countries.

4. Difficulties related to the lack of the financial resources

The lack of financial resources constitutes the main barrier to the development of regional cooperation as we have just seen above. The students, teachers and researchers are then forced to privilege the cooperation with the north or other more affluent areas of the world, being thus diverted from the resolution of the local problems. That is why they used to go to the South-North cooperation, which is often preferentially directed to African centres having a better infrastructure. This means that these centres must have a minimum of equipment to be able to start a scientific and training cooperation.

Table 1 below shows the share of financing devoted in 2002 to the infrastructure in Africa. The part of sub-Saharan Africa is much smaller than that of South Africa; with strong demographic growth (3 to 3.6 percent per year), the flow of students increases annually to become plethoric. This situation creates unfavourable conditions to attractively motivate the partners to collaborate with such universities.

Table 1. Evolution in per cent of the scientific and university cooperation of France in Africa according to the level of equipment in each region. (Source: The Directorate-General of the International Cooperation and Development, MAE, France, 2002.)

Year	*South Africa*	*Southern Africa*	*Sub-Saharan Africa*
1999	31	9	14
2000	32	10	14
2001	32	11	16
2002	30	14	17

4.1. Financing of regional cooperation

The institutions of higher education and research in Africa have very difficult financial standings. The principal causes are as follows.

- the economic and financial recession, person in charge for the weakness of the national savings and on the level of the households, not allowing to allocate a consequent budget with research on a national basis (cf. document of general policy, published by the World Bank in 1998);
- the reduction of the government aid to development;
- the implementation of the programs of structural adjustment, imposed by the international financial institutions; such a policy investing preferentially in the direct financial sectors.

In view of the above, the financing granted to higher education by the states of sub-Saharan Africa are so modest that they are used only for social and administrative expenses for the salaries of the personnel and training fees for students (Zeleza & Olukoshi 2004:95). They do not allow an expansion of the system. They cannot make it possible to build a true regional cooperation, built around a project of regional scale. Indeed it is noted that the funds allocated to higher education are relatively constant in comparison with the demands at this level (cf. financing of the University of Ouagadougou between 2000 and 2004).

Table 2. Budgets from 2000 to 2004, University of Ouagadougou, in thousands of francs CFA. (Source: the financial and accounting service of the University of Ouagadougou.)

Year	*Personnel*	*Operation*	*Investments*	*No. of students*
2000	1,465,403	700,000	153,500	9,000
2001	1,465,403	850,000	149,372	11,000
2002	1,465,403	637,500	116,400	13,000
2003	2,065,304	756,805	197,962	16,000
2004	2,716,600	711,000	391,188	20,000

However, the universities from their legal statute are very dependent on the budget of the state, not having for the moment other mechanisms of financing.

In view of this diagram, to lead today a solid regional cooperation in sub-Saharan Africa, in particular in West Africa, it is necessary to look for external financial partners and international organizations interested in higher education and thus in developing the countries of this region. The organization of a regional cooperation supposes a topic-carrying development for the area, a mobility of the actors (teachers, students, researchers), infrastructures for the reception (well-equipped laboratories, logistics of lodging for the actors) and of powerful means of communication. All that has a cost that the national budgets allocated at the universities or the research centres cannot support.

5. Difficulties related to the lack of a legal framework favourable to university and scientific cooperation

Scientific and university mobility aims at the development of the body of teachers and researchers in the South, the reinforcement of scientific competence and academics of the establishments of the South. It amplifies thus the flow of the scientific exchanges and intellectual, reduced disparities in university space.

But this academic mobility is only possible if a legal framework is dedicated to it, guaranteeing the movements of the populations. Several organizations in West Africa work in this direction. The African and Malagasy Council for higher education (CAMS) tries to set up a single university area between the French-speaking peoples of West Africa and Central Africa. The UEMOA made considerable progress for the creation of a common university area for the eight countries which constitutes it (Benin, Burkina Faso, Côte d'Ivoire, Guinea Bissau, Mali, Niger, Senegal, Togo). Texts of harmonization of the expenses of inscription for the students of the Community Area were signed by the ministers in charge of the higher education. It is even planned to arrive one day at the harmonization of the salaries of the teachers of the area. If all these provisions will be taken, the university regional cooperation and scientist cooperation will be facilitated. One cannot obtain such a result without a strong political commitment for the realization of this legal framework.

6. A case of successful regional cooperation

In the case of regional cooperation animated by R.A.BIOTECH, Table 3 lists constant expenditure committed each year apart from the purchase of heavy equipment.

The University of Ouagadougou has a contribution to the level of the expenses of hotels by lodging some invited professors at the Guest House when possible. Sometimes it takes care of the expertise fees of a limited number of invited professors. It is obvious that the activities undertaken within the framework of our regional cooperation would drop if we were not to support partners such as the UEMO, ISP/IPICS as is the case at present.

Table 3. Annual expenditure for a minimum operation of R.A.BIOTECH.

Headings of the constant expenditure	*Total expenditure* (FCFA)
Travel documents of the partners of the cooperation	8,000,000
Expenses of Hotels	1,800,000
Per diem	2,100,000
Fees of the interventions	6,750,000
Organization of the exchange rates	2,500,000
Operation of research (laboratories)	15,000,000
Minimum operational budget a year	34,260,000

In eight years of regional cooperation, supported mainly by the international partners, R.A.BIOTECH has recruited, for an education of quality, 200 students coming from 14 countries (Benin, Burkina Faso, Cameroon, Central Africa, Côte d'Ivoire, Djibouti, Egypt, Gabon, Guinea, Mali, Niger, Rwanda, Chad, Togo) including 32 % females. None of the participating universities could alone have carried out such a result (cf. Table 4).

Table 4. Students trained within the framework of the activities of R.A.BIOTECH.
BMC: Microbial and Cellular Biotechnologies;
BV: Plant Biotechnologies;
BA: Animal biotechnologies.

Country	*Number of students*	*Males*	*Females*	*BMC*	*BV*	*BA*
Benin	14	6	8	12	2	0
Burkina Faso	114	75	39	99	10	5
Central Africa	1	1	0	1	0	0
Cameroon	3	1	2	1	0	2
Côte d'Ivoire	7	7	0	5	2	0
Djibouti	1	0	1	1	0	0
Egypt	1	0	1	1	0	0
Gabon	8	5	3	6	2	0
Guinea	3	3	0	2	1	0
Mali	12	12	0	5	4	3
Niger	24	15	9	11	12	1
Rwanda	1	1	0	1	0	0
Chad	4	4	0	3	1	0
Togo	7	6	1	3	3	1
Total	200	136	64	151	37	12
Per cent of total	100	68.0	32.0	75.5	18.5	6.0

The regional cooperation suffers from the same constraints as higher education in general. Indeed, as from the year 1980 until the year 2000, the majority of the African governments under the advice of the principal donor countries of the international organizations give to higher education in Africa only a marginal priority compared to basic education. Several major considerations will lead these actors to adopt an attitude more favourable to higher education: First, the key role of higher education in any development process has been recognized by UNESCO during its General Assembly in Paris in 1998; secondly, the last two decades saw a fast increase in the enrolling of students at African universities; and finally a continuous escape of brains towards the developed countries has been noticed. These three factors provided negotiable instruments on questions relating to quality, to the practical utility and the social rentability of our universities. Today the image of our universities must be improved in civil society, which does not appreciate their impact on promoting development in Africa.

Consequently, there appears the need for joining through regroupings and networks for mutualize the human and material means with a view to ensuring an education of excellence. Thus, it will be possible for our universities to enter in competition on the worldwide market for the creation and the production of knowledge. R.A.BIOTECH has been privileged in this way.

7. Conclusion

We have just presented in this document the positive contribution of the university and scientific regional cooperation. It reduces the disparities of quality and level between the institutions. It contributes in a way more visibly and concretely with construction of a sustainable development. But its setting up in place meets several constraints of which the major constraint proves to be the financing. The political leaders and the financing partners must be conscious to provide to the regional cooperation the means necessary for its survival and installation. That passes by the exploitation of new mechanisms of financing by developing the expertise of the actors of the universities and the research centres through the calls for projects targeted on the priorities of development. It clearly apperas that at this price it will be possible to build, in short and medium terms, university cooperation in West Africa, focusing on the local problems and bringing the various actors to a balanced relation of production and sharing the results. To make a success of this qualitative change, it is desirable that contacts and a closer cooperation of complementarity be established between the partners for development and the governments of the countries concerned: support in the strategic plans of development, stronger implication of the universities and the researchers in the execution of these plans, and consequent support for the education and research to enable the success of the execution of these plans.

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Alfred Traore has also written the article on the West African Biotechnologies Network, page 241.

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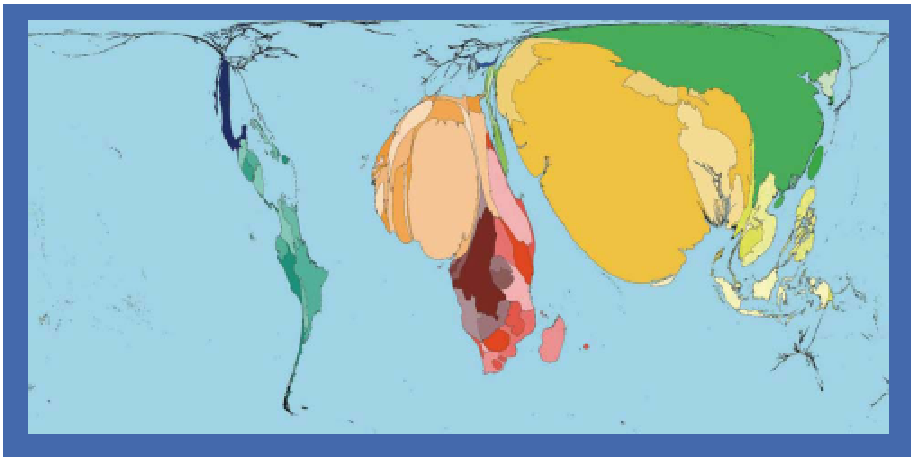
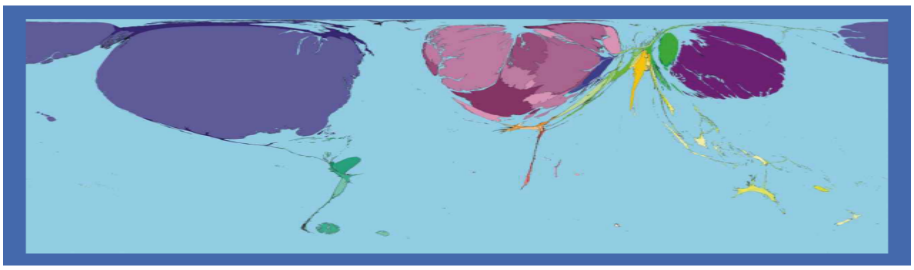
The Joint EU-Africa Stategy and the partnership on the information society, science and space technologies

Harry De Backer

1. Introduction

I started my presentation with two remarkable pictures that I've borrowed from the UNCTAD.





The first one describes the Global Distribution of Extreme Poverty, the second Global Distribution of Knowledge. Unfortunately for Africa, the continent remains poor and therefore is only working on basic necessities. The Knowledge Economy has not taken off in Africa.

2. A possible way out

I'm afraid that Africa cannot solve this backlash on its own, at least not in our lifetime.

Moreover, Africa should concentrate on Innovation and products that are immediately applicable on the continent. More need for applied science than research in state-of-the-art technologies. This is also the message of the UNCTAD in the 2007 report: Knowledge, Technological Learning and Innovation for Development.

The Universities should start knocking at the door of the Finance Ministers of their country because they hold the key to the budget, but also to ODA.

Europe offers Africa a unique opportunity to close the Scientific Divide: The EU-Africa Partnership on Science. This is no philanthropy, but bare necessity.

3. What are the EU views on science and innovation?

The European consensus, which is the common EU development policy, recognizes the importance of research for development: "The EU will promote the integration of development objectives, where appropriate, into its RTD and innovation policies, and will continue to assist developing countries in enhancing their domestic capacities in this area." However, ODA functions according to the Principle of African Ownership and therefore, since the demand from the African side is really limited to not existing, the implementation is still lacking. Hence one needs to stimulate the demand by the African side.

4. The European Parliament

But also the European Parliament has tackled the issue in the EP Resolution of 18.02.2008, in which they call for the

- reinforcement of existing research infrastructure in Africa;
- urges the EU MS to promote S&T cooperation with Africa; and
- recommend EU MS to promote knowledge and technology transfer between the EU and Africa.

5. The EU-Africa summit in Lisbon and the EU-Africa joint strategy

The purpose of this Joint Strategy is to take the Africa-EU relationship to a new, strategic level with a strengthened political partnership and enhanced cooperation at all levels. The partnership will be based on a Euro-African consensus on values, common interests and common strategic objectives. This partnership should strive to bridge the development divide between Africa and Europe through the strengthening of economic cooperation and the promotion of sustainable development in both continents, living side by side in peace, security, prosperity, solidarity and human dignity.

This Joint Strategy, which will provide an overarching long-term framework for Africa-EU relations, will be implemented through successive short-term Action Plans and enhanced political dialogue at all levels, resulting in concrete and measurable outcomes in all areas of the partnership.

6. The eight partnerships

In order to meet the common objectives, Africa and the EU will need to take concrete action and to make significant progress in the following eight strategic inter-related priority areas (P8):

- Peace & Security;
- Democratic Governance and Human Rights;
- Trade and Regional Integration, Infrastructure;
- Millennium Development Goals;
- Energy;
- Climate change;
- Migration, mobility and employment;
- Information Society, Science and Space Technologies.

7. P8: Objectives

Chaired by France and co-chaired by Portugal and Finland, the P8 objectives are:

(1) Support development of inclusive Information Society in Africa and implementation of the African Regional Action Plan for the Knowledge Economy (ARAPKE);

(2) Support S&T capacity building in Africa and implementation of Africa's S&T Consolidated Plan of Action (CPA);

(3) Enhance cooperation on Space applications and Technology.

8. P8: Information society: Progress so far

- HIPSSA: Telecom Regulation project (6 MEUR) in collaboration with the ITU and African Telecom Union that aims at creating a unique set of directives for the telecom regulation that should then be transposed by the AU Member states in national legislation.
- EASSy: an 8,000 km submarine cable at the east side of the continent, in which the EU institutions have invested 3.6 MEUR in grants and 15.6 MUSD in loans.
- Connect Africa (13 MEUR) which will connect the National R & D networks in sub-Saharan Africa to the European GEANT network.
- AXIS: Will improve access to the Internet by creating local Access Points and Clearing Houses between countries (3 MEUR).

9. P8: Science: Progress so far

- African Research Grant (15 MEUR): in the pipeline and approved by a number of EDF bodies. First call expected after summer 2010.
- FP7 Africa 2010 Call — 63 MEUR for Water, Food Security and Better Health; launch 09.09.2009. There are 974 participants, with the highest number in Kenya (61), followed by South Africa (59), Ethiopia (37), Tanzania (32), and Egypt (30).
- African Science rewards will be given on September 9, 2009, by the EU Commissioner Potocnik to 5 women scientist.
- Further screening of 12 S & T Flagship projects proposed by AUC.

10. P8: Space technologies: Progress so far

- Lisbon Process on GMES and Africa. The Action Plan is in the Drafting phase. The worldwide consultation will start in the spring of 2010. The results will be presented to the EU-Africa Summit in December 2010.
- EC Joint Research Centre African Observatory has been sidelined and might be replaced by the AFREF.
- ESA Telemedicine project (INFRA) is collaboration between the European Space Agency, the WHO, the African RECs, NEPAD, the AUC and the EC. The pilot will be operational mid-2010.
- The extension of the EGNOS (European Geostationary Navigation Overlay Service) to Africa is an essential project to increase airline security to smaller airports in order to stimulate the tourist sector on the continent.

11. P8: State of play

- In spite of the enormous effort of the French Chair (IRD), progress has been limited.
- Not all EU Member states are represented at the EU Implementation Group.
- Meetings are not always attended by the appropriate persons: diplomats are no Science, ICT or Space experts.
- EU Delegation to the AU has been and will be further bestowed with S & T and ICT expertise.
- Financing of the Partnership remains an issue. A mapping exercise of EC + MS initiatives and instruments could solve the issue.
- African interest has been very limited, but this is changing!

12. P8: The future

- The Lighthouse Projects are only a start!
- Africa and the EU need to engage in a Policy dialogue on how this Partnership should evolve. This should lead to:
  - Much stronger collaboration between African and European scientists that should lead to Brain Gain for both continents.
  - Learning from each other: We hope for a highly increased twinning of EU and African research centers.
  - Drastic increase of the R & D budgets in Africa through proper means, but also ODA and Direct Foreign Investment.

13. State of play for the other seven partnerships

General assessment: Novel comprehensive dialogue and implementation structure in place, ... but AUC is not yet EC:

Implementation delays on the level of the AU (many actors involved, very ambitious, technically complex and multi-layered process.

Mixed assessment of core objectives of the partnership (beyond development, beyond Africa, beyond institutions).

Overall, structuring of a new relationship which will bring visible results in the long run.

14. Assessment by political leaders

Slow start, but good learning curve.

Troika Ministers welcomed efforts to strengthen the dialogue between the two sides.

Full implementation of the Strategic Partnership is a long-term project and progress is achieved only step by step.

Ministers stressed the need for adequate financial resources to implement the Joint Strategy and reiterated their request for efforts to be made by both sides to allocate the necessary funds in order to foster implementation.

15. Conclusion

- The EU-Africa Joint Strategy and its Partnerships is a unique occasion for the continent to make a giant leap in the socio-economic development of the African continent.
- It is the responsibility of every EU Member state to carry his share of the burden and to fully cooperate in the Partnerships.
- But it is also necessary that the African side organises itself in an appropriate way to grab the opportunity.

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Three proposals to strengthen regional, continental and intercontinental cooperation in favour of basic sciences in Africa: Abridged version

Pascal Kossivi ADJAMAGBO

Abstract. We explain how the creation of regional Institutes for Excellence in Science, Technology and Art, in each of the five regions of Africa, under the leadership of the African Union Commission, UNESCO, and leading African states, could boost fundamental and applied research in basic sciences in Africa, while being also powerful motors of the economy of knowledge in favour of the global economy in Africa, following the example of the irresistibly emerging economies of China and India, solving structurally by this way the problem of reaching a critical mass of researchers in basic sciences in Africa.

This first proposal leads us naturally to a second one, the organization as soon as possible, under the leadership of the African Union Commission, UNESCO and the UNECA, of an educational and economic *World Summit on Economy of Knowledge in Africa*, to start up the innovation economy and innovation companies on the African continent like on the Asiatic continent, and to power both the global economy in Africa and fundamental and applied research in basic sciences in Africa.

Finally, thanks to the specificities of research in mathematics, we also explain how the strengthening and the creation of online networks of researchers and thesis students in mathematics, with adequate electronic, administrative and financial means, could contribute to strengthen fundamental and applied research in mathematics in African and to solve the problem of obtaining a critical mass of researchers.

1. An introductory wisdom sentence

Ne me nya afisi ne le yiyima, na nya afisi ne tsoa, which means, in the Ewegbe language spoken in Ghana, Togo and Benin: ‘If you don’t know where you are going to, know where you are coming from’. In accordance with this African proverb, in the integral version of the present paper,[1] we first remind, with

[1] This article is the last part of a much longer paper, which contains an extensive presentation of Africa as the cradle of modern humanity, art, science, and technology. It is available at www.isp.uu.se/nwc/

extensive scientific references and illustrations of exhibits, which are precious data for any scientific interested in the scientific and not ideological history of Africa, the prestigious past of Africa as the cradle of modern humanity, art, science and technology, and the social and state structures which favoured the invention and the impressive growing of basic sciences, technologies, and arts in the Ancient Black Egypt, according to the analysis of the philosopher Aristotle in his book *Metaphysics* and of the historian Strabo in his book *Geography*.

2. Institutes for Excellence in Art, Science, and Technology in Africa

In his opening lecture yesterday, The Commissar of the African Union for Human Resources, Science and Technology, Professor Jean-Pierre Ezin, announced to us the current joint project on which are working the African Union Commission and the Department of Education of UNESCO, concerning a Pan-African University, on the model of the United Nations University.

More precisely, the introduction of the document *Establishing Pan African University, Project Summary Report, June 2009* says:

> The African Union is deeply aware of the importance of Universities in the attainment of its vision of peace, integration, prosperity and peerage in the global economy; through its NEPAD philosophy ... It is proposed that one way of achieving such rationalization is through a network of differentiated Pan African university networks. Under the area of higher education, the Plan of Action of the second decade of Education in Africa, the Consolidated Plan of Action (CPA) and the Action Plan for the Joint Strategy UA-UE call for enhancing collaboration among institutions of higher learning and research, enhancing links with industry as well as identification and strengthening of networks of Centres of Excellence to enhance the capacity of Africa to contribute to the global pool of knowledge and innovation.[2]

But, beyond the present most prestigious universities in the world like Harvard, MIT, Berkeley, Oxford, Paris 6, Orsay, Moscow State University, Tokyo University, everybody in this audience knows that the most prestigious and efficient Centres of Excellence, playing the role of catalyst in chemistry and more precisely the alchemy of excellence in art, science and technology, are research institutions of modern leading countries like the following.

(1) The Institute for Advanced Study of Princeton (IAS),[3] created in 1930. Its emblematic members who founded its exceptional reputation are: Albert

[2] African Union, Department of Human Resources, Science and Technology, Establishing Pan African University, Project Summary Report, June 2009, AUC/HRST June 2009.

[3] Institute for Advanced Study, Princeton, USA, www.ias.edu/. Wikipedia, Institute for Advanced Study, http://en.wikipedia.org/wiki/Institute_for_Advanced_Study

Einstein, Kurt Gödel, John von Neumann, Robert Oppenheimer and André Weil. One of its present emblematic members is Pierre Deligne.

(2) Steklov Mathematical Institute of Moscow,[4] with a department at St. Petersburg,[5] created in 1932 after the scission of an Institute of Mathematics and Physics created by Steklov in 1921. Its present emblematic members are: I. Shafarevich, P. Novikov, Y. Manin, V. I. Arnold,[6] V. Popov.

(3) Tata Institute of Fundamental Research of Bombay,[7] created in 1945, located presently at Mumbai, Pune, and Bangalore, and composed presently of the School of Mathematics, the School of Natural Sciences, and the School of Technology and Computer Science.

(4) Max Planck Institutes,[8] a network of research centres created in 1948 and composed at present of more than 80 decentralized institutes, among which are: Institute for Mathematics at Bonn, Institute for Physics at Munich, Institute for Informatics in Saarbrück.

(5) Institut des Hautes Études Scientifiques (IHES),[9] created in 1958 with the assistance of Robert Oppenheimer and Jean Dieudonné. Its emblematic members who founded its reputation are: A. Grothendieck and J. Dieudonné. Its emblematic present members are: A. Connes, M. Gromov, M. Kontsevich.

(6) Research Institute for Mathematical Sciences (RIMS),[10] created in 1963 within Kyoto University. Its present emblematic members are: S. Mori, M. Kashiwara, T. Kawai.

2.1. First proposal: Creation of Institutes for Excellence in Art, Science, and Technology in relation with the Pan-African Universities

Since our conference is a brain-storming to strengthen basic sciences in developing countries, in particularly in Africa, let us suggest to the African Union Commission and UNESCO to enrich and strengthen their project of a network of Pan-African Universities in each of the five regions of Africa and not forgetting its sixth Diaspora Region, by associating to each Pan-African University on the model of Ancient Egypt Excellence Centres, on the model of the decentralized Max Planck Institutes and of the model of the double structure of the

[4]Steklov Mathematical Institute, Russian Academy of Science, www.mi.ras.ru/index.php?l=1

[5]Petersburg Department of Steklov Institute of Mathematics, http://202.38.126.65/mirror/www.pdmi.ras.ru/index.html

[6]Vladimir I. Arnold died on June 3, 2010.

[7]Tata Institute of Fundamental Research, www.tifr.res.in/About_TIFR

[8]Max Planck Institutes, www.mpg.de/english/portal/index.html

[9]Institut des Hautes Études Scientifiques (IHES), www.ihes.fr/jsp/site/Portal.jsp

[10]Reseach Institute for Mathematical Sciences, Kyoto University, www.kurims.kyoto-u.ac.jp/en/index.html

Institute of Advanced Studies and the University of Princeton, an ambitious *Institute for Excellence in Art, Science and Technology*, in accordance to the African wisdom sentence, *It is on the model of the ancient rope that the new one is twisted* (Ewe proverb).

Regions of Africa. The five geographic regions of Africa, to which the African Union added a sixth: the Diaspora Region. (See Figure 16 of the complete version of this paper.)

North Africa Western Sahara (EH), Mauritania MR, Morocco MA, Algeria DZ, Tunisia TN, Lybia LY, Egypt EG
West Africa Cap Verde CV, Senegal SN, Gambia GM, Guinea Bissau GW, Guinea GN, Sierra Leone SL, Liberia LR, Mali ML, Côte d'Ivoire CI, Burkina Faso BF, Saint Helena SH, Ghana GH, Togo TG, Niger NE, Benin BJ, Nigeria NG
Central Africa São Thomé and Príncipe ST, Cameroon CM, Gabon GA, Equatorial Guinea GQ, Chad TD, Central African Republic CF, Republic of Congo (Brazzaville) CG, Democratic Republic of Congo (Kingshasa) CD
Eastern Africa Sudan SD, Uganda UG, Ethiopia ET, Rwanda RW, Tanzania TZ, Kenya KE, Eritrea ER, Somalia SO, Djibouti DJ, Somalia SO, Réunion RE
Southern Africa Angola AO, Namibia NA, South Africa ZA, Botswana BW, Zambia ZM, Zimbabwe ZW, Lesotho LS, Swaziland SZ, Malawi MW, Mozambique MZ, Comoros KM, Madagascar MG, Mayotte YT, Seychelles SC, Mauritius MU
African Diaspora In all other continents

2.2. The missions of the Institutes for Excellence in Art, Science and Technology in relation with the Pan-African Universities

The first mission of such an Institute for Excellence should be to boost both fundamental and applied research in basic sciences by the teachers and researchers of the Pan-African Universities, by being for all the departments of each Pan-African University what the locomotive is for the cars of a train and what a catalyst is for a chemical reaction.

The second mission should be to invest the intelligence of the members of the Institute for Excellence into winning strategies to be also a powerful motor of the economy of knowledge in favour of the global economy of Africa on the model of emerging economies of China and India, in assistance to the

Pan-African Universities, in accordance with African Union Commission conception of Pan-African Universities stated as follows in the introduction of the cited AU document.

> The Pan African University aims to promote Science and Technology on the continent and link scientific research to economic development. It will enhance universities triple mission of education and training; research; and public service or assistance to the African community. (See footnote 2)

3. A World Summit on the Economy of Knowledge in Africa

3.1. Introduction

The speed of Japan's economic and industrial growth from the end of the second world war, and the speed of the same present growth for China and India for a decade, mainly in the field of data processing for India, confirm that we already left the industrial era to enter the post-industrial era or the knowledge economy era, where technological innovations, like computers, email, and mobile phones, became the motor of economical growth and where intelligence is more and more demanded.

The challenge which Institutes for Excellence could efficiently contribute to take up in Africa, consists of winning firms in exploiting cleverly the mines of scientific knowledge and of technological know-how, in order to convert intelligence into ingenuity and ingenuity into technology, thanks to research and development activities, which need competent and motivated human resources, with an adequate initial and continuous education.

Africa is presently far away from this challenge of intelligence, ingenuity and technology, although the products of challenge coming from abroad are coveted and consumed with avidity everywhere in Africa, not only by African elites, but also by urban and country masses, like for TV with satellite dishes, mobile phones or internet. With this situation, African societies seem condemned to a status of miserable parasites, consuming more and more what they are less and less able to produce.

So, in order to make soon the dream of its scientific, technological and economical renaissance become a reality, Africa needs not only to make its future Institutes for Excellence efficient as soon as possible, but also to follow strategically and methodically, like in a running competition, the good, stimulating and brisk examples of its immediate economic predecessors which are emerging in continent-sized countries like China and India, to exploit from right now the gold mine of the economy of knowledge, to produce itself the products of knowledge it consumes with such avidity, to create millions of new jobs of knowledge for its educated children, to create merited and not stolen wealth, as well as true and sustainable development instead of waiting for help from others, to make the economy of knowledge become the spearhead, the propulsion power and the strike force of its economy in the competition of the economic globalization and the undeclared (but real) economic world war.

3.2. The merits and limits of phase one of the African Regional Action Plan on Knowledge Economy (ARAPKE)

In the dynamics of the two *World Summits on the Information Society* organized by the United Nations Organization at Geneva in 2003 and Tunis in 2005, in order to take advantage of these opportunities provided by the economy of knowledge, especially in the domain of Information and Communication Technology (ICT), the African Union cleverly adopted the *African Regional Action Plan on the Knowledge Economy* (ARAPKE).[11]

In the framework of this information and communication technology, a Steering Committee of the ARAPKE selected in February 2007 a "phase one list" of eleven *ARAPKE Flagship Projects*, the most constructive of which seem to be the *ITC Broadband Network Infrastructure* and the *African Internet Exchange System*.[12]

But in consideration of all the products of knowledge economy consumed in Africa and all the opportunities provided by this economy as we just saw, especially in the technology of different kinds of energy consumed in Africa and in the electronic technology needed for all kinds of electronic products consumed in Africa, and mainly in comparison with the examples of China and India, the proposed phase one of the ARAPKE is clearly too timid and inadequate to a real and dynamic starting up of a knowledge economy in Africa.

On the model of cited stimulating examples of China and India, Africa needs the decisive phase one of the ARAPKE Flagship Projects to be more ambitious, more productive, more able to create thousands and millions jobs, wealth and sustainable development, and covering more varied domains of the real economy, from data processing activities to energetic and electronic industries, like in China and India.

We think that the decisive phase one of the ARAPKE Flagship Projects cannot be the result of a selection of isolated projects as the ARAPKE Steering

[11] See its official document: African Union Commission, Human Resources, Science & Technology Department, Science and Technology & ICT Division, The African Regional Action Plan on the Knowledge Economy (ARAPKE) Flagship Projects (Phase One), www.africa-union.org/root/ua/Annonces/The_African_Regional_Action_Plan_on_the_Knowledge_Economy.doc See also the Addis Ababa Conference website at www.isp.uu.se/nwc/ for more information.

[12] See the reference in footnote 11 for more details.

Committee did, but needs to be seriously and globally rethought, like the plan of the different battles of a war need to be seriously thought by the competent strategists of a global war council.

So we are convinced that, instead of wasting energy and money to realize the selected projects Phase One ARAPKE Flagship Projects before selecting projects in Phase Two,[13] the new African Union Commission should take advantage, for the benefit all of Africa, of the following suggestion.

3.3. Second proposal: A World Summit on the Economy of Knowledge in Africa

In front on the dangerous and degrading economical position of Africa in comparison with Asia and South America, in order to take really advantage of all the opportunities offered by the economy of knowledge and to rethink and rebuild in a coherent, efficient and ambitious way the Flagship Projects of the African Regional Action Plan on the Knowledge Economy beyond its initial limits of Information and Communication Technology, it is a moral and urgent obligation for all those who are in charge of African nations or institutions, especially for the Commissar of Human Resources, Science and Technology of African Union, to organize as soon as possible, under the leadership of the African Union Commission and other international economic and scientific institutions like UNESCO and the United Nations Economical Commission for Africa, an educational and economic *World Summit on the Economy of Knowledge in Africa*, with the participation of the political, financial and industrial decision-makers at the highest level like President Obama, African Presidents, AU President, UN Secretary-General, UNESCO Director-General, UNECA Executive Secretary, World Bank and IMF Director-Generals, etc., to start up the innovation economy and innovation companies on the African continent as on the Asiatic continent, in all domains of the Economy of Knowledge, from data processing methods to electronic and energy technology, including the engineering of the expected SKA project,[14] with the hope to power in this way the global economy in Africa as well as fundamental and applied research in basic sciences in Africa thanks to the creation of specific research centres in the neighbourhood of universities or Institutes for Excellence, like in China and in India,[15] tending by this way to the solution to the crucial problem of a critical mass of researchers for fundamental and applied scientific research in Africa.

[13]See page 7 in the ARAPKE report mentioned in footnote 11.

[14]See the article by Charles H. McGruder III, Africa and the Square Kilometer Array (SKA), page 163 in this volume.

[15]See the very interesting article by Brice Pedroletti, Matière grise, la nouvelle révolution chinoise, *Le Monde*, 28 September 2008, www.europe-solidaire.org/spip.php?article11610

4. Online international networks of researchers and thesis students in mathematics in favour of Africa: A last proposal

To conclude our brain-storming, let us just formulate our last proposal, motivated by our personal rich experience on the matter: according to the specificities of research in mathematics, it would be efficient for the strengthening fundamental and applied research in mathematics and a contribution to solve the problem of critical mass of African researchers and the training of future leaders in teaching and research in mathematics, to strengthen and to create online networks of international researchers and thesis students in mathematics, in favour of African mathematicians and open to interested non-African mathematicians.

These networks, under the auspices of an international or academic institution, should be granted with adequate electronic, administrative and financial means, like individual and portable virtual libraries, online access to rich libraries of great mathematical institutions, personal and community videoconference meetings, real mathematical meetings, etc.

Not to waste time, we are ready to start an online network in algebra and algebraic geometry in favour of researchers and thesis students of the universities of Porto-Novo in Benin and Lomé in Togo, after discussion at the beginning of our conference with our colleague J. Tossa, the head of the Institute of Mathematics of Porto-Novo and the discussion two weeks ago with the colleagues of the Department of Mathematics of Lomé University. Only the economic problem remains to be solved. So, we are open to any offer of the kind.

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Regional cooperation: Some reflections with respect to Eastern and Southern Africa

Lennart Hasselgren[1]

Introduction

Most countries in Eastern and Southern Africa have for many years been neglected what concerns funding to build research capacity, especially in the basic sciences – mathematics, physics, chemistry and biology. In most cases it is still the question of building a base in order to be able to contribute the higher educated people badly needed in the societies. In that process, regional cooperation could be an efficient component. It could mean that more advanced groups in the region could be used as resource groups to enhance the building up of research capacity at other universities in need of such cooperation, it could be one way to strengthen MSc and PhD programmes through the access to more qualified people to serve as lecturers and supervisors, it could mean that more people can be educated in the region despite low or no capacity at the own university, it could mean that more advanced equipment can be made available to regional scientists, it could imply that research of complementary nature through networking will make the region stronger and more competitive, it could mean less research of the very same nature and a spread in the number of research activities, ... However, already now I want to stress that regional cooperation can only be complementary to the long-term, directed support needed to build active research groups within the strategic areas chosen by departments and institutions, especially in weak scientific environments. By the time research activities grow in strength the importance will increase and in the parts of the world where science has developed as a natural part of the society, although weak, regional and international cooperation will play an important role.

In the following I want to consider three different forms of regional cooperation, i.e., networks, resource groups and links, with emphasis on the first two. It will be from a cooperation partner's point of view, based on some experiences from the ISP[2] way of working. I will use a few examples of networks and resource groups to underline what I mean.

[1]Read by Bernard Aduda, the University of Nairobi.

[2]ISP is the acronym for *International Science Programme*, Uppsala University. For further information see *URL:* www.isp.uu.se

When does regional cooperation start to be meaningful?

Cooperation means that all parties involved would be able to contribute and benefit. When starting to build research capacity from scratch, there must be careful planning and partners must be found to take care of the basic training, etc. During that phase it may look as a one-way directed activity even if the more advanced partner already from the beginning will benefit from the research work conducted and from an exchange with a different culture. With time and the more local resources being built up, a cooperation may develop in its real meaning.

The choice of cooperation partners is very important and undoubtedly a partner in the nearest region would be beneficial in many respects. It would imply more similar culture, working conditions and maybe a partner with fresh experiences from building science in difficult environments. Further, it could be very cost-effective. This is where regional resource groups could play a crucial role. Take Rwanda as an example. I am convinced that the ambitious plans for building science in Rwanda would be enhanced by possibilities for regional cooperation at the same time as there is a programme to strengthen the local environment for research.

By the time regional research capacity develops, networks will start to grow in importance. Research can never be performed in isolation and formal networks could be useful. However, there must be clearly defined programmes and purposes. People of course have to meet, but a conference now and then should not be enough. There could be other ways to make it possible for people to meet occasionally. Further, the network must be formed from the inside through a genuine regional interest. However, it should not be forgotten that the individual groups constituting the network also need individual support.

As good knowledge as possible of the environment where science is going to be built up is important. In the following I should like to point at some matters regarding the situation for science in the region under consideration. I will not go into a deeper discussion on this issue here. Somewhat more detailed presentations can be found in my paper (2008).

Situational analysis in Africa South of the Sahara

Few PhD holders

Africa South of the Sahara, excluding South Africa, is a region where science is weak. In chemistry, mathematics and physics, surveys made by ISP (Hasselgren & Kivaisi 1998; material available at ISP) clearly show the difficult situation. Thus, as one example, in Eastern and Southern Africa from Sudan and down to Angola and Namibia but excluding South Africa (17 countries,[3] and more than 310 million inhabitants) there are not more than one to two PhD holders per two million inhabitants within each one of these disciplines. In biology, that at first instance may look comparatively strong, the applied disciplines, i.e., medicine, animal production and crop sciences, cover more than 60 % of the total production of scientific publications in refereed journals from universities, whereas fundamental activities like taxonomy, biodiversity and microbiology, only cover a small fraction of the publications. This makes the base for applied research narrow, affecting the sustainability of projects.

Undoubtedly, the building up of domestic research work in applied fields of direct importance to these countries and controlled by them will be very difficult under such circumstances. There are a limited number of people to build on and this points to the need to strengthen the universities and their capacity to conduct MSc and PhD programmes.

Young universities

Most universities in this part of the world are very young institutions in different stages of development. Some started just a few years back and have only undergraduate education with an academic staff out of which a high number only have BSc degrees, and where the dependence on expatriates is very high. Others have been conducting MSc and PhD programmes for some years and a majority of the staff are locals with PhD degrees. Further, in some countries there is an expansion of the higher education sector adding more universities but still with very few local academic staff. With some exceptions, governmental grants are small and the need for support from the outside is very substantial indeed. The need for long-term planning is obvious. Many countries have formulated science policies and more and more universities have started to develop strategic plans.

Small departments

Departments very often consist of 10–20 academic staff members only, sharing very high teaching loads. Allowing younger staff members to work for their MSc and PhD degrees of course increases the teaching load of others, even if in some cases governmental funds allow for hiring expatriates. This means limited time for research. At many universities it has also not been allowed to recruit new staff members. This has resulted in a skewed age profile with few young staff members, which has alarmingly made the situation more

[3] Sudan, Eritrea, Ethiopia, Kenya, Uganda, Rwanda, Burundi, Tanzania, Malawi, Zimbabwe, Mozambique, Botswana, Swaziland, Lesotho, Namibia, Angola.

vulnerable than it ought to be. The death of one person can be a severe handicap for teaching loads as well as the research activities conducted. Further, even if salaries have been improved upon during recent years, a second job may be needed. In fact, salaries for university lecturers are in many cases still not competitive, and there are signs that less and less young students are interested in taking up careers as lecturers because of the low pay compared to other lucrative professions.

Internal brain drain can also be a severe problem for small departments. Very qualified people are attractive for higher positions within governmental and private organizations. Administrative duties within university administration or public office appointments will draw people away from teaching as well as research. In such cases it is important to quickly find a new key person who can take on the responsibilities to continue the work.

The importance of a balanced age profile, i.e., where young staff members are gradually taking over roles and responsibilities from senior staff, is clearly seen in the performances. Departments with a healthy age profile have a more steady positive development than otherwise. The critical mass needed for a productive research activity is reached quicker, the MSc and PhD programmes are more stable and there is a critical mass of teaching staff.

The small size of departments also implies that the number of research activities, especially in experimental fields, will be limited to two or three groups.

Student situation

To a large extent students entering the universities have had limited access to textbooks and they have limited experience in conducting experiments. There are cases where in secondary schools natural science is taught by people without any background in the field. This makes the subjects more abstract and difficult than it ought to be. Also students in Sweden look upon physics, for example, to be difficult, but the problem is more accentuated in many developing countries. This makes not only teaching more difficult and demanding for university staff, but it also means that many talented pupils will not take up studies in natural sciences. Furthermore, local fellowships for MSc and PhD studies have been very much reduced in number during recent years and in some cases even completely vanished. Thus, even if there are students interested in such studies, economical realities make it impossible. Students are most important for university research.

The lack of opportunities for primary and secondary pupils to conduct experiments or for their teachers to make demonstrations means that in some cases an extra introductory year is needed before the university studies can start. In other cases there has been introduced domestic regional centres, which are better equipped and where pupils from other schools can do experiments and get teacher demonstrations. Regional centres for universities have also been discussed in some countries where more than one university or institution of higher learning exist.

Female pupil-drop-outs start in some cases as early as after primary school. At the university level, the number of female MSc and PhD students is normally quite small in for example mathematics and physics, while the figure is better for chemistry and biology. Measurers should be taken to improve on the situation for example by offering local fellowships, and cooperating partners should be able to give such fellowships.

Crucial equipment

There are cases where excellent research results cannot be published in good international journals because of lack of equipment for certain studies. When there is a need to make use of more heavy equipment like electron microscopes, X-ray diffraction units, XRD, sputtering units, etc., the only option could be to make use of cooperation partners in the North. For example, there is no XRD unit suitable for materials science work in all of Eastern Africa, there are few facilities if any for mass spectrometry, etc. A transmission electron microscope, TEM, is available in Tanzania and there is a scanning electron microscope, SEM, in Kenya even if not directly accessible to physics for example. There is a great need for support in this respect. However, the support must be given with care. It is most important that the units are installed at institutions with the capacity to handle and maintain the equipment. Thus training of technicians and scientists for these purposes is very important as well as understanding how maintenance will be undertaken and financed. Even if the situation has improved tremendously, there is still equipment found idle due to lack of competent staff, spares and consumables. Further, there are still examples of heavy equipment being purchased without a proper survey and understanding of what the equipment is to be used for, without detailed specifications for quotations, without training of personnel, without plans and finances for maintenance and without an understanding of what extra facilities are needed for a proper utilization of the equipment. This is one example where often mistakes are being made.

In this context it is interesting to note that universities start to take more and more interest in upgrading experimental facilities and local funds start to be available even if only in very small amounts. This has resulted in the possibility to co-finance more costly equipment and it also means better possibilities to solve the problem of running costs and maintenance.

Regional cooperation

As said in the introduction, regional cooperation can only be complementary to the direct support in building research teams. This direct support must be long-term and based on the local situation for research and the needs expressed. It must also focus on strengthening MSc and PhD programmes. The formation of stable research teams is in this respect very important, since it is around them such programmes can be built. Thus, long-term commitments are necessary for periods of 10–20–30 years. It must also be understood that a realistic number of university research teams in for example experimental physics is limited to three to five in most cases. There could also be research activities conducted by one-man research teams, taking a MSc student now and then, but meaningful MSc and PhD programmes can only be built around the stable groups. Further, stability requires research work in fields in line with university/institutional plans.

Regional cooperation could be an efficient component to assist

- young universities in staff development programmes, preferably making use of resource groups working in areas of importance;
- in building MSc and PhD programmes up through the involvement of resource groups and networks;
- by taking MSc and PhD students to work for degrees where a university lacks capacity;
- making more advanced equipment available to scientists and students in the region;
- maintaining advanced equipment when local resources are missing.

It also means a possibility to get a spread in research activities making the region as such more competitive and improve upon local ownership and control.

Resource groups

A resource group is a group that has grown into such a strength that it can take responsibility to assist MSc and PhD students from outside the own university either by guiding them towards degrees at its university or making it possible for them to conduct research work and training making use of its facilities and guidance but with a degree from another university, normally the parent university of the student. They can also put more advanced equipment to the disposal of scientists from the region and they normally have quite a good access to information.

I will give one example which I think clearly shows what is meant and how efficient this could be. The example is the IPPS-supported group TAN:01/2 at the University of Dar es-Salaam working in the field of Condensed Matter Physics and on projects in Materials Science for Solar Energy Conversion. The group started to receive support from IPPS already in 1976. The support during the first years concentrated on training and it was not until in the beginning of the 80s that support was extended also for procurement of equipment, etc. In those days, IPPS was supported by SAREC,[4] and through special applications to SAREC it was possible also to assist with more costly equipment as evaporation units and sputtering units. The group developed in a very positive way, and in 1986 some small grants were given to explore the possibilities for regional cooperation since it was known to be a high demand in their area of competence. The group started to take MSc and later on PhD students from other universities in the region, and in 1990 the group arranged the first College on Thin Film Technology with participants from, besides Tanzania, also Kenya, Malawi, Mozambique, Uganda, and Zambia. Today there have been nine such colleges arranged and about 200 young scientists have been trained from 12 countries in the region besides Tanzania. Eight people from outside Tanzania have received PhD degrees where part or in some cases the major work has been conducted in Dar es-Salaam and there are more than nine MPhil/MSc degrees where the work had been conducted in Dar es-Salaam or where the group has contributed in a major way. Besides this, there have been four local people graduating with PhD degrees and seventeen with MSc degrees from the University of Dar es-Salaam. The brain drain is almost zero. The total support from IPPS to TAN:01/2, including 2008, amounts to 10.9 MSEK only. About 30 % of that support has been for regional cooperation. This clearly points at how efficient the support of a regional resource group could be in order to strengthen the scientific capacity in the region.

Unfortunately this group has been negatively affected during the last years by the death and sicknesses of key people. It is our hope that it will be possible to continue to support the group and the young people ready to take over the responsibilities.

The diversity of research fields in the region is very much dependent on resource groups and their possibilities to take regional responsibilities and it is rewarding to see that more and more groups have reached that capacity – but they must be funded!

[4]Then the acronym for *Swedish Agency for Research Cooperation with Developing Countries*, later changed to *Department for Research* within Sida. Today this activity within Sida is named *Secretariat for Research Cooperation*. Sida is the acronym for *Swedish International Development Cooperation Agency*.

Networks

Networks can also be an efficient complement. However, a network must have a clear programme and strategy. It is not enough just to allow people to meet now and then or maybe to arrange conferences. The purposes could be different. Three examples will be given below. All three are presented in more detail elsewhere at this conference

One example from physics is ESARSWG, Eastern and Southern Africa Regional Seismological Working Group. Seismology is a small discipline and seismological events have no national border lines. Sharing of data would of course be of importance, but also to have the possibility to control one's own data is important.

ESARSWG was formed in 1993 with the aim

- To monitor the seismic activities of the East Africa Rift system falling within the Eastern and Sourthern Africa Region through a continued operation of seismic stations in the 8 countries that comprise ESARSWG and collectively analyse data to produce seismological bulletins for the region. Bulletins up to 2007 have been produced;
- To enhance capacity building in the region in both equipment and personnel to enable seismology-related research to be carried out. During 2008, two MSc students, one from Malawi and one from Zambia, graduated from Addis Ababa University. They were the first to graduate under the ESARSWG umbrella;
- To plan and conduct joint research programs in the region. Proposals for projects in *Active Fault Mapping* and *To Determine Attenuation Relations* have been worked out.

Another example is MSSEESA, *Materials Science and Solar Energy Network for Eastern and Southern Africa*. This network was initiated a few years back. Presently it consists of IPPS-supported groups in Kenya, Tanzania, Uganda, and Zambia all involved in complementary work within Condensed Matter Physics with specializations on *Materials for Solar Energy Conversion*. They idea is to strengthen the MSc and PhD programmes through a more efficient use of regional manpower for lecturing and a more efficient use of advanced equipment as well as reaching a critical number of students. It is viewed important that the MSc and PhD programmes are recognized by the universities involved. Further, it is also viewed important that the network is recognized by the respective countries. Once again I want to stress the importance of individual support to the groups constituting the network.

I want to end by taking the last example from mathematics. It seems to me that support of theoretical activities can be conducted in a somewhat different way than experimental fields and networks can play a very important role. EAUMP, Eastern African Universities Mathematics Programme, is a network between departments of Mathematics at University of Nairobi, Kenya; the University of Dar es-Salaam, Tanzania; and Makerere University, Uganda. The network was constituted to introduce new areas of mathematics in the region and to run joint MSc and PhD programmes making an efficient use of the regional manpower and getting a critical number of students. The experiences are very good and details are presented elsewhere at the conference.

Concluding remark

Science cannot develop in isolation. Cooperation is essential. This is very true also when building research capacity. Supporting agencies should have the possibility to integrate support to individual groups, including resource groups, with networks. International organizations and governmental bodies may have certain restrictions on their agenda including limitations what concerns countries to cooperate with, etc. However, it must be understood that development of science is very dependent on the possibilities for international cooperation. In weak scientific environments this is further accentuated. Individual countries may have a possibility to have only few research activities. Taking a whole region into consideration could change that picture and make the research work very competitive. It would be a strength to be able to conduct the activities within the region instead of having to go far away to achieve the goals. However, this needs planning and economical support, and the building up of research capacity should not always have to strictly follow country regulations for example.

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He has been awarded doctorates *Honoris Causa* from the University of Khartoum (Sudan), Prince of Songkla University, and Chiang Mai University (Thailand), and the University of Colombo (Sri Lanka). He is a *Professor of Honour* at the Universidad Nacional de Trujillo, Trujillo (Peru), Universidad Nacional de Ingenieria, Lima (Peru), and Escuela Politecnica Nacional (Ecuador). He has received *Special Recognition* from Universidad Nacional de Colombia

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Dr. Hasselgren has served as Chairman for the Interdivisional Group on Physics Development, IGPD, of the European Physical Society, 1992–1996, and as Secretary of the Commission on Physics for Development, C. 13 of the International Union of Pure and Applied Physics, IUPAP, 1990–1996.

Africa and the Square Kilometer Array

Charles H. McGruder III

The Square Kilometer Array (SKA) will be by far the largest radio telescope in the world. It will consist of 3,000 separate dishes (each 12 meters in diameter). The total area of all of the dishes is one square kilometer. The physical extent of the entire telescope is 3,000 kilometers. It will cost at least 2 GUSD. Both Africa and Australia are vying for the project. If Africa wins the competition for the site, parts of the telescope will be put in South Africa, Namibia, Botswana, Mauritius, Mozambique, Madagascar, Zambia, Ghana and Kenya, meaning that an extremely high degree of African interregional cooperation in the areas of higher education, basic sciences, and technology would be required. It would make Africa number one in radio astronomy for decades to come and some of the answers to most fundamental questions in physics—dark energy, dark matter, and the future of the universe may come from African soil, the same continent that produced the first human beings.

Why should Africa host SKA? The reason is growth—economic, scientific and technological. But, how can a radio telescope, whose primary purpose is to answer some of the most fundamental questions of science lead to economic growth? A World Bank study concluded: "for every 10 % increase in bandwidth for connectivity for developing countries, you get a 1.3 % growth in GDP of the host country." Because SKA will gather and transmit enormous amounts of data over the internet and SKA dishes must be located in rural areas in order to avoid radio interference, SKA will drive the development of internet connectivity in both rural and developed areas in large parts of Africa, thus leading to economic growth.

How will SKA lead to growth in science and technology? First, SKA will attract some of the best scientists and engineers in the world to work in Africa. Secondly, it will provide unrivalled opportunities for African scientists and engineers to work with cutting-edge instrumentation and to collaborate with some of the most renowned research institutions in the world. Thirdly, because SKA will be one of the biggest science and engineering projects in the world, it therefore represents a unique opportunity for the development of very high level skills and expertise in Africa. Finally, SKA will allow Africa (for the first time since ancient times) to be a significant contributor to the global knowledge economy.

The expectation that SKA will be sited in Africa has already lead to significant signs of growth. 120 students have received SKA scholarships—80 postgraduate and 40 undergraduates. In addition 11 postdoctoral SKA fellowships have been awarded. Kenya is introducing astronomy at the University of Nairobi this October. South Africa is building the Karoo Array Telescope (MeerKAT) consisting of 80 dishes, which is a precursor instrument for the SKA. Finally, the government of Mauritius is making funds available to assist in the installation and testing of a MeerKAT type telescope.

It is expected that SKA will significantly contribute to answering the most fundamental questions of science:

How and when did the first stars and galaxies form in the universe?
What is the mysterious dark energy and dark matter that fill the universe?
How did the universe, and the galaxies in it, evolve?
Was Einstein always right about gravity?
Where did the magnetic fields in the universe come from?
Is there life of any sort anywhere else in the universe, and is it intelligent (like us)?

There is one major requirement for Africa to win the SKA bid—an extremely high degree of African interregional cooperation in the areas of higher education, basic sciences, and technology must be achieved. It is the explicit purpose of this conference to generate such cooperation.

Finally, in summary, we ask: What is SKA all about? It is about making Africa #1 in a fundamental area of science that is characterized by an extremely high level of technology and about encouraging Africa's youth to make great accomplishments in science and engineering.

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Lessons learned from ten years of network activities

Hamidou Touré

1. Introduction

It is well known that Science and Technology (S & T) provide the tools to address local challenges in agriculture, health, energy and other fields, and thus stimulate the innovations that fuel economic growth. Hence for developing countries to make significant steps in their economic development, they need to pay particular attention to the training and retention of scientists, engineers and mathematicians, with particular attention to advanced training and research at the university.

The situation of mathematics and basic sciences in Africa is very different from region to region, from country to country. While some countries have serious difficulties concerning teaching in school, in other places, there do exist research groups, PhD training and networks in biology, chemistry, mathematics, and physics, connected to international level research teams all over the world.

I made the following statement in the workshop *Mathematics in Africa South of Sahara* held in Arusha in November 2001.

> The general situation is well known, I just want to mention:
>
> - Isolation of mathematicians, barriers of frontiers;
> - Environmental problems;
> - Lack of scientific literature and equipment;
> - National budgets for research are too low and mathematics receive no or extremely low priority, for example, in my own country, there is no budget for research in universities, up to now;
> - Teaching mathematics in schools and universities is not a lucrative career; in most countries in Africa South of Sahara, one cannot live quite normally with just his salary.
>
> But in spite of this working environment, there does exist a few research groups in central and western Africa, good PhD programs in mathematics, like in Benin, Burkina, Cameroon, Côte d'Ivoire, Nigeria and Senegal.

The situation is almost the same eight years after the Arusha meeting. But now we do have some great reason to be really optimistic.

The impact of regional and interregional cooperation connected with the development of internet has improved very much the situation of researchers within Africa.

We will focus our discussion on how regional and interregional cooperation in our region has improved the research capacity building within our countries in mathematics; in particular, we will

- provide schools and universities with adequate text books, computers and softwares;
- identify and sustain promising good students with grants and scholarships;
- develop joint post-graduate programs;
- develop real sandwich programs and training schools;
- develop regional doctoral programs.

2. Input and output of networking

2.1. The Network Partial Differential Equations, Modelling and Control

First of all, the development of internet access, despite its high cost, has had a great positive impact on scientific communication and the link of African scientists to the research world. Internet has broken the isolation of scientists and border barriers between countries.

What was our own situation in 1999?

When we founded the Network Partial Differential Equations, Modelling and Control in 1999, we had in the three teams in these fields: one full professor, two professors and nine PhD holders. We had bad internet connection and we were suffering from isolation.

What has been achieved by the networking and the reinforcing of regional cooperation?

Activity of research training within the network has been intensified. It gathers each year more students, PhD students and researchers. By taking support on the problems of development of sub-Saharan Africa, the Network is patiently building active and dynamic research capacity throughout the region.

We organize each year workshops involving members of network and colleagues within the region. We also organize conferences with partners involving researchers in the continent, lecturers and participants from elsewhere. We organize an international conference every three years to give opportunity to researchers in the network and in the region to present their own results

The network supports both local PhD training and sandwich PhD programs. From 1999 to August 2009, 29 PhD theses have been defended, of which 3 habilitations, 4 local training, and 22 sandwich programs. According to publications (see details in the appendix to my other article, page 276), 59 articles have been published in international journals, three in regional journals, and three in national journals, that is, a total of 65 publications.

We have had quite an interesting experience of regional doctoral research training in West Africa. We call it *West African Training School* (WATS). WATS has been set up by Professor F. K. A. Allotey, SAPAM President and Director of the Mathematics Institute, Ghana; Professor Hamidou Touré, Network Coordinator; Professor Charles Chidume; and Professor Claude Lobry.

WATS has completed its three-year cycle 30 September 2005 in Saint-Louis. Eighteen students followed 24 weeks training of 360 hours courses and 240 hours of tutorials, during eight weeks each year from September to August since 2003. This training was in four fields: real analysis, functional analysis, ordinary differential equations (ODE), partial differential equations (PDE), optimization, and digital simulation.

WATS students could reinforce their training in the wide field of analysis directed towards differential equations and associated areas of control and numerical methods. The courses started on the basis of a level of master degree (Master 1) until it reached the level of PhD and research training the last year. Thanks to this training school, WATS students had a good background to hold classes at university level and to carry out their own research with a view to obtain their PhD thesis.

These three years were mainly devoted to building a strong culture of analysis for young universities teachers coming from French-speaking and English-speaking countries in West Africa. Some other colleagues had organized in Côte d'Ivoire a similar school in algebra. They called this training school *WATS in Algebra*.

This experience enables us to consider the next steps of WATS in a more flexible form. The duration of WATS will be shorter and the training is especially completely directed on research bases. It is a question of gathering students of Africa South of the Sahara, during four weeks on the set of research subjects on which they work or plan to work. The training will supplement their knowledge in this set of research fields, bring support and a methodological follow-up to them. It will also put them in relationships and synergy with active researchers in these fields in Africa and outside Africa.

WATS was mainly financed initially by the Abdus Salam Centre for Theoretical Physics (ICTP), but due to lack of funding, the program was stopped.

From the sessions of the African Council for Tertiary Education (CAMES), which evaluate the teachers of most African Francophone Countries, the members of the network got the following qualifications: two full professors, eight professors, and fifteen assistant professors. All the assistant professors and six professors defended their PhD during this period within the network.

The current staff of the Network Partial Differential Equations, Modelling and Control includes now four full professors, six professors and 42 PhD holders.

2.2. The Millennium Science Initiative and the African Mathematics Science Initiative

The Millennium Science Initiative (MSI) is designed to accelerate the development of nations by building stronger capacities in science, scientific leadership, and the uses of science. The mission of the African MSI is to support the African scientific leadership in equipping more Africans with the tools of modern science, linking scientific programs together as partnerships, and promoting the uses of science for the benefit of society.

The African Mathematics Millennium Science Initiative (AMMSI) is a distributed network of mathematics research, training and promotion, throughout sub-Saharan Africa, with five Regional Offices located in Botswana, Cameroon, Kenya, Nigeria and Burkina. It was established by the Millennium Science Initiative (MSI), a program administered by the Science Initiative Group (SIG). AMMSI currently operates as a program of the African Academy of Sciences (AAS).[1]

Initiative like the AMMSI need to be supported.

Research networks have been developed within Africa these last ten years. A lot of success stories, like our own experience, are due to the combination of regional and interregional cooperation, with the financial and scientific support of donors.

I would like to mention especially the support of ISP to our network since 2003, through Sida funding. Since 1999, we have had support from the Abdus Salam Centre for Theoretical Physics (ICTP).

We may notice also at the same time the emergence of public policy on applied research in basic sciences. This is starting with very small public funding for research. However, this is one very favourable tendency. It is well known that public funds grants, loan and support to basic sciences is the key to their development.

By way of contrast, in the private sector, the multinationals prefer to draw up research contracts in northern countries instead of appointing local researchers.

We will give in the following lines our view on the way to go ahead by strengthening regional and interregional cooperation in basic sciences.

[1]For more details visit www.ammsi.org

3. The way to go ahead

No underdeveloped basic sciences should be done in Africa nor in other countries of the Third World. African scientists are part of the scientific international community; they have to take the place they deserve in that community.

I agree with the idea that what is important, is to do good quality research and training in basic sciences, especially in mathematics, that will align African scientists and African mathematicians with the rest of the world.

The objectives to strengthen basic sciences by regional and interregional cooperation can be achieved through a variety of activities involving the following.

3.1. Generating good students for research in basic sciences

Funds have to be made available to:

- provide schools and universities with adequate text books, computers and softwares;
- identify and sustain promising good students with grants and scholarships;
- develop joint post graduate programs;
- sustain and develop real sandwich programs and training schools;
- sustain and develop doctoral programs.

3.2. Development of research and building the critical mass

3.2.1. Centre and Research Network

Develop and sustain National and Regional Centres and Research Networks. This has to be done by financial and scientifical support to precise program selected and evaluated by an independent scientific committee.

3.2.2. Financial support to basic sciences

- Grants for research program;
- Grants for workshops and meetings;
- Grants to scientists (additional salary);
- Promotion of contracts with the private sector;
- Support for several research projects that address problems pertinent to Africa, in collaboration with the private sector.

3.2.3. Doctoral program

Local PhD training programs are organized by local scientists with sometime some external support. The largert part of the staff of our universities obtained their PhD in these programs. In my understanding this kind of programs are the main basis to develop basic sciences research in Africa. The need to be sustained by grants for students, facilitating regional mobility, exchange and visits of lectures and researchers.

It is of great interest to grant research and visiting fellowships to university staff to enable them to engage in collaborative research and postgraduate training at host universities.

We need to develop doctoral training at regional and interregional levels, like WATS and other regional postgraduate training. Those programs have to be combined with sandwich PhD programs.

3.2.4. Dissemination of knowledge

It is important to sustain existing journals, like in mathematics *Afrika Mathematika* and *IMHOTEP*. African scientists need to have good journals at the international level published in Africa. We think that, to have good input, it is better to focus funding and efforts on a few selected journals, so that they will be able to reach and maintain an international scientific level. This can be done, for example, by funding the subscription for five years of all African universities to those journals.

The only way to go forward, for mathematics and basic sciences in Africa South of Sahara, is to sustain real work, which is done by African scientists living and working in Africa.

The main shortage is long-term support by donors and local government to basic sciences and African scientists. I hope that the current conference will be a real chance for a new age of develpment for basic sciences in Africa.

4. Conclusion

To conclude, I would like to mention some key factor of success, learned from our own experience: training the young generation and ownership.

So many young people willing to learn the sciences, willing to have access to scientific knowledge, are left behind. Training the young generation of Africans in basic sciences is one of the main ways to give them hope in African renaissance.

The freedom of the scientific teams in the choice of scientific topics covered is important. The ability to conduct applications relevant to their community may be very motivating also. Without ownership, basic sciences cannot face the need of our community. Ownership is for that reason crucial in the process to strengthen basic sciences in developing countries.

Hamidou Touré was born in October, 1954, and is a Full Professor at the University of Ouagadougou, Burkina Faso, since 2003. He is Coordinator of the Network Partial Differential Equations, Modeling and Control.

Currently he is also the Director of the Applied Mathematics and Modelling Laboratory and Scientific leader of ISHANGO, *la Fondation Institut International d'Ingénierie de l'Eau et de l'Environnement* (2iE; International Institute for Water and Environment, based in Ouagadougou), and Associate Professor there.

Hamidou Touré has also written an article on the network PDEMC; see page 265.

URL: www.2ie-edu.org

Towards a new collaborative model for strengthening capacity in mathematical research in Africa

Mohamed E. A. El Tom

1. Introduction

Recently, El Tom (2008a) observed

> some thirty years ago the University of Khartoum sponsored the first *International Conference on Developing Mathematics in Third World Countries*. It was realized then that mathematics was young in much of the third world and providing a platform for the exchange of ideas and experiences in different parts of the world on how to build mathematics would benefit those interested in promoting mathematics in third world countries (El Tom, ed., 1979). The conference recommended to UNESCO the establishment of three regional centres of excellence in mathematics, one each in Africa, Asia and Latin America. Instead, the International Centre for Pure and Applied Mathematics (ICPAM/CIMPA) in Nice (France) was established in 1978.

Nearly 15 years after the Khartoum conference, Coomb (1991) and El Tom (1995) reported that the state of mathematics in Africa was poor.

Despite some progress here and there, the data presented in section 3 show that today the state of mathematical research in almost all sub-Saharan African countries remains poor and in need of urgent action.

Following the discussion of sections 3, a new model for strengthening capacity in mathematical research in Africa is presented in section 4. The paper ends with some concluding remarks.

The main source of data on mathematical research cited in this paper is *MathSciNet*, an electronic publication that continues the tradition of the paper publication *Mathematical Reviews*, which was first published in 1940. The items in the *MathSciNet* database are classified in accordance with the *Mathematics Subject Classification* (MSC) established by the American Mathematical Society.

While the coverage of *MathSciNet* is extensive (over 1,800 current journals are covered), its coverage of periodicals, monographs and conference proceedings published in developing countries, especially in languages other than

English, is rather limited. However, the database provides an excellent and reliable qualitative indicator of the state of mathematical research in a specific country.

2. Basic descriptive indicators of African regions and countries

The regional groupings of a total of 53 independent African countries is presented in Table 1 below. Of these 53 countries, just over one half (27 countries) do not score a single hit in the entire database. These countries are marked with an asterisk (*) in the second column of Table 1.

Table 1. Regional groupings of 53 African countries. An asterisk indicates a country without any hit in the database.

Region (number of countries)	*Countries*
North Africa (5)	Algeria, Egypt, Libya, Morocco, Tunisia
Eastern Africa (10)	Burundi, Djibouti*, Eritrea, Ethiopia, Kenya, Rwanda*, Somalia*, Sudan, Tanzania, Uganda*
Central Africa (8)	Cameroon, CARep, Chad*, DRCongo*, Equatorial Guinea*, Gabon, Rep. Congo*, São Tomé & Príncipe*
West Africa (16)	Benin, Burkina Faso, Cape Verde*, Côte d'Ivoire, Gambia*, Ghana, Guinea*, Guinea-Bissau*, Liberia*, Mali*, Mauritania, Niger*, Nigeria, Senegal, Sierra Leone*, Togo*
Southern Africa (14)	Angola*, Botswana, Comoros*, Lesotho, Madagascar*, Malawi*, Mauritius*, Mozambique*, Namibia*, Seychelles*, South Africa, Swaziland*, Zambia, Zimbabwe

The state of mathematical research in Africa exhibits, not unexpectedly, significant variations between and within regions as well as between universities in the same country. Some basic indicators can help explain the state of mathematical research in many African countries and these variations. The relevant data are presented in Table 2 on page 176.

In terms of population, the data in the second column show that each region is dominated by a single country: Egypt and Nigeria are each home to about 50 % of their respective region's population, more than 63 % of the Central region total population are in DR Congo, and about 30 % of the Eastern and Southern regions are to be found in Ethiopia and South Africa, respectively.

The data in the third column of Table 2 indicate that, on the average, North Africa is the richest of the five regions, followed by Southern Africa, and with a GDP per capita of 1,578 USD, Eastern Africa is the poorest African region.

The Human Development Report (HDR) classifies countries into three groups according to the value of their Human Development Index (HDI): High Human Development ($0.8 \leqslant \text{HDI} < 1$); Medium Human Development ($0.5 \leqslant \text{HDI} < 0.8$); and Low Human Development ($0 \leqslant \text{HDI} < 0.5$). According to this classification, the data in El Tom (2008a, b) show that only 3 African countries are in the first group: Seychelles, Libya, and Mauritius; 3 of the Central Africa region, 4 of the Southern Africa region, 6 of the Eastern Africa region, and 10 of the West Africa region are in the Low Human Development group. In fact, on the average, both East and West Africa are low human development regions. Poor countries with a low human development level are unlikely to devote sufficient resources for the development of an effective national science and technology base and a dynamic mathematical community.

The data in the fifth column of Table 2 suggest that countries of North Africa have, on the average, 15 universities each and the corresponding number of universities for the Central, West (excluding Nigeria), and Southern Africa region (excluding South Africa) is 2 universities each. In East Africa, countries have, on the average, 9 universities each. However, there is no readily available current data that tell us which of these universities offer undergraduate and graduate degree programmes in the mathematical sciences. For instance, in the case of Sudan only 6 of its 33 universities offer undergraduate degree programmes in the mathematical sciences. Similarly, in Ethiopia only 1 of its 22 universities offers a graduate programme in the mathematical sciences. However, the last column of Table 2 does give an indication of those African countries where graduate degree programmes are or have been offered by at least one university in the country in question. For earlier data in this regard see El Tom (1999).

Again, the data in El Tom (2008a, b) show that only six African countries have more than 100 earned doctorate degrees in mathematics, namely Cameroon, Egypt, Morocco, Nigeria, South Africa, and Tunisia. If one considers the number of doctorate holders in mathematics per one million inhabitants, then it turns out that, on the average, the relevant number for North, Southern, Western and Central Africa are 5.7, 4.8, 2.5, and 1.9, respectively. The corresponding number for East Africa is less than 1. In fact, altogether, there are 10 countries with less than one doctorate holder per one million inhabitants: Libya, Ethiopia, Somalia, Sudan, Tanzania, Uganda, Chad, DR Congo, Angola, and Mozambigue. Clearly, most African countries lack a critical mass in mathematical research. Moreover, the data in the last two columns of the table strongly suggest that a relatively significant level of research in the mathematical sciences is to be expected in the six countries mentioned earlier and in Algeria. And, in view of the poverty and low human development level of most African countries, these countries can produce very little mathematical research.

Table 2. Population, wealth, human development index (HDI), number of universities, doctorate degree holders, and mathematics doctoral degrees awarded: African regions. Numbers include those who may have passed away or brain-drained. *Sources:* Population data: Wikipedia at en.wikipedia.org/wiki/List_of_African_countries_by_population UNDP (2007/2008), El Tom (2008), Gerdes (2007).

Country	Population 2007 estimates (million)	GDP (PPP) per capita (USD) 2008 estimate	HDI	Number of universities	Number of doctorate holders in maths	Number of maths doctoral degrees awarded
Egypt	80.3	5,643	0.708	15	500	85
North Africa	163.7	9,202	0.734	75	929	334
Ethiopia	76.5	1,346	0.406	22	48	–
East Africa	255.3	1,578	0.477	91	252	36
DR Congo	65.8	957	0.411	5	41	–
Central Africa	104.3	5,133	0.530	19	193	27
Nigeria	135	1,373	0.470	45	233	88
West Africa	267.5	2,133	0.465	73	657	180
South Africa	44	14,529	0.674	18	502	432
Southern Africa	141.1	7,402	0.574	45	671	450

3. The level and structure of mathematical research output

The overall continent-wide picture of the level of mathematical research output may be gleaned from Africa's share of the corresponding world total output over the past decades. Africa's share as well as that of six Latin American countries of total world output is presented in Table 3 below. The data in Table 3 (page 178) and Figure 1 (page 183) below show that while Africa's contribution to the world mathematical literature has increased progressively during the period 1980–2005, it still remains small both absolutely and relative to some other developing regions.

It was noted in section 2 above that 27 African countries are not covered by *MathSciNet*. Naturally, these 27 countries will be excluded from the discussion that follows regarding the level and structure of mathematical research in the continent.

Figure 2 (page 184) shows each region's annual share of total world mathematics publications during the period 2000–2008. It is clear from Figure 2 that North and East Africa exhibit the highest and lowest level of mathematical research output in the continent, respectively. Indeed, North Africa's share of total world research output in mathematics during the period 2000–2008 is about 0.89 % per year, and the corresponding share for East Africa is 0.01 %. The corresponding share for the other three regions is 0.03 %, 0.09 %, and 0.40 % for Central, Western and Southern Africa, respectively (see Figure 2).

It is worth noting that the data in El Tom (2000a, b) show that research output in Central, Western and Southern Africa is largely concentrated, in each case, in one country, namely Cameroon (more than 80 % of the region's total publications), Nigeria (its share of the region's total publications ranges between 71.4 % (2007) and 92.5 % (2000)), and South Africa (contributes over 90 % of all publications in the southern Africa region). Also, in addition to Nigeria, two other countries, Burkina Faso and Senegal, account for almost all publications of West Africa. In the case of southern Africa, the data show that besides South Africa, Botswana is the only other country in Southern Africa that sustained a modest level of research through the period being considered.

The North Africa region presents a special case. First, its total research output exceeds that of the other four African regions together. Second, on the average, Egypt contributes just over one half of the region's total annual research output (51 %) during the period under consideration. On the other hand, with an average annual research output of 26 %, Morocco's contribution to the region's output is twice that of Algeria's (13 %) and nearly triple that of Tunisia's (9 %) (El Tom 2000a, b).

Institutional research output

An interesting feature of African mathematical research concerns the institutional distribution of research output. El Tom (1995) found that mathematical research in African countries is usually dominated by one or two of a country's universities. More recently, El Tom (2008a) found that this phenomenon continues to characterize African research output.

It is further shown in El Tom (2008a) that 4 of Algeria's 25 universities account for more than three quarters of all the country's mathematics publications during 2000–2007. In the case of Egypt, 8 of the country's 15 universities contribute 81.6 % of its total publications during the same period. However, two Egyptian universities, Cairo and Mansoura, account for 38.5 % of total publications. For Morocco, one third of its 15 universities account for nearly 90 % of total publications, and one university, Cadi Ayyad in Marakesh, account for 31.8 % of the country's publications. As for Tunisia, only 2 of its 7 universities produce more than 92 % of total publications.

In 4 African countries, namely Cameroon, Burkina Faso, Botswana and Senegal, a single university accounts for all the country's publications during the 8-year period 2000–2007. While Botswana has only one university, Cameroon, Burkina Faso, and Senegal have 7, 2, and 3 universities, respectively.

Nigeria and South Africa also exhibit the phenomenon of concentration of mathematical research in a few of a country's universities. Thus, 6 of Nigeria's 45 universities and 7 of South Africa's 18 universities account for 83.1 % and 74.5 % of their country's total publications during 2000–2007, respectively. Moreover, in the case of Nigeria one university, Obafemi Awolowo, accounts for 30.5 % of total publications, and in South Africa, the university of the Witswatersand accounts for 21.1 % of all of the country's publications in mathematics during the period being studies (El Tom 2008a, b).

Table 3. Africa's and Latin America's* share of total world mathematical research output, 1980 (5) 2005.
* The data are for Argentina, Brazil, Chile and Venezuela.
Source: *MathSciNet* and author's calculations

	1980	1985	1990	1995	2000	2005
Africa's share (%)	0.02	0.70	0.85	0.97	1.27	1.44
Latin America's share (%)	0.03	0.96	1.31	1.59	2.14	2.26

In view of the modest research output of most of the countries considered in the previous section, it is more meaningful to limit investigation of the structure of mathematical research to the following six countries.

- North Africa: Algeria, Egypt, Morocco, and Tunisia.
- West Africa: Nigeria.
- Southern Africa: South Africa

The structures of mathematical research for the six countries considered here for the 8-year period 2000–2007 are presented in Figures 3–8. Again, for lack of space, I refer the reader to El Tom (2008a, b) for a detailed discussion of these structures.

4. Towards a new model for strengthening capacity in mathematical research

There are relatively few models whose aim is to build capacity in basic sciences in developing countries, perhaps not more than a handful. El Tom (2008a, 2008b) discusses two of the better-known models for strengthening capacity in mathematical research in Africa.

The traditional model, adopted by African countries for developing mathematics, especially in the 1960s following independence, involves sending top students for postgraduate studies in mathematics (and rarely in mathematics education) in western countries. The poor state of mathematics in Africa attests to the failure of this model of capacity building in mathematics. The model suffers from four drawbacks:

(a) It is expensive (the cost of a doctorate degree in mathematics in a western country is estimated at 100,000 USD);
(b) It is risky (because of the well-known phenomenon of the brain drain);
(c) It does not aim for quality (students are sent to any institution that offers a PhD programme in mathematics rather than to institutions that are known to offer strong graduate programmes in mathematics); and
(d) It is insensitive to the importance of mathematics education (ignores the fact that mathematical research and mathematics education are organically linked: a weakness in either will undermine the other as well as the S & T base).

In fact, the model has been largely abandoned since the economic crisis of the mid-1970s that afflicted most African countries. The Ministers with responsibility for science, participating or represented at the Round Table on "Science and Technology for Sustainable Development and the Role of UNESCO" held on 26 and 27 October 2007 during the Thirty-fourth Session of the UNESCO General Conference arrived at common positions including "Innovative approaches should be developed and adopted to attract young people to the study of science and mathematics, and to pursue careers in research." (UNESCO 2007).

The proposed model recognizes that the poor state of mathematics is a problem affecting almost all sub-Saharan Africa and, moreover, most of these countries lack the capacity to deal with this problem effectively within a reasonable period of time. Accordingly, the model adopts a Pan-African approach to strengthen mathematical research in Africa significantly, Specifically, the model sets itself the objective of establishing a **world class Pan-African centre for graduate studies in mathematics in Africa**. The major goal of the centre is to create and strengthen *leadership in mathematical research* in the continent.

The establishment of the Centre is conceived as a *process*. Initially, a *masters degree programme in mathematics* would be established. Students, 20–30 in number, would be selected on the basis of academic ability in a continent-wide competition and would be offered grants that cover tuition fees, travel and subsistence. Since the quality of the qualifications of students admitted to the programme would inevitably vary, the masters programme would act as a sieve for the promotion of students to the PhD programme.

The whole project would be implemented by a prestigious western university (PWU), with a particularly strong graduate programme in mathematics, in partnership with an African university (AU). Graduate degrees would be awarded by PWU for a period to be determined by the two partners.

AU should be located in a country enjoying political stability and relative economic prosperity. In addition, the university administration and the government of the country should make their commitment to host the proposed Centre in concrete terms: adequate space for the Centre, housing for its faculty, and to accord it, according to a Charter governing the Centre, a level of academic and financial autonomy that would allow it to grow unencumbered by possible bureaucracies.

The involvement of PWU, through its institution responsible for graduate education in mathematics, would ensure that the project is endowed with a quality that is difficult to surpass internationally. Also, the prospect of earning a doctorate degree from PWU would prove to be a powerful factor in persuading young African talent to pursue studies in mathematics.

The Centre shall strive to achieve regional and international recognition by insisting on recruiting dedicated and first-rate academics who are committed to its mission, by carefully designed programmes of study, by adopting a rigorous selection procedure of students from all over the continent, and by undertaking research, networking individuals and institutions in Africa engaged in research in mathematics, and by providing a forum for the exchange of ideas and experiences between researchers, practitioners and policy makers. Graduates of the project, whose expertise should be keenly sought by universities and research institutes, are expected to initiate and lead efforts towards the enhancement of mathematical research, and the improvement of the image and the teaching and learning of mathematics in the continent. Thus, through its own activities as well as those of its graduates, the proposed Centre should have a considerable influence on the articulation of the agenda for the advancement of mathematics in the continent. Also, by being a pioneering Pan-African project in higher education, the Centre is highly likely to have a significant institutional impact.

While the first phase of the project is meant to be externally funded, its sustainability is best achieved through the establishment of an *endowment fund* to be managed by a *Board of Trustees* in which PWU, AU as well as other major partners would be represented. The major contributors to such a fund should be African governments, institutions and business enterprises.

5. Concluding remarks

Building mathematics in Africa is a complex and long-term process (El Tom, ed., 1979). The nature of mathematics and its role in sustainable human development is poorly understood in many parts of the world, but particularly so by African power elites. The onus of responsibility for improving the image of mathematics in African society at large and convincing power elites to include the promotion of mathematics in their list of priorities lies on mathematicians, national associations of mathematics, and the African Mathematical Union. An important task for these bodies is to undertake the establishment of national systems for the identification and nurturing of young talent in mathematics.

At present there are a number of initiatives and projects that include improving mathematics in Africa as one of their major aims: the International Mathematical Sciences Programme based in Uppsala University, the Mathematics Program at the Abdus Salam International Centre for Theoretical Physics, Trieste, Italy, the Academy of Sciences for the Developing World (TWAS), the African Institute of Mathematics (AIMS) based in South Africa, and the Millennium Science Initiative (MSI). Some measure of coordination between these efforts is highly desirable and, perhaps, one of them may initiate this coordination effort.

The proposed model should be seen as an addition to, rather than a replacement of, existing or future models whose aim is to strengthen mathematics in the continent.

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El Tom is a co-founder of Sudan Centre for Educational Research, a non-governmental and not-for-profit organization based in Khartoum. He is currently Dean, Garden City College for Science and Technology, Khartoum.

Mohammed El Tom was the rapporteur of Theme 3; see page 401.

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Note added in proof: The author is delighted to report that last January Stockholm University, Sweden, and the University of Dar es-Salaam, Tanzania, adopted the model proposed in the paper and agreed to collaborate in establishing a Pan-African Centre for Mathematics in the latter university. A Memorandum of Understanding has been signed by the Vice-Chancellors of the two universities in May 2010.

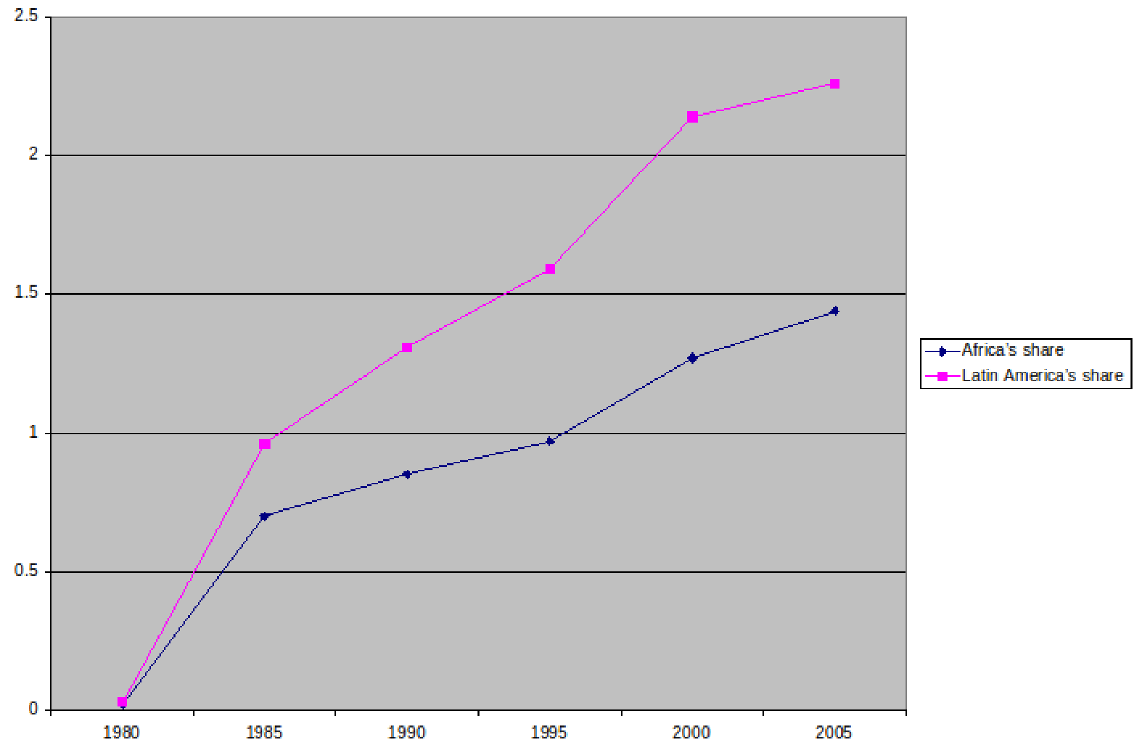

Figure 1. Africa's and Latin America's share of total world mathematical research output, 1980 (5) 2005. The data for Latin America are for Argentina, Brazil, Chile and Venezuela. Source: *MathSciNet* and author's calculations.

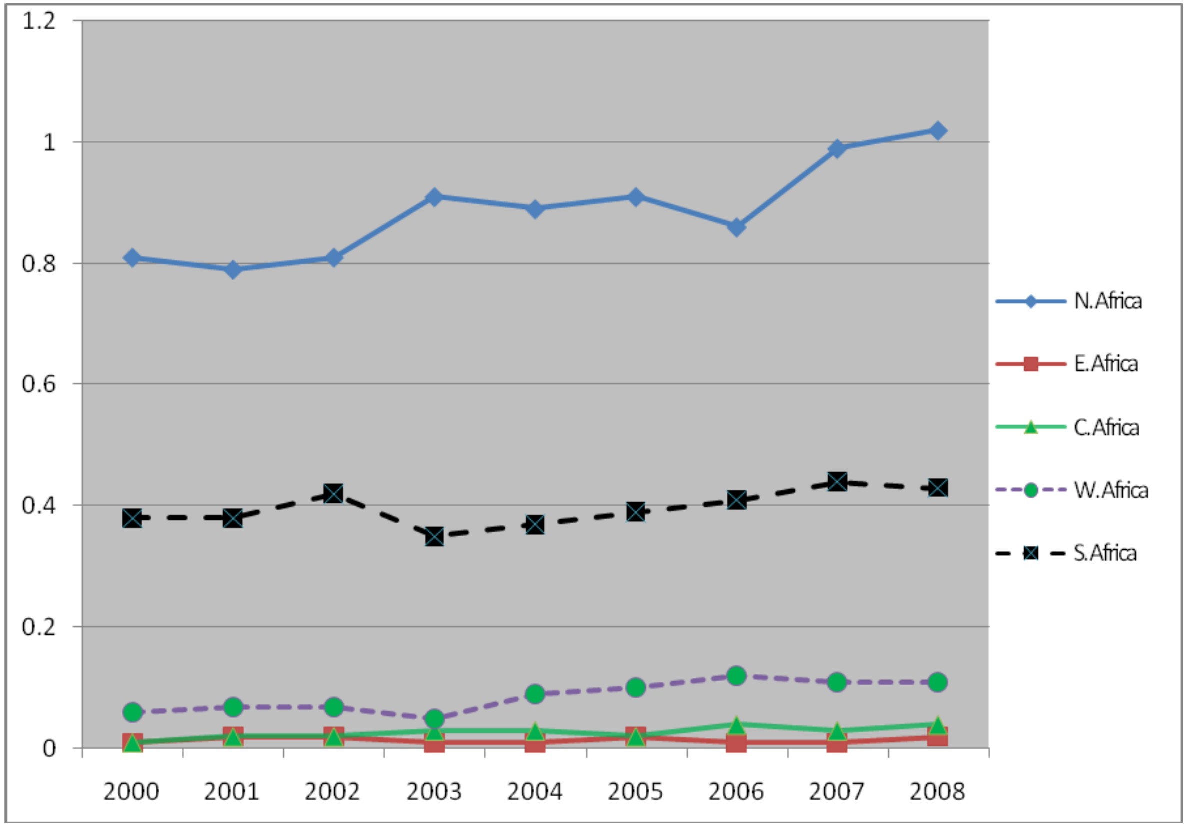

Figure 2. African region's share of total world mathematics publications, 2000−2008.

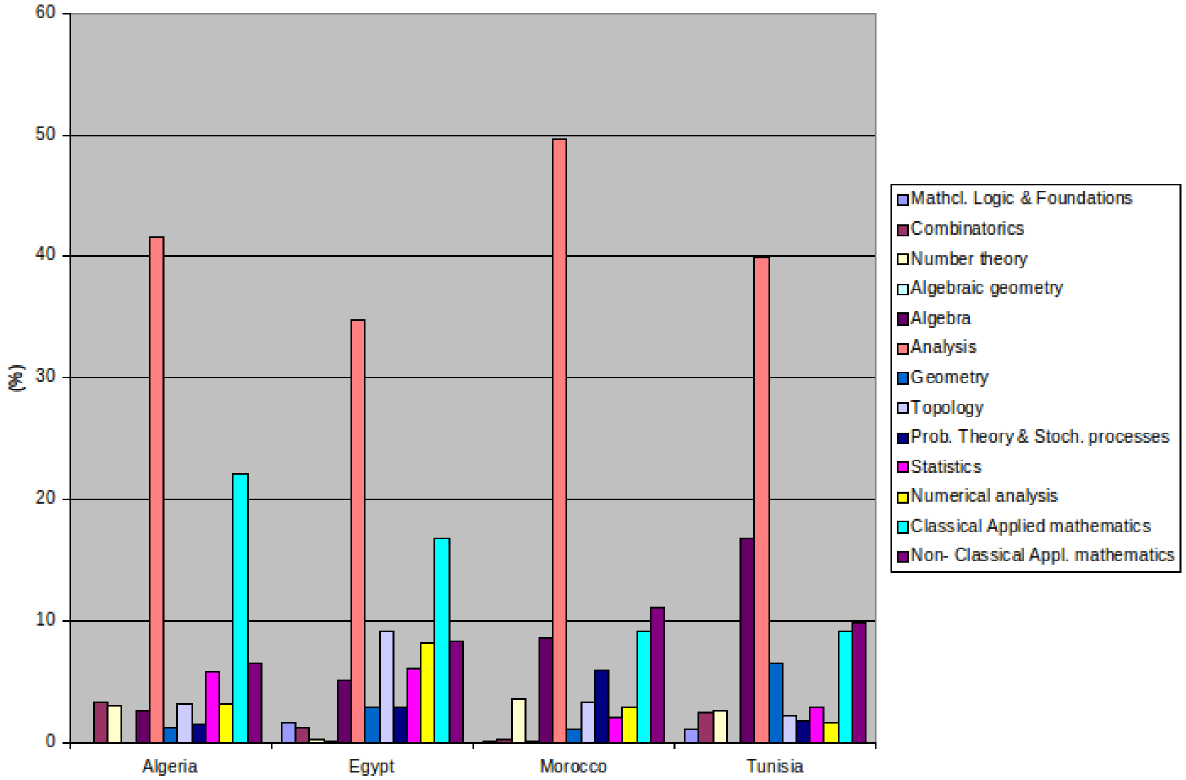

Figure 3. North Africa: The structure of mathematical research, 2000–2007.

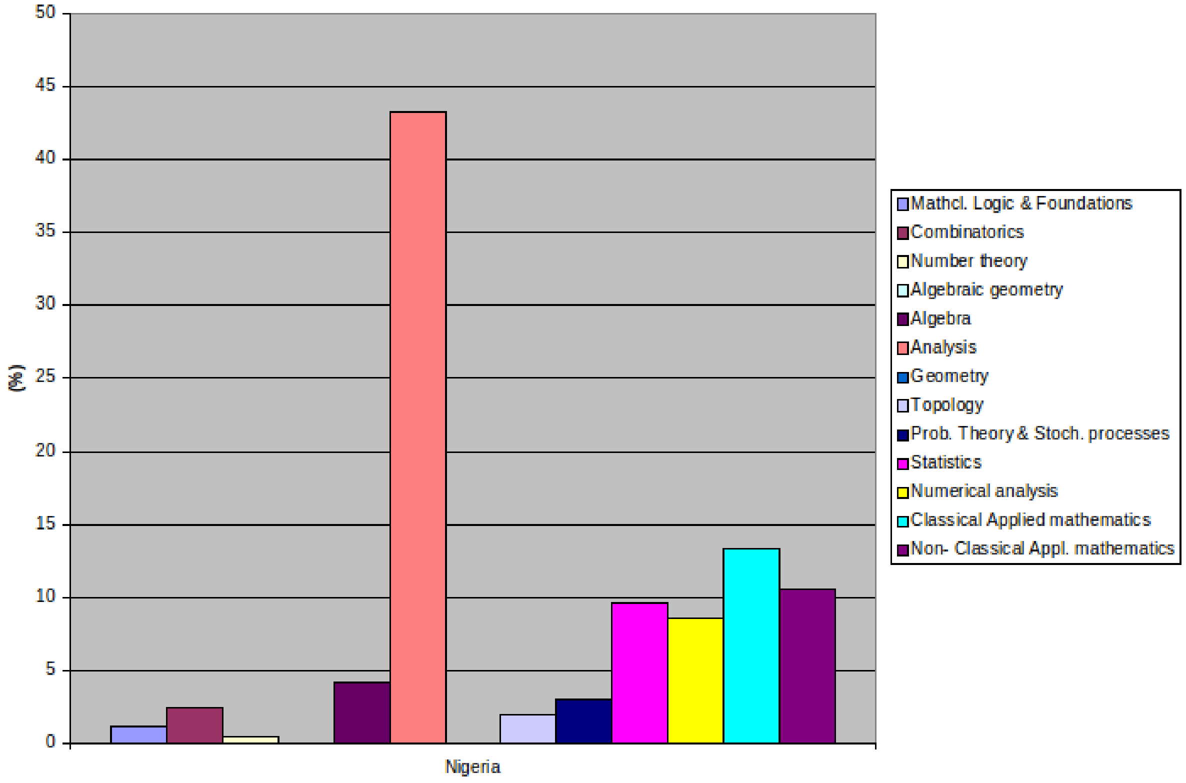

Figure 4. Nigeria: The structure of mathematical research, 2000–2007.

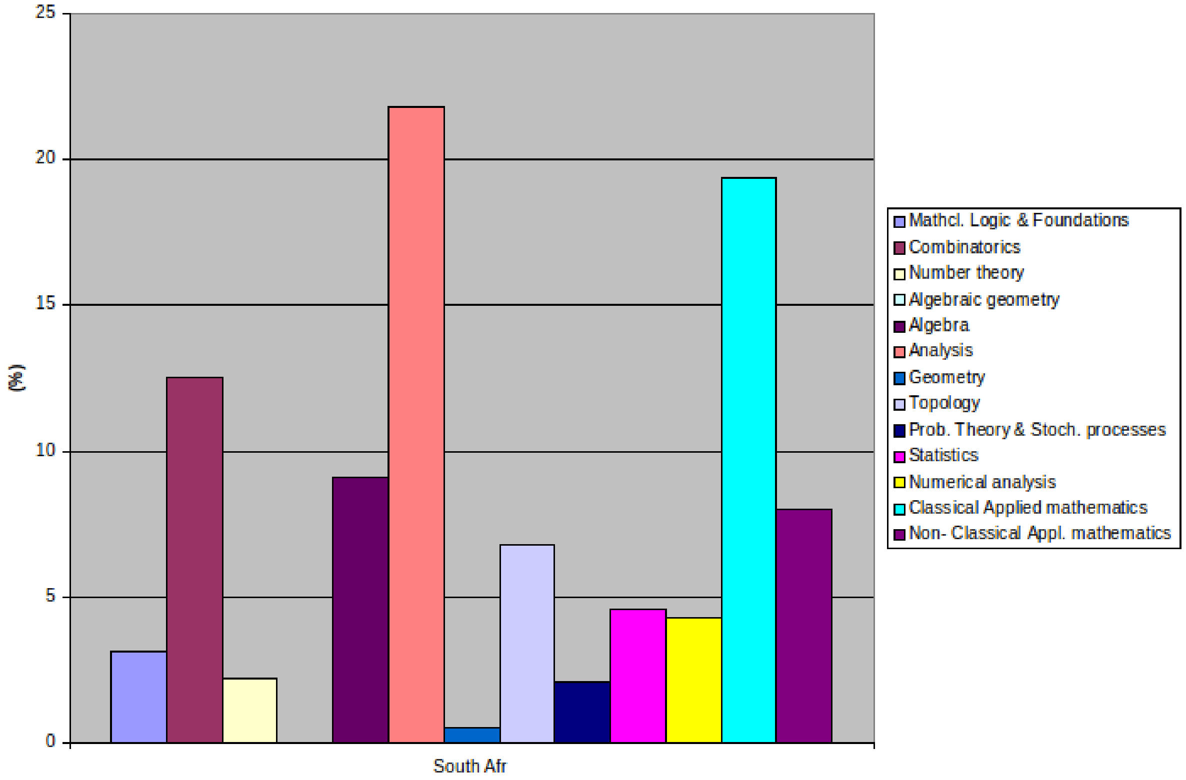

Figure 5. South Africa: The structure of mathematical research, 2000–2007.

Proposal for a new network on chemicals management in sub-Saharan Africa

Yogeshkumar S. Naik

1. Background

The economies of sub-Saharan countries are based primarily on agriculture and mining. Recently, however, they are increasingly also becoming engaged in export-dependent industrial activity. Imported items also contain a variety of known and sometimes unexpected contaminants such as that found in electronic waste and the newer nanoparticles. These anthropogenic activities inevitably lead to the release of various chemicals into the environment and many of these can be harmful not only to humans but also to ecosystems.

There is a need to monitor and evaluate the information related to environmental pollution in the region and the information needs to be shared with decision makers and appropriate policy makers and legislators.

There are several IPICS-supported networks that are involved peripherally in various aspects related to chemical pollution. However there is currently no network dedicated to the coordination and management of information on chemical pollutants in the region.

The author proposes that ISP should consider the introduction of a new interdisciplinary network that is dedicated to the management of information generation and dissemination and training on chemicals management.

2. Chemicals as pollutants

Table 1 shows the various chemical pollutants and their sources. It is clear that the various human activities can generate a wide variety of pollutants. Pesticides have been used widely in agriculture to increase crop yields but these can lead to deleterious effects when the pesticides reach water bodies and enter the non-target species. Metals, such as mercury used by small-scale gold miners and discarded into the terrestrial and aquatic ecosystems, can also cause toxicity or death in aquatic reservoirs.

Table 1. Various human activities and the chemicals they use or generate in sub-Saharan Africa.

Activity	*Chemical used/generated*
Agrochemicals	pesticides, plant regulators
Commercial	plastics, flame retardants
Domestic	toys, detergents, personal care products
Industrial	hydrocarbons, dioxins
Mining	Hg, Pb, Cd, Cr, etc.,

Potential chemicals pollutants include various organic compounds that are used (e.g., solvents, plastics and flame retardants) and generated by industry (aromatic hydrocarbons and dioxins). Domestic effluents are likely to contain a wide variety of personal care products that range from fragrances, oils and detergents. In addition, the importation of electronic goods ranging from computers to cell phones and audio visual items results in the influx of large amounts of complex waste matter. This waste will include both metals and organics which are potentially toxic if they are to be leached form the waste dumps/land fills where they accumulate.

3. Biological effects of pollutants

Chemicals are known to have a number of side effects as has been established from laboratory and human studies, although at times the effects on ecosystem health are unpredictable since little is known about the effects in non-target species in the environment. Such information is important and is slowly being provided by research studies, primarily in the Developed World but also from the Developing World.

Table 2 shows some of the effects caused by chemicals that are used in agriculture and industry as well as domestically. It is slowly emerging that the pollutants effects usually begin at the cellular level and the effects can then manifest themselves at the whole-organism and ecosystem levels. The effects would range from cancers and nerve inhibition to changes in behaviour. Changes in the endocrine system leading to imposex in fish have also been noted for pesticides and other plasticizers.

Table 2. Various effects of chemicals on plants and animals in the ecosystem.

Target/Effect	*Effect*
Biochemical/Cellular	
Enzymes	Inhibition, activation
DNA	Strand breaks
Membranes	Lipid peroxidation
Energy production	Inhibition
Photosynthesis	Inhibition
Physiological	
Endocrine	Mimic of natural hormones, e.g. thyroxine, oestrogens
Immunological	Immunotoxicity, Disrupted antibody production
Nervous transmission	Inhibition of electrical and neurochemical transmission
Reproductive	
Development	Retarded
Fecundity	Altered
Sex ratio	Altered
Population	
Biodiversity	Reduced
Numbers	Altered
Food webs	Unbalanced

4. Known and emerging chemicals issues

Most chemicals in use are known in terms of their chemistry. However, there may be little knowledge about its toxic effects. Chemicals already used in certain parts of the world and shown to be unfriendly have been banned but continue to be used in parts of Africa. Some of these chemicals have not previously been used in Africa and when they have, their arrival time and their quantities are also not known. This is due to insufficient training of the relevant personnel or due to communication and knowledge gaps.

In addition, there are classes of chemicals already in use whose toxic effects are only now becoming known. Issues related to such chemicals have been referred to as “Emerging Chemicals Issues.” Such chemicals may already be in Africa or may not have arrived in Africa. Still, with the globalization of the world’s economies they will be used in the coming years in sub-Saharan Africa.

Nanoparticle toxicology is not well understood and these are already in the environment through imported products. Several countries receive large quantities of near-end-of-life electronic goods that are "donated" to them. Such goods usually have short remaining lives and are soon discarded into landfills and other dumps. Such electronic goods contain metals as well as plasticizers and flame retardants, whose effects have already been highlighted above. Besides the human exposure to chemicals the threat to wildlife is also apparent. Through leachates, the toxins can travel further through underground into aquatic systems.

5. Existing interests

Fortunately there are several organizations that are already working on this issue at the global level. These include UNEP and their related activities such as SAICM (Strategic Approach to International Chemicals Management) which falls under the ICCM (International Conference on Chemicals Management).

Besides such international bodies there are also some scientific societies such as SETAC (Society of Environmental Toxicology and Chemistry) and the IPCP (International Panel on Chemical Pollution) that are also involved in awareness and research activity.

These interests are global and may not reach their intended targets within sub-Saharan countries due to communication or infrastructure constraints. Furthermore, the information may reach academic and related communities but not necessarily the legislative or policy-making authorities that also need the information.

6. Need for a network

The various known and unknown effects that chemicals may have on human and ecosystem health is becoming known. However, chemicals use will remain essential for the foreseeable future for sustainable development, particularly in Developing Countries. There is then the need to have a sound management of chemicals for sustainable development and the eradication of poverty and disease. This will ensure improved human and ecosystems health.

In order to achieve this goal, there is a need to generate information which is largely done by academic and scientific institutes. This information has to be shared with others, particularly the decision makers and policy arms of governments. The policy makers as well as those generating information need to be sufficiently informed and trained to generate and acquire information and facts based on which to make their decisions.

There is also very little cross talk between academia, government and industry and society at large. The information generated by academics does not find its way into practical solutions for problems facing a region. There is therefore insufficient regulation of the movement of chemicals between the region and the rest of the world on the one hand, and within the region on the other.

There is a need to coordinate these activities and share the information by a network that is dedicated to this task.

The *modus operandi* of the network and the composition of the board can be debated, but is best left to the potential donors. However, if the board is represented by the concerns and the interests of government and academia but without an input from industry then it is unlikely to meet its objectives.

7. Proposed activities and outputs

Although not exhaustive, the following is a list of issues that can be addressed: *Emerging chemicals issues*; *Exposure and risk assessment and risk communication*; *Effects of climate change on chemical distribution*; *Life cycle management of chemicals*; *Chemicals management legislation*. The issues can be addressed through several activities, which include the following:

i. Interdisciplinary training workshops/courses independently and/or jointly with other ISP projects;
ii. Support for training workshops/courses for young students and staff less than 30 years (ISP projects);
iii. Focused regional thematic symposia with various stakeholders (government/academia/NGOs);
iv. Preparation of monographs and course material for distribution;
v. Facilitate information exchange with networks;
vi. Stakeholder (policy makers/academics/etc.) workshops held regionally (Central, Eastern, South and West Africa).

It is expected that as a result of the networks activities, the following outputs will be realized for the sub-Saharan region.

- Trained and relevant young scientists and staff deployed for government policy/academia/NGOs;
- More crosstalk between academia and government;
- Information exchange between academia, societies and non-academic organizations;
- Literature generated/available for distribution;

- Informed and responsible decision makers deployed in academia, industry and government so as to have more relevant, appropriate and effective policies/legislation;
- Increased awareness of issues related to chemicals management in various sectors of society;
- Contribution to the aims and activities of UNEP and other related global activity.

8. Funding

While core activities can be supported from ISP funding, it should be possible to raise additional funding from various NGOs as well as from governmental bodies if there is sufficient lobbying carried out.

Yogi Naik has a PhD in biochemistry and is currently an Associate Professor in the Department of Environmental Health and Science in Bulawayo, Zimbabwe. His own research is now focused on environmental toxicology and chemistry. He is the immediate past president of the Society of Environmental Toxicology and Chemistry (SETAC), Africa Branch. He has held several other positions in international societies such as the Pan-African Environmental Mutagen Society (PAEMS).

Yogeshkumar Naik has also written an article in this volume on the SARBIO network, page 235.

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Centers of Excellence: Thailand's experience

Manat Pohmakotr

1. Introduction

The Center for Innovation in Chemistry is a consortium of thirteen universities, with Mahidol University, Thailand, as the lead university.

Our vision is to become a world-class center of excellence in chemistry for innovation.

Our primary missions are

- to foster high-quality research with high-quality publications;
- to create knowledge-based innovation;
- to produce high-quality human resources; and
- to bolster research collaboration with industry.

The three focus research areas are in Analytical Technology, Innovation in Bioactive Natural Products and Materials Science, and Nanotechnology. The highlights of industrial collaborations are with cosmeceutical, petroleum and analytical instruments industries. Our outstanding innovations are *Test-kit* for measuring trace elements in the environment, *Gasohol meter* for measuring quantity of ethanol in gasohol, cosmetic based on Thai natural products (Plaitanoids^{TM} and Lotusia^{TM}), and collaboration with petroleum industry. The mission and the strategic plan of the Center are dynamic and tuned to the needs of the country.

The excellence can only be achieved by the wholehearted devotion of all stakeholders, i.e., students, faculties and member universities, industrial partners and administrators. I am deeply grateful to all and looking forward to the continuing collaboration and an exciting period of developing chemical and pharmaceutical sciences research and innovation in support of national strategic goals.

2. Background

Strengthening science and technology capability of Thailand has been identified as one of the ways to increase the country's economic growth and sustainability. Centers of excellence (consortia) are parts of the Royal Thai Government's long-term investment plan on high-quality human resources development for enhancing international competitiveness. The program is administered by the S & T Postgraduate Education and Research Development Office (PERDO), the Commission on Higher Education (CHE), the Ministry of Education.

Phase I of *the Consortium of Postgraduate Education and Research Program in Chemistry* (PERCH) was funded by the Royal Thai Government with a loan from the Asian Development Bank (ADB) and government counterpart fund over the period of 1999–2006. The funding for Phase II of the program has been approved for the period of 2006–2010. A new name, *Center for Innovation in Chemistry* with the acronym PERCH-CIC, has been adopted to reflect the history, ongoing research and innovation activities.

PERDO and PERCH-CIC together with other Centers of Excellence have been institutionalized and transformed into an autonomous organization under CHE.

The number of member universities has been expanded from the original five members to thirteen universities, strategically located in different parts of the country, offering 27 postgraduate programs at MEd, MSc and PhD levels, with Mahidol University as the lead university.

Members of PERCH-CIC (2006–2010)

Lead University
Mahidol University, MU.

Consortium (Phase I)
Prince of Songkla University, PSU;
Chiang Mai University, CMU;
Khon Kaen University, KKU;
Kasetsart University, KU.

New Members (Phase II)
Burapha University, BUU;
Ramkhamkaen University, RU;
Mahasakharam University, MSU;
Lampang Rajabhat University, LPRU;
Suratthani Rajabhat University, SRU;
Naresuan University, NU;
Ubon Rachathani University, UBU;
Bansomdejchaopraya University, BSRU.

3. Vision

To become a world-class center of excellence in chemistry for innovation.

4. Mission

1. To strive for knowledge-based innovation;
2. To create high-quality collaborative research in various areas of chemical sciences, pharmaceutical sciences and related disciplines, particularly in bioactive natural products, instrumentation and analytical method development, chemical nanotechnology and catalysis;
3. To produce capable human resource needed in the government, education, research and private sectors in chemical sciences, pharmaceutical sciences and related disciplines;
4. To leapfrog research excellence by the establishment of funding for post-doctoral fellows;
5. To establish research collaboration and innovation with the industry.

5. Future Prospects

We are entering an exciting period of developing chemical and pharmaceutical sciences research in support of achieving national strategic goals.

1. The consortium will be a very strong foundation for development of chemical and pharmaceutical sciences in Thailand;
2. The linkage of research and innovation will be a cornerstone for enhancing national competitiveness;
3. It is anticipated that the center will be a regional hub for chemical and pharmaceutical sciences research. We are on the way to become the World Class Center of Excellence in Chemistry.

6. Activities

6.1. Research focuses

The strong research capability of the Center for Innovation in Chemistry continues to strengthen the foundation of the organization. The research direction is focused into three target areas.

Analytical Technology

Development of trace analysis; Quality analysis of the environment; Quality and safety control of food and agricultural products, especially in the food export industry, which will give the Thai exports competitive leverage in the world market—thereby increasing Thailand's competitiveness, which is consistent with the national strategic plans.

Innovation in bioactive natural products

Utilization of the national biodiversity for the development of new drugs and improvement of health and living quality of the public; Encouragement for new innovation in herbal medicine by supporting the development of herbal products, as well as products from microorganisms and marine resources; Investigations of bioactive substances in plants using chemical biology and organic synthesis techniques to pave the way for new specific drug targets and discoveries, which will serve domestic needs and promote the export industry.

Materials science and nanotechnology

Advancement in drug delivery, new materials and new polymers for medical and industrial applications; Development of novel catalysts and other compounds for alternative energy technologies such as bioenergy and solar energy, including cellulosic technology for bioethanol production, which will result in reduction of imported energy sources and enhance national energy security and sustainability.

6.2. Research for new knowledge in chemistry and pharmaceutical sciences

Many of the research projects aim to provide new knowledge in chemical sciences and related areas. The research outputs are continually published in international journals—a process that potentially leads to innovation development.

6.3. National and international collaborations

1. Effective collaborations among research groups in different focus areas are being carried out by the members of the partner universities. Inter-consortia research collaboration is also being undertaken.
2. Collaborations with Rajabhat Universities and Rajamangala Universities have been initiated and are being strengthened.

3. Research collaborations, including staff exchanges with prestigious universities in countries such as Australia, Switzerland, Germany, Belgium, Japan, Singapore, Taiwan, UK, and USA are ongoing. Additionally, education and research collaborations with the Greater Mekong Subregional Countries (GMS) have been established.

6.4. PERCH-CIC Congress series

The Congress series has become one of the milestone activities of the Center; it creates team spirit, allows researchers from the thirteen member universities to discuss and share their research results as well as their facilities and opportunities. The Congress has also become the most important international meeting in the chemical sciences in Thailand with the attendance of distinguished participants from abroad and from within Thailand. The general meeting at the conclusion of each Congress with the participation of staff, students and supporting personnel has been an extremely important forum for strategic planning of the Center.

6.5. Industrial linkages and outstanding innovation

1. Extensive collaborations with the National Innovation Agency (NIA) on product innovation and productive communication with the entrepreneurs;
2. Linkages with major companies such as the Siam Cement Group (SCG) and the Petroleum Authority of Thailand (PTT) are being developed. The existing ongoing collaborations with the Pollution Control Department, UNICEF, Bangkok High Lab Co., Ltd., Kovic Kate International (Thailand), International Laboratories, Corp. (ILC), and Metrohm Siam are being strengthened;
3. Four outstanding innovations, Plaitanoids™, Lotusia™, Field Test Kits and Siam Gasohol Kit, have been commercialized, while Gas Trap and Sensor on Chip (Microfluidic), Fluid Conductivity Meter and Flow-Based Analyzers including Lab-at-Valve Analyzer and Hydrodynamic Sequential Injection Analyzer are at the engineering stage.

7. Postgraduate education programs

○ = *MSc* or *MEd* = *Master of Science* or *Master of Education*;
● = *PhD*

Postgraduate program	MU	PSU	KKU	CMU	KU	BUU	RU	MSU	UBU	NU	LPRU	SRU	BSRU
Analytical Chemistry	●		○ ●	○ ●	○ ●	○							
Applied Chemistry							○ ●						
Applied Analytical and Inorganic Chemistry	○												
Biochemistry				○ ●	○ ●	○							
Biochemistry & Biochemical Technology				○ ●									
Chemistry		○ ●		○ ●				○ ●	○ ●	○ ●			○
Chemical Education	○ ●*	○	○					○			○	○	○
Chemical Physics	○ ●												
Cosmetic Sciences										○ ●			
Inorganic Chemistry	●		○ ●		○ ●	○							
Organic Chemistry	○ ●	○ ●	○ ●		○ ●	○							
Physical Chemistry	○ ●		○ ●			○							
Pharmaceutical Chemistry / Pharmaceutical Technology / Pharmacology				○ ●						○ ●			
Polymer Science and Technology	○ ●		○			○							

* Collaboration with the Institute for Innovative Learning.

8. Funding and Achievements

During phase I of the Program, total funding of 645 MTHB was allocated. A total of 310 MTHB has been approved for Phase II. Since the inception of the Program, the consortium has admitted 327 PhD and 1,091 MSc students, of which 107 PhD and 515 MSc students have graduated with an output of 593 international publications and 65 national publications, 24 patents and 5 innovative products. The academic staff consists of 242 persons; 220 international and 1,727 national conference papers have been presented. We have had 89 visiting academics and admitted 327 PhD students and 1,091 MSc students. We have had 3 postdoctoral fellows. More statistics is presented in the following tables.

International publications (2000−2009)

Field	*# of publications*
Innovation in bioactive natural products	199
Materials science and nanotechnology	198
Chemical education	3
Analytical technology	193
Total number of international publications	593

In addition to these, there have been 65 national publications.

Academic Staff

University	*# of employees*
MU	42
PSU	27
KKU	24
CMU	47
KU	11
BUU	22
RU	6
MSU	14
UBU	13
NU	20
LPRU	4
SRU	5
BSRU	7
Total	242

MSc graduate output

Field	*# of MScs*
Innovation in bioactive natural products	137
Materials science and nanotechnology	110
Analytical technology	268
Total number of MSc graduates	515

PhD graduate output

Field	*# of PhDs*
Innovation in bioactive natural products	30
Materials science and nanotechnology	20
Analytical technology	57
Total number of PhD graduates	107

Employment of MSc graduates

Sector	*# of employees*	*Percent*
University /Academic Institute	169	32.8
Government sector	65	12.6
Industrial / Privat sector	75	14.6
International organization	1	0.2
Freelance	15	2.9
Higher Education	142	27.6
Other	48	9.3
Total number of employees	515	100

Employment of PhD graduates

Sector	*# of employees*	*Percent*
University /Academic Institute	73	68.2
Government sector	9	8.4
International organization	7	6.5
Other	10	9.4
Total number of employees	107	100

Note: As of September 2009.

8.1. Intellectual Properties

Mahidol University

Professor Vichai Reutrakul

- Xanthone Compounds, their Preparation and Use as Medicament. 2001, International Patent No. EP 1 200 44 B1, WO2001/002408.

Professor Juwadee Shiowatana

- Method for Determination of Sulfide in Water. 2003, Application No. 085063;
- Gas Trapping Device for Chemical Analysis. 2005, Petty Patent No. 2052;
- Gas Trapping Device. 2006, Patent No. 19341.

Assistant Professor Duangjai Nacapricha

- Alcohol Analyzer for Petrol. 2006, Application No.0601003935;
- Simultaneous Process for Extraction and Detection by Using Automatic Analyzer. 2007, Application No. 0701002170.

Prince of Songkla University

Associate Professor Proespichaya Kanatharana

- Real-Time Electrochemical Sensor for Electrical Measurement. 2009, Application No. 0901000618.

Chiang Mai University

Associate Professor Prachya Kongtawelert

- Sesamin Inhibit Cartilage Degradation and Its Applications. 2009 (Petty pending).

Naresuan University

Associate Professor Jarupa Viyoch

- System and Method for Preparing a Controlled Release Preparation. 2008, International Application No. PCT/SG2008/00457;
- Thermosensitive Hydrogel of Blending Crab Chitosan/Starch for Controlled Release of Therapeutic Agents or Biomaterials. 2008, Application No. 0803000 087.

Kasetsart University

Assisant Professor Atchana Wongchaisuwat

- Composition of pH Sensitive Glass. 2006, Patent No. 19724.

Associate Professor Pakawadee Sutthivaiyakit

- Test Kit for Semiquantitative Analysis of Nickel Ion. 2007, Application No. 0701000663;
- Synthesis of Palladium Complexs of Pyridylazo Compounds for the Design and Development of Detector Tube for Rapid Detection of Arsenic. 2009, Application No. 0901000359.

Associate Professor Boonsong Kongkathip

- Inhibitors of Microtubule Polymerization and Its Utilization. 2008, International Application No. 2008-026621.

Associate Professor Ngampong Kongkathip

- Method of Qualitative Analysis of Borapet (*Tinospora crispa*) and the Test Kit for Qualitative Analysis of Borapet Using N-Formylnornuciferine as Marker. 2007, Application No. 0701002133;
- Method of Extracting N-Formylnornuciferine from Borapet (*Tinospora crispa*) and Active Cardiotonic Compounds. 2007, Application No. 0701002134;
- Method of Extracting N-Formylannonaine from Borapet (*Tinospora crispa*) and Active Cardiotonic Compounds. 2007, Application No. 0701002135;
- Method of Qualitative Analysis of Borapet (*Tinospora crispa*) and the Test Kit for Qualitative Analysis of Borapet Using N-Formylnornuciferine as Marker. 2007, Application No. 0701002136;
- Novel Antimalarial 1,4-Napthoquinone Aliphatic Esters Derivatives which Inhibit Plasmodium falciparum. 2007, Application No. 0701003412;
- Method to Stimulate Aroma Resin Production of Agarwood by Organic Compounds. 2007, Application No. 0701006251;
- Method to Stimulate Aroma Resin Production of Agarwood by Nontoxic Organic Compounds. 2007, Application No. 0701006252;
- Method to Stimulate Aroma Resin Production of Agarwood by Fungi and Organic Compounds. 2007, Application No. 0701006253;
- Use of the Mixture of Three Compounds Isolated from Borapet (*Tinospora crispa*) for Diabetic Treatment and Quality Control of Borapet as Adjunctive Drug for Diabetic Treatment. 2008, Application No. 081005093;
- Virus and Target Cell Interaction Inhibition. 2008, International Application No. PCT/SG2008/00456.

9. Track records: Innovation and awards

- "Plaitanoids" innovation of herbal product by Professor Vichai Reutrakul
    - Inventor Award 2005 from the National Research Council of Thailand;
    - National Innovation Award 2005 from the National Innovation Agency;
    - Top innovation granted by the National Innovation Agency (NIA) on national Thai herb project.

- "Lotusia" innovative cosmetic products by Professor Vichai Reutrakul
    - The winner: Saha Innovation Award 2005 from Saha Group;
    - National Innovation Award 2005 from the National Innovation Agency;
    - Top innovation granted by the National Innovation Agency (NIA) on national Thai herb project.
- Field test kits for water quality monitoring by Professor Juwadee Shiowatana
    - Projects granted by UNICEF;
    - Invention Award 2003 from the National Research Council of Thailand (Consolation Prize);
    - "Gas trapping device for field test kit determination of arsenic and ammonia."
- Siam Gasohol Kit (SG-Kit) and Gasohol Meter: Automatic instrument for mobile and laboratory measurement of ethanol in gasohol by Assistant Professor Duangjai Nacapricha
    - Thailand Innovation Awards 2006 (Second Prize in Physical and Biological Sciences and Consolation Prize in Business Plan).
- Research and development of capsaicin and its product by Associate Professor Sakchai Witthaya-areekul
    - Thailand Research Fund (TRF) Distinguished Research Project 2007
- FIA Honor Award for Science
    - Professor Kate Grudpan.
- FIA Award for Younger Researchers
    - Associate Professor Jaroon Jakmunee from the Japanese Association for Flow Injection Analysis (JAFIA).
- Multiple-unit floating drug delivery system based on gas formation technique by Associate Professor Srisagul Sungthongjeen
    - National Research Council of Thailand (NRCT) Research Award 2008.

- Passive sampler for volatile organic compounds (VOCs) in air by Associate Professor Proespichaya Kanatharana
    - Invention Award 2009 from the National Research Council of Thailand.
- Krisna (Agarwood): new method to stimulate aroma resin from agarwood by fungi and organic compounds by Associate Professor Ngampong Kongkathip
    - Invention Award 2009 from the National Research Council of Thailand.

Outstanding Scientist Award

- Professor Apichart Suksamrarn, 1998 (Organic Chemistry);
- Professor Kate Grudpan, 2001 (Analytical Chemistry).

Young Scientist Award

- Associate Professor Taweechai Amornsakchai, 2000 (Polymer Physics);
- Associate Professor Chakrit Sirisinha, 2001 (Polymer Physics);
- Associate Professor Palangpon Kongsaeree, 2003 (Organic Chemistry);
- Associate Professor Jaroon Jakmunee, 2003 (Chemistry);
- Assistant Professor Tienthong Thongpanchang, 2004 (Chemistry);
- Assistant Professor Yuthana Tantirungrotechai 2005 (Chemistry);
- Assistant Professor Apinpus Rujiwatra, 2006 (Chemistry);
- Assistant Professor Atitaya Siripinyanond, 2007 (Chemistry);
- Associate Professor Vinich Promarak, 2007 (Chemistry).

National Outstanding Researcher Award, The National Research Council Thailand

- Professor Kate Grudpan, 1999 (Chemistry and Pharmacy);
- Professor Apichart Suksamrarn, 2001 (Chemistry and Pharmacy);
- Professor Somsak Ruchirawat, 2004 (Chemistry and Pharmacy);
- Professor Vichai Reutrakul, 2005 (Chemistry and Pharmacy);
- Professor Manat Pohmakotr, 2008 (Chemistry and Pharmacy).

TRF Senior Research Scholar

- Professor Vichai Reutrakul, 1996, 2000 and 2003;
- Professor Somsak Ruchirawat, 1997 and 2001;
- Professor Apichart Suksamrarn, 1999 and 2002;
- Professor Kate Grudpan, 2001 and 2004;
- Professor Vatcharin Rukachaisirikul, 2008.

Strategic Scholarships for Frontier Research Network of Thailand's Commission on Higher Education (CHE-RES-RG)

- Professor Manat Pohmakotr, 2006 (Molecular Bioscience Research Group);
- Professor Kate Grudpan, 2006 (Research Group for Analytical Instrumentation Innovation for Better Quality of Life);
- Associate Professor Vinich Promarak, 2007 (Advanced Organic Materials and Devices Research Group).

Research Team Strengthening Grant, National Science and Technology Development Agency

- Professor Apichart Suksamrarn, 2004 (The Use of Chemistry and Biotechnology to Modify the Structures and Enhance the Biological Activities of Natural Products).

Selected Outstanding PERCH-CIC Graduates

- Assistant Professor Surat Laphookhieo: Young Scientist Award 2009 (Chemistry);
- Ms. Asiya Methar: Outstanding Oral Presentation Award (The Pure and Applied Chemistry International Conference; PACCON 2009);
- Dr. Chongdee Thammakhet: Young Chemist Program, 2007 (The 41th International Union of Pure and Applied Chemistry; IUPAC World Chemistry Congress); Young Scholar Award, 2005 (The International Congress on Pacific Basin Societies; PACIFICHEM 2005);
- Dr. Nuanlaor Ratanawimarnwong: Excellence Award, 2003 (The Ninth International Conference on Flow Analysis);
- Dr. Warakorn Limbut: Outstanding MSc Thesis, Year 2002 and Outstanding PhD Thesis, Year 2007;
- Ms. Jongjit Jantra: Outstanding MSc Thesis, Year 2003;
- Mr. Tapparut Lelasattarutkul: Outstanding PhD Thesis, Year 2003;
- Ms. Supaporn Dawan: Outstanding MSc Thesis, Year 2007;
- Ms. Areeporn Ontam: Outstanding MSc Thesis, Year 2008;

- Ms. Chompoonut Tianjiripipat: Outstanding MSc Thesis, Year 2008;
- Dr. Natthinee Anantachoke: Outstanding PhD Thesis, Year 2008;
- Dr. Chongdee Thammakhet: Outstanding PhD Thesis, Year 2009.

10. Major equipment and services

Mahidol University

Flow-Based Instrument;
X-Ray Fluorescence Spectrometer;
High Resolution Mass Spectrometer;
500 MHz NMR Spectrometer;
GC-MS;
CHN-Analyzer;
X-Ray Fluorescence;
LC-MS, LC/MS/MS;
Powder X-Ray Diffractometer;
Single Crystal X-Ray Diffractometer;
Circular Dichroism-Optical Rotatory Dispersion (CD-ORD);
EPR Spectrometer;
FT-IR Spectrometer.

Prince of Songkla University

Surface Plasmon Resonance Instrument;
500 MHz NMR Spectrometer;
300 MHz NMR Spectrometer;
GC-MS;
Single Crystal X-Ray Diffractometer.

Chaing Mai University

High Resolution Mass Spectrometer;
Flow-Based Instrument;
GC $\times$ GC;
LC-MS, LC/MS/MS.

Khon Kaen University

High Performance PC Cluster for Parallel Computing;
Flow-Based Instrument;
UV-VIS-NIR;
TG/DTA Lab System;

Kasetsart University

LC/MS/MS;
GC/MS;
Graphite Furnace Atomic Absorption Spectrometer;
Ion Chromatography.

11. Comments from the evaluations by Technical Advisor Group (TAG)

Professor Jim Swindall, Professor Alastair North and Professor Kenneth Seddon, Members of the Technical Advisor Group

Fifth Review, September 22–26, 2008

The 2008 Technical Advisor Group (TAG) review of PERCH-CIC demonstrated once again that the main original aims of the HEDP programme to 'achieve excellence in R & D with strong private industry collaboration and research and postgraduate education with strong commercial application' and to raise the performance of all the consortium partners is being fully met. The harmonious addition of eight new members of the consortium in Phase II, on the basis of complementarity, has been a truly remarkable achievement which augurs very well for the future.

The TAG was very impressed with the enthusiasm of the representatives of the new members and their obvious pleasure in being included in PERCH-CIC. This enthusiasm will maximize the benefit their universities as a whole gain from the Programme. This was something we observed had occurred in the original four junior partners of PERCH.

The TAG was delighted to hear details of the excellent overall progress that has been made in Phase II. Worthy of special note is the continued progress of liaison with and services for industry, especially in the Provinces, the launching of Lotusia and the Gasohol meter on the market, the number of publications in reputable international journals, the reduction in time MSc and PhD students take to graduate and the excellent publicity which PERCH-CIC continues to generate. The intention to reach out to nearby ASEAN Countries is highly commended.

A major strength of PERCH-CIC is the clear vision for the future and the excellent strategic plan in place to achieve this vision. However, part of the strategic plan included a funding line for a vital cadre of postdoctoral research fellows, and it is unfortunate that insufficient funding has been provided to fulfill this core requirement for a fundamental research based CoE, that is at an appropriate stage in development, such as PERCH-CIC.

In conclusion, PERCH-CIC has developed a momentum and a status that will ensure that it has a bright future. It is well on the way to becoming a World Class Center of Excellence in Chemistry, of great value to Thailand, and an exemplar for neighbouring countries.

12. Comments from the evaluations by Technical Expert Group (TEG)

Professor Jim Swindall and Professor Amilra Passana de Silva, Members of the Technical Expert Group

Fourth Review, September 7, 2005

The fourth TEG review of PERCH clearly demonstrated once again that the main aims of the HEDP programme to 'achieve excellence in R & D with strong private industry collaboration and postgraduate education and research with strong commercial application' and to raise the performance of all the consortium partners is being fully met.

The new chemistry being developed in PERCH is clear evidence of the innovative ethos in PERCH and we believe that this will continue to bring new products to market to build upon the excellent products that have already been developed. There is also clear evidence that this attention to the relevance to the commercial and societal needs of Thailand in the research carried out has been eagerly taken on board by the research staff in PERCH.

It is evident that the structure of PERCH is very well suited to achieve a major goal of the project, namely to use a lead university to work with a number of additional universities to bring them up to the standard of the lead university thereby improving the human resource capacity of Thailand.

The Summary of the Overall Evaluation of PERCH, 2000–2005

The TEG believes that the following features of PERCH have been the main success factors:

Strong leadership
Good management structure
Development of industry linkages
Good communication, both internal and external
Development of identity
Rigorous financial management
Goal setting
Harmony between the five groups
Willingness to attempt difficult tasks
Annual conference of everyone involved in the centre

Third Review, March 8–12, 2004

The third TEG review of PERCH demonstrated that the main aims of the HEDP programme to 'achieve excellence in R & D with strong private industry collaboration and postgraduate education and research with strong commercial application' and to raise the performance of all the consortium partners is being fully met.

PERCH has developed a momentum that will ensure that it has a bright future as a Centre of Excellence in Chemistry of great value to Thailand.

13. Comments on PERCH-CIC Congress VI (May 3–6, 2009)

Professor Berhanu M. Abegaz, University of Botswana, Botswana

The most striking and interesting aspect of the congress, and what indeed surprised me immensely, is the focus on young people and the wide opportunity it gave for scientific interaction between and among the international visitors and the students. The fact that the international visitors were encouraged and urged to listen to the presentations, ask questions and make suggestions; the provision of a large number of poster boards, and the two opportunities (during two days) made it possible for us to examine most, if not all of them. Students were very keen to explain what they were doing and also were eager to get our feedbacks. Both scientific contents and the preparations of the posters are of international standard.

Professor Mary Garson, The University of Queensland, Australia

The quality of the student presentations was exceptional; there were some very inventive PowerPoint displays, and some excellent talks. Each meeting, I have noticed increased scope and technical depth in the student presentations, and more confidence in answering scientific questions from overseas delegates. This ever-growing awareness of international standards in the chemical sciences, and the very high standard of training delivered to the students by the Thai academic mentors is a very significant outcome of the PERCH program.

Professor Chun-Chen Liao, Chung Yuan Christian University, Taiwan

The success of this Congress results from the fruitful achievements of the PERCH-CIC program. Education, especially the higher education, is of the most importance for the future developments of a country. The PERCH-CIC program was designed to upgrade the quality of university education and research in chemistry in Thailand. The reports and performance by the students and the contents of the oral and the poster presentations in the Congress reveal the outstanding success of the program, and the original goals of the program have been accomplished.

Professor István E. Markó, Université catholique de Louvain, Belgium

But, even more importantly, the quality of the science being presented has significantly increased. It has now definitely reached a state where we can easily say that the quality of the research performed by Thai students equals, and, sometimes, is even better than most sciences presented at international congress by other researchers worldwide. I have been particularly impressed to see, besides natural product extraction, bioassay and structure determination, some excellent synthetic methodology and some work clearly directed towards total synthesis. All the students understood and mastered their science.

Professor Peter H. Seeberger, Recipient of Tetrahedron Young Investigator Award 2010, Max-Planck Institute for Colloids and Surfaces, Potsdam, Germany

In my opinion PERCH is an impressive example of what can be done when the vision of individuals meets with the support, both financial and otherwise, of the government. PERCH is succeeding in producing a generation of strong chemists that will give Thailand the opportunity to establish industries currently not present in this country. The nation will receive dividends on this investment. While this dividend is paid with some delay as is typical, it will be bigger and more sustainable. I can only hope that the PERCH efforts will be continued to see substantial support in Thailand. PERCH can be a shining example for many countries including many in the industrialized western countries, where some seem to have forgotten that scientific progress is the basis for prosperity. Thailand has realized that and is catching up fast. Keep it up!

14. Comments on Previous PERCH Congresses

14.1. PERCH Congress III (May 9–12, 2004)

Professor Charles P. Casey, President of American Chemical Society, University of Wisconsin at Madison, USA

The importance of the annual PERCH Congress is a key to improving quality across all five institutions. I was impressed by the high quality of oral presentations from graduate students and young faculty. I was in Thailand five years ago and visited one or two PhD institutions. I had an impression that significant progress has been made in the past five years.

14.2. PERCH Congress IV (May 8–11, 2005)

Professor Soo-Ying Lee, Nanyang Technological University, Singapore

The PERCH Congress has provided a platform for both faculty and graduate students from across Thailand to showcase their outstanding research, to share their achievements, to forge collaboration, to spark new areas of research and, equally important, to make new friends. There was an excellent balance between the oral and poster presentations. Clearly, PERCH is making a difference and creating impact in chemical research in Thailand and the international community.

14.3. PERCH Congress V (May 6–9, 2007)

Professor Gary D. Christian, University of Washington, USA

I was impressed with the quality of students' research and their presentations, both oral and poster. I think there was an improvement even over the third PERCH Congress which I attended, and it is apparent that PERCH funding is paying off and having a big impact. The expansion of the number of participating universities will further impact chemical graduate training and research throughout Thailand.

Professor Christopher Hardacre, Queen's University, Belfast, Northern Ireland

Overall, the conference was a great success. The range of chemistry which is being performed in PERCH is wide ranging and varied and has a good balance of the main subject areas. The enthusiasm of the staff and students to talk science and discuss their results as well as question me about my work, outside the lecture theatre, was excellent and this has led to a number of potential collaborations in a number of areas in addition to the catalysis students we already have in Queen's. This interaction is invaluable for both myself and PERCH and has been made possible by the conference and encouragement from the management of PERCH.

Professor E. Peter Kündig, University of Geneva, Switzerland

Needless to say that your conference program was excellent and I enjoyed listening to and discussing research with Thai and foreign colleagues. But what made the days particularly memorable to me were the short presentations of Thai University students enrolled in Master or PhD programs. This impression was intensified in numerous discussions I had with this future generation of chemists in Thailand. The students were curious, eager, cheerful and well informed in the area of their research topic. In international comparison, the level was good, occasionally even outstanding. Investment in higher education in chemistry by establishing a program of innovation and excellence was timely and necessary for Thailand. Chemistry, with its links to material science, pharmacy and the earth and life sciences takes a central place in science, technology, and health. Chemistry is also of primary importance for the preservation of our environment. I am very impressed to see what has been achieved in the framework of the PERCH-CIC program.

Professor Paul Walton, University of York, UK

For me, the elements of a good conference are well-presented talks, good organization, active participation from the audience and lively discussion in between lectures and at poster sessions. PERCH-CIC certainly has all of these. I would particularly comment on the excellent organization. But, there's something extra to PERCH-CIC which makes it not just a good conference but an excellent one. The extra dimension is the fantastic involvement of your young people. To my mind, the massive positive that this conference offers is that it encourages and galvanizes your young minds to see the many possibilities of chemistry and science. It also equips those with a passion for research with the courage to continue on this path.

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Results-based management of basic research

John Mathiason

The issue of improving Regional and Interregional Cooperation to Strengthen Basic Sciences in Developing Countries is significant and can benefit from an application of the results-based management approaches being used by international organizations, bilateral development assistance agencies and many governments.

The discussions took place at a critical moment for scientific research in the world. Beyond what would have been considered a normal imperative for research, the world is on the verge of a significant imperative for implementing new basic scientific research as a precondition for addressing climate change.

As the 2009 World Economic and Social Survey says:

> The separation of the climate change and development agendas has distorted the global debate on the two biggest policy challenges facing the international community. According to the World Economic and Social Survey 2009, an integrated approach based on the concept of sustainable development is urgently needed. The key to such an approach is a low-carbon, high-growth transformation of the global economy—a transformation that can keep temperature increases consistent with environmental stability, as identified by the scientific community, while at the same time fostering the strong growth and economic diversification in developing countries that would allow convergence of incomes worldwide.

The 15th meeting of the Conference of Parties to the United Nations Framework Convention on Climate Change in Copenhagen this December will, hopefully, further expand the global regime for managing climate change. Both of its elements, adaptation and mitigation, will require an expansion of basic research in developing countries. Both adaptation and mitigation will have to be tailored to national and regional needs and conditions, and for this to happen, there needs to be a firm basis of research results. Moreover, the massive increase in funding for activities will require that the research results are built into the programs and projects that will be funded under existing instruments like the Global Environment Facility, the Adaptation Fund and new institutions that will be created.

As an indicator of both the problem and of the opportunity, the composition of the Intergovernmental Panel on Climate Change shows the extent to which researchers from developing countries are players in defining the issue. Table 1 shows the distribution of IPCC members in 2001 and 2007.

Table 1. Distribution of Participants in the Intergovernmental Panel on Climate Change by Country and Group.

	2001		
Country/Group	*Working Group 1 (scientific aspects)*	*Working Group 2 (adaption)*	*Working Group 3 (mitigation)*
US	39.6 %	38.9 %	27.9 %
Other JUSCANNZ	16.7 %	16.4 %	14.4 %
EU	33.5 %	23.9 %	26.1 %
Other developed	4.4 %	2.7 %	4.5 %
G-77	5.8 %	18.1 %	27.0 %
Total	771	586	222
	2007		
Country/Group	*Working Group 1 (scientific aspects)*	*Working Group 2 (adaption)*	*Working Group 3 (mitigation)*
US	33.4 %	16.0 %	22.0 %
Other JUSCANNZ	17.6 %	19.2 %	18.1 %
EU	34.1 %	31.2 %	27.0 %
Other developed	5.7 %	7.5 %	4.6 %
G-77	9.2 %	26.1 %	28.2 %
Total	619	375	259

Clearly, developing countries are not well represented in Working Group 1, which deals with scientific aspects, but are increasingly represented in Working Group 2, dealing with adaptation.

This is the context that results-based management (or RBM) should be seen. In the coming years, the need for research in basic sciences will increase exponentially, and the funding for this will be built into the climate change management institutions.

Ensuring that developing country scientists are able to avail themselves of this challenge and its resources, they will have to build projects and programs that are results-based. This approach has been used by international organizations and by bilateral development assistance organizations for some time, and will clearly be applied to assessing proposals for research. It follows that research universities will have to apply these concepts to their work.

RBM is an approach to program development, implementation and evaluation that is increasingly used by national governments level. It establishes the intended results of the project or program during the planning phase, and then uses that framework to guide and adjust implementation depending on whether they are being achieved. Evaluation or self-assessment is conducted using that same framework as the basis for determining what the project or program is achieving. It is increasingly used by national governments, bilateral development cooperation agencies, such as Sida, and international organizations.

While to an extent RBM has been promoted by funding organizations, for their own purpose of showing that the funds have been well spent, it should also be considered a major management tool. It can help ensure that the research enterprise is successful. It can also be used to increase the amount of funding for research.

The approach that will be described has been tested in the context of Sida-supported research in both networks and universities, where researchers have been able to show how their programs can utilize the approach.[1]

One way of looking at the RBM process is to see it as a circle. As Figure 1 shows, you start with *program planning* where you set out a vision for the program in response to a problem, define objectives and outcomes, set priorities and determine resource needs.

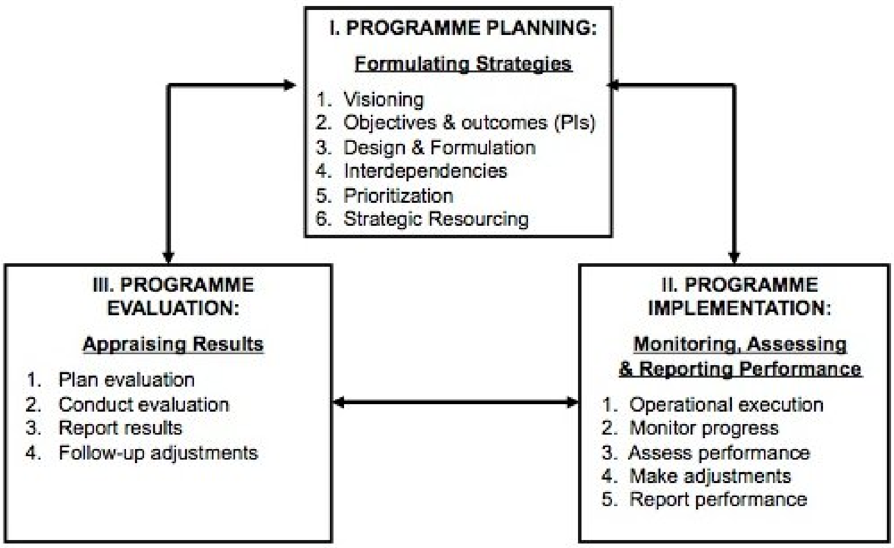

Figure 1. Results-based Management Process.

[1]Workshops have been conducted for networks and regional arrangements, including WIOMSA and Bio-Earn in Africa, and CSUCA in Latin America. They have been conducted for universities such as the Universidade Eduardo Mondlane, the National University of Rwanda, the Universidad Mayor de San Simon, the Universidad Mayor de San Andres, the four main universities in Nicaragua and the Universidad Nacional Autonomo de Honduras.

You then *implement* the program, including monitoring and reporting performance. This when most performance data can be collected as the programs or projects are implemented. The results can be evaluated and appraised and this information fed into the next round of planning. RBM includes an art of adjusting to reality.

We start with program planning first. It usually has to take place before final evaluation or self-assessment results are available, since it defines what you are measuring. The first stage of planning is to define the problem to solve.

Problems are typically multi-dimensional and the planner should sketch out the most relevant dimensions. A first step is to give the problem a name. This is harder than it would seem. If names are correct and to the point, they can both inspire and guide. For example, while the mission of the World Food Program is "to eradicate hunger in the world," the name for one problem it addresses is "emergency needs for food" in the context of natural disasters like the tsunami in 2004.

Many assistance organizations use a technique called a *Problem Tree* for problem analysis. It is conceptually simple: You work back from the problem to the various types of causes. The purpose of the tree is to isolate the specific causes that can be addressed by a program. Like most of these analytical tools, you have to start with the problem expressed in the broadest sense (e.g., poverty needs to be addressed) and then work out the conditions that explain the problem and that have to be addressed. Then you look at the specific conditions and then at the behavior that produces each condition. It is that behavior or systemic condition that can be influenced by actions.

Many planners, in examining problems and their causes, forget the time dimension. Most problems are long-term, not amenable to easy solution. Most programs, however, are time-limited, at least in terms of funding and management. In defining problems, the time-factor has to be built in.

As a final step, planners should determine whether the problems thus identified are susceptible to solution by what their program or project can produce, through research, networking or other activities.

Once this is done, results-based management planning can be done. In this, there are a series of concepts that are usually applied. These include the definition of a result, *the logical framework* as a tool and its component results, objectives, outcomes and output.

The OECD/DAC Glossary of Evaluation terms defines result as 'The output, outcome or impact (intended or unintended, positive and/or negative) of a development intervention.' As such it is a hierarchy of terms, starting with the achievement of objectives (impact), which is the result of obtaining desired outcomes which are induced by producing programd output. These are translated into what could be called the RBM logic, as shown in Figure 2.

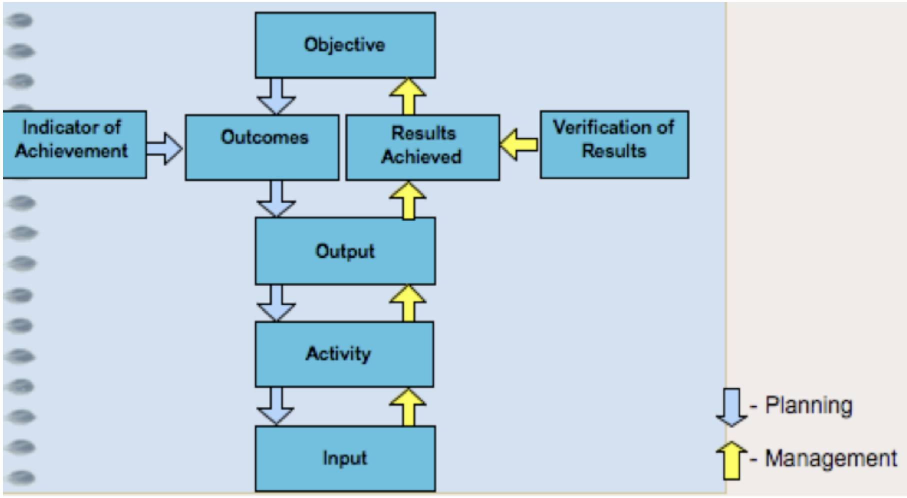

Figure 2. Results-based Management Logic. (Source: IAEA training.)

The idea is to plan from the future (specified by the objective) to the present, by determining the intermediate results that are needed and can be produced by the project or program's activities. Then, once implementation begins, you work from the present toward the future and, at the stage of evaluation, you show whether the results have been obtained.

For most international organizations, the tool used in planning is *the logical framework*. This tool has existed for forty years but has evolved over time. The main evolution is in the precision with which the elements of *the logframe* (as it is called) are defined. The current standard logframe being used in training in the context of Sida's support to research is shown in Table 2. With the exception of the column on outputs, it follows the standard used by most international organizations and bilateral development assistance organizations. The column on outputs has been added to enable testing whether expected outcomes can be clearly linked to the output of programs and projects.

Table 2. Structure of the Logical Framework.

Outputs	*Outcomes*	*Performance Indicator*	*Source of data*	*Means of obtaining data*	*Assumptions*
Specific Objective 1:					
	1.1				
	1.2				
	1.3				

The logic behind the logframe is that in determining how to achieve objectives, it is necessary to specify a hierarchy of results. This means that to achieve a specific objective, it is necessary to specify what must happen first (what are called outcomes) and then how to measure whether it has happened.

In filling out the logframe for research activities, experience has shown that there are different types of outcomes for what could be called an academic track and a non-academic track. In the academic track, these include

- Research results used by other academics;
- Research improves credibility of the university;
- Quality of education improves.

In the non-academic track, they may include that

- Research results used for policy;
- Research results applied by industry, government or local communities.

Another consideration that experience has found important is how to deal with a frequently expressed objective of "improving research capacity." The difficulty is determining how to measure whether capacity has been improved, since capacity is essentially a passive concept. A better approach is to measure capacity by its use. For example, this could include the connection of postgraduate education and use of thesis results, that networks increase inter-university cooperation and research is used by intended beneficiaries.

The preparation of a strategic plan using an RBM approach should be seen as making promises to the stakeholders about what will happen as a direct consequence of a program or projects. In making the promises, however, care needs to be exercised in drafting the text of objectives and outcomes. Both need to

- Specify an observable end-state;
- Be measurable (uses descriptive terms such as increase, eliminate, establish);
- Identify the time-frame, especially the end-point; and
- Identify explicitly or implicitly the end-user (who or what is supposed to change).

The idea of an end-state is critical. The text of an objective or outcome must describe the situation that should be observed. It is a snapshot of the future. It has to be clear and cannot be an activity. Many "objectives" presented use terms like "to promote" or "to assist," but these are not end-states (and could be achieved by sending a memo to promote something.)

The check on whether an end-state is useful is whether it is observable and therefore capable of being measured. Put another way, if you can't see it, how do you know that it is there? All of the descriptive terms in the objective should be observables. For example, "increase" and "eliminate" imply baselines that can show whether there has been a change over time. "Establish" or "create" means that you can see the organization or institution created.

If an objective is an end-state, you have to know *when* that situation is to be observed. All plans must have an intended point in time when the result should be observable. The point in time can be determined by programming cycles, established as a medium-term planning horizon, other times it is defined by the budgetary cycle. In the case of the United Nations and many countries, many programs set their endpoint at 2015, which is when the Millennium Development Goals are expected to be met. At least one set of objectives for the new climate change agreement will be 2020. Whether determined by programming considerations or by arbitrary determination, there must be a point in time when the end-state should be observed.

Finally, an objective or outcome statement must either directly indicate or at least have clearly in mind the intended beneficiary or target of the change being sought. Without this, it is impossible to measure whether the change happened. This can be particularly tricky for research, where the probable users are not always clear. Some of them can be other researchers, but they can also include the private sector, government offices, specific communities. An effort needs to be made, in drafting text, to think "who has to change or be affected" if the result is to be obtained.

While objectives are important, in that they define the destination that research seeks to reach, in strategic planning outcomes are more important, since they specify the intermediate results that must be obtained to reach the destination. Outcomes are defined by the OECD as 'The likely or achieved short-term and medium-term effects of an intervention's outputs.' In drafting outcomes, most authorities state that they should be "SMART," which is an acronym for Specific, Measurable, Achievable, Relevant and Timely.

Well-formulated outcomes describe, to stakeholders, what the program will do to achieve agreed objectives. They are about what program managers will be held accountable. For that reason,

- They have to be specific so that they can be linked to output;
- They also have to be expressed in observable, therefore measurable, terms since if they cannot be observed, it will not be possible to determine whether they have been accomplished;
- They have to be defined so that they can reasonably happen as a consequence of what is produced;

- They have to have a logical connection with achieving the objective if they are to be relevant;
- And finally, they need a clear time frame, since outcomes can be intermediate or longer-term and a focus more heavily on the intermediate outcomes is preferred.

Once the outcomes have been provisionally defined, the logframe requires that for each a performance indicator should be selected. Performance Indicators are the answer to a generic question: Did the outcome (change) happen? Put simply, they are what will be seen if the outcome happens and will help verify that progress is being made (or not). As such, they can be an early warning system for identifying problems. When defining performance indicators, a key question is: "How am I going to measure and collect data on it?" Part of the exercise of defining performance indicators is the reality check of determining where data can be acquired and how to acquire it.

The final check on outcomes is whether the output of the research can be expected to make it happen. Output can be a product, like a research report, or a service, as when researchers give advice or train other researchers. Each expected outcome needs to be looked at to see whether it can reasonably be induced by the output, and each output needs to be looked at to see what outcome it is expected to make happen. Table 3 shows some of these connections.

Table 3. Examples of the relationship of outcomes and output.

Outputs	Outcomes (Outside the project)
Products: Reports, guides, tools, data bases, analysis, products, technique Research report is ... New technique is ... Protocols are ...	 adopted, applied, implemented, used project products or services ... used by manufacturers ... adopted by farmers ... implemented by other parties
Services: Training, advice Training is ... Meeting participants ...	 ... used by trainees on the job ... agree to follow-up strategy

Once planning is complete, the next stage of result-based management is implementation. This consists of producing the output that is supposed to lead to the outcomes. However, part of the implementation process is also preparing to verify that the results have been obtained. During implementation, this means acquiring the information necessary for verification.

The verification process generally involves two dimensions:

1. Accountability—proving that you did what you said you would do;
2. Management—determining what data to collect and ensuring that the systems are in place to collect the necessary information on an ongoing basis.

When the expected outcome involves a change over time, care must be exercised to ensure that data can show change. More often than not this involves ensuring that baseline data exist. For new outcomes, the baseline may be zero, but for others it may have to be created. If no base-line data exists there are several ways to determine changes. One is to set up a quasi-experimental design (with a control group to suggest changes). Another is to find other ways to make comparisons. A third is to recognize that the results from the current period will provide a baseline for future assessments.

There are two key concepts used in verification—validity and reliability—that need to be applied throughout the process. Validity means that what is being measured is what is supposed to be measured. Reliability is ensuring that another researcher using the same data collection method would acquire the same data.

There are a number of data collection methods that can be used. The tools are now fairly standard. The idea is to select the tool that can extract the right information, at a reasonable cost and on time. The usual menu includes content analysis, use of existing statistical series, focus groups/interviews, surveys, field visits and case studies. To make data collection easier, the methods should be set up early, involve co-partners in collection process, and, most importantly, to build data collection into routine administrative processes. This last reduces cost.

The appraisal of performance should look for two things: what happened, and why. The first stage is determining what happened, by comparing the observed reality with the promises. Once that is determined the next step is to ask:

- Why did it happen?, or
- Why didn't it happen?

A key part of the exercise is to establish a causal relationship between the observed result and the output of the research program or project. This is often difficult, if only because the relationship can be indirect. One method is to use time as a factor: if the result happened after the output was delivered, the case can be made for causality. Another method is to use a paired comparison with a control group. If the result was observed where the output was delivered but not where it was not delivered, a causal relationship can be declared. There is always a concern that the result happened irrespective of the output, but careful analysis can help meet that concern.

In doing a self-assessment of results, as the final stage of using a RBM approach, experience has shown that a participatory approach is particularly useful. This is because the analysis can benefit from having people with different perspectives look at same data and see if they draw similar conclusions. There is a general value in diverse feedback. In addition, there are real advantages to involving those being evaluated since they are more likely to use conclusions and be committed to results if they have been part of the appraisal than if they have not.

The experience of one self-evaluation illustrates the value of both RBM and its self-assessment stage. In the self-assessment of the Sida/SAREC bilateral research cooperation program undertaken by the Universidade Eduardo Mondlane in Mozambique, one conclusion was that:

> The self-evaluation permitted a review, for the first time, of the use being made of research results from Sida/SAREC supported projects. While these had not always been systematically recorded, the evaluation permitted identification of a large number of instances where use of UEM research had led to policy changes, affected negotiations, permitted researchers to apply their work as part of panels, led to changes in practices as varied as building construction, water use, energy use and veterinary health. The evaluation concluded that this use is one of the most important results of achieving a critical mass of researchers.

This is a useful model for all programs seeking to extend and deepen basic research by ensuring that its products are used to address key issues for the countries concerned.

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LANBIO: Latin American Network for Research in Bioactive Natural Compounds: Past, Present and Future

Alejandra J. Troncoso and Hermann M. Niemeyer

LANBIO was founded in 1990 with the financial support of the International Program in the Chemical Sciences at Uppsala University (IPICS) and the encouragement of the International Foundation for Science (IFS). The main objectives behind the creation of LANBIO were to share resources, to stimulate collaborative and multidisciplinary research on indigenous natural resources and to provide training to promising young scientists in Latin America. Along its almost 19 years of life, LANBIO has applied different strategies to fulfill its mission of promoting natural product research in Latin America. At the start, LANBIO offered support to all affiliated groups in terms of contributions to urgently needed equipment repairs and spare parts, exchange of scientists, training fellowships and support to courses and meetings. However, this meant a huge dilution of efforts. Hence, it was decided to concentrate support in two areas which were receiving direct long-term support from IPICS: Neurochemistry (LANBIO-NC) led by Dr. Federico Dajas at the Clemente Estable Institute in Montevideo, Uruguay and Ecological Chemistry (LANBIO-EC) led by Dr. Hermann M. Niemeyer at the Laboratory of Chemical Ecology, University of Chile in Santiago, Chile.

The LANBIO-NC program had a strong research focus due to the comparatively high degree of development of the discipline in Latin America; thus, it emphasized collaborative research and international meetings and courses. On the other hand, Ecological Chemistry was at the time a discipline with a relatively poor degree of development in Latin America; hence, the emphasis of LANBIO-EC was mainly on training. Table 1 summarizes some performance parameters for both programs. Thus, while scientists participating in LANBIO-NC were able to produce several patents through collaborative research and as many as 10 international events were organized, LANBIO-EC emphasized longer-term training fellowships with a lower unit productivity. The fellowships programs at LANBIO-NC and LANBIO-EC are further characterized in Table 2.

Table 1. Main activities and achievements of LANBIO (1990−2008).

Activity	*LANBIO-NC*	*LANBIO-EC*
Patents	5	0
International courses	6	3
Meetings	4	3
Fellowship-months	238	390
Average fellowship (months)	5.8	13.4
Publications	39	34
Fellowship-months/publication	6.1	11.5

Table 2. Fellowships awarded by LANBIO-NC (Neurochemistry) and LANBIO-EC (Ecological Chemistry) programs. Above the double line upper middle income countries, and below it lower middle income countries (World Bank, 2008). Figures inside the bars correspond to average duration of fellowships. Numbers to the right of each bar correspond to total number of fellows.

	Neurochemistry		*Ecological Chemistry*	
Argentina	7.3	6	1.5	2
Brazil	3.5	5		
Chile	9.2	6		
Cuba	4.9	7		
Uruguay	5.5	6		
Venezuela			4	1
Bolivia	4.5	4	13.9	8
Colombia	7.5	2	13.9	4
Paraguay	3.2	2		
Peru	5.0	4	17.4	14

The outcome of LANBIO activities has been manifold: it has enriched research environments in the laboratories participating in LANBIO-NC program (principally Cuba, Peru, Argentina, Chile and Brazil) and has created new research groups under the LANBIO-EC program (Peru and Bolivia). Work by fellows has resulted in numerous presentations at meetings and publications in international peer-reviewed journals, several fellows have received grants from international organizations, particularly IFS and TWAS, and the international courses and meetings organized have had strong regional participation.

Additionally, LANBIO was of decisive importance in the creation of the inter-regional network, AFASSA, aiming at sharing resources and expertise among scientists in Africa, Asia and South America.

Training activities of LANBIO-EC were concentrated first in Peru (1990–2000) and later in Bolivia (2001 – present). In Peru, fellowships were directed mostly to graduates from Universidad Peruana Cayetano Heredia in Lima. Over a period of 10 years, a group of 14 fellows were trained in Santiago, most of whom are back to teaching and research positions in Lima. Collaborations established between former fellows have begun to yield results in the last couple of years.

In Bolivia, fellowships have been granted mostly to graduates from Universidad Mayor de San Simón (UMSS) in Cochabamba. The first aim was to choose a potential leader who could eventually create and lead a strong and sustainable research group at UMSS. After scouting among participants to international courses (chosen by open competition), Alejandra J. Troncoso was the candidate invited as a LANBIO fellow to Santiago. Very soon it became clear that the choice had been adequate and the fellow was provided with a range of opportunities for her development as scientist: advanced training in a local PhD program with a fellowship awarded by the Chilean government, a thesis project of her own choice and partly funded by the Chilean government, participation in meetings and international courses, short research visits abroad, organization of local and regional courses, supervision of younger LANBIO fellows in their research and participation in the selection of other students to become LANBIO fellows. After finishing graduate studies and returning to Cochabamba, plans are being drawn to provide support in the form of establishing research collaborations, training her students, jointly applying for international grants and establishing collaborative research programs in Chemical Ecology with the participation of two productive UMSS institutes: Centro de Biodiversidad y Genética (CBG) with expertise in Ecology and Biodiversity Conservation and Centro de Tecnologico Agroquímico (CTA), with expertise in Natural Products Chemistry. These activities, focused on a research area linking two disciplines—Ecology and Chemistry—which show promising degrees of development at UMSS, complement the vast capacity building program at UMSS with funding from Sida/SAREC.

Along its history, IPICS has targeted at increasing scientific development in less developed countries by providing long-term support to scientists and their associated research groups in order to develop local sustainable research environments, and also by creating regional networks to stimulate the transfer of knowledge and experience from those supported groups to less developed and promising groups in the region. The activities of LANBIO-EC have been in line with the IPICS philosophy. Thus, LANBIO-EC has provided long-term support to Peru and Bolivia through fellowship programs aimed at creating sustainable research environments and has disseminated the experience gained by an IPICS-supported laboratory within the region—a resource laboratory. LANBIO-EC has further created families of fellows with complementary research expertises and interests, with mutual trust and united under a common goal and developed new multidisciplinary research lines addressing basic science problems close to an applications environment.

Future actions of LANBIO-EC include the further development of the Chile-Bolivia collaboration in Ecological Chemistry with re-insertion fellowships, fellowships to train former fellows' disciples, and support to multidisciplinary courses leading to graduate programs at UMSS. It is expected that cooperation will evolve from a trainer-trainee relationship to one of collaborating colleagues (and hence jointly applying for collaborative research grants).

Alejandra J. Troncoso was trained as a biologist at the UMSS in Cochabamba, Bolivia, from 1996 to 2002. During her undergraduate studies she worked as a research assistant at the CBG and studied bird ecology in fragmented habitats for more than three years. Her new interest in the study of biological interactions made her apply for a LANBIO fellowship in 2002, which started only three days after her biology degree dissertation. Once at the LCE, she shifted from studying birds to studying the role of semiochemicals in host plant selection by aphids, which made her get interested in ecological chemistry. In 2005 she begun a PhD program in Ecology and Evolutionary Biology at the Universidad the Chile under the guidance of Professor Niemeyer and continued her ecological chemistry training. She is about to finish her PhD thesis; in the process she has guided the research work of three LANBIO fellows from Bolivia (C. Pinto, M. Córdoba and A. Lemaitre) in diverse ecological chemistry research themes. Once she obtains her PhD degree she plans to return to Bolivia and start the first Ecological Chemistry Laboratory in Bolivia centered at UMSS and sheltered by the Chile (LCE) − Bolivia (CBG-CTA) collaboration in Ecological Chemistry. For more information visit http://uchile.academia.edu/AlejandraTroncoso

Hermann M. Niemeyer received trained during his graduate and postgraduate studies in Physical Organic Chemistry and Theoretical Organic Chemistry, in the US and Sweden, respectively. After a period in which he devoted himself to theoretical studies of the reactivity of organic molecules, he shifted to experimental studies of the reactivity of molecules of natural origin. This led him seamlessly into the study of interactions between organisms—with emphasis on plants and insects—based on chemicals produced by the interacting species. This research, which had an important component of plant chemistry, led him to study the chemistry of native plants of Chile; in doing so, he has isolated and identified more than 200 compounds new to science and has conducted an extensive study of volatile chemicals emitted by native plants. Professor Niemeyer has recently expanded his interests to include the analysis of plants and biologically active chemicals used by pre-Hispanic populations of Chile. For a complete list of publications by Professor Niemeyer see http://abulafia.ciencias.uchile.cl

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The contributions of LATSOBIO to protein biotechnology: A short-time experience generating long-term potentials

Laura Franco Fraguas and Francisco Batista-Viera

The Latin American Network for Solid Phase Protein Biotechnology (the LATSOBIO network) was sponsored and financed by the International Program in Chemical Sciences (IPICS, Uppsala University, Sweden) during the period 2003–2007. The starting point of this network has been the consolidation of our research group in Uruguay as a *Resource group* in the region. The long-term general objectives of the network were: (i) to promote high-level education in the area of solid phase protein biotechnology; (ii) to contribute to the general scientific knowledge in this field; and (iii) to generate tools that can facilitate the transfer of these technologies to the industry and health centers.

The emphasis of these goals was focused on the development and strengthening of collaborative activities in Latin America and the main target countries for this purpose have been Bolivia, Colombia, Ecuador, Paraguay, and Perú.

Two main strategies were followed to accomplish these objectives: (i) the organization and promotion of postgraduate courses/workshops in countries of the region, and (ii) the encouragement of South-South exchange, providing research training stages for scientists and postgraduate students from Latin America, thus contributing to the formation of human resources.

Two different postgraduate courses have been organized and coordinated: one oriented towards *affinity techniques for the purification of biomolecules* (lectins, glycoproteins, enzymes), and the other oriented towards *enzyme immobilization techniques and their biotechnological applications*. Both courses include high content of laboratory exercises, thus supplying students with the necessary practical experience in solid-phase protein technology, to be applied later for basic research as well as applied science. Both courses are supported with *bibliographic material* prepared, organized and optimized by members of LATSOBIO (Franco Fraguas and Carlsson 1990, Ovsejevi and Manta 1996). Regional postgraduate courses have been organized in Quito (in cooperation with LANFOOD), Lima (two editions), Cochabamba, Asunción, and Montevideo.

The network has also provided fellowships to scientists from countries in the region to attend these postgraduate courses with priority given to postgraduate (MSc and PhD) students but also including young graduated researchers aiming to provide them with tools useful for their respective research projects. Students from Colombia, Ecuador, Perú and Bolivia have received training in our laboratory in Montevideo during different periods (between 1 and 3 months). In other cases, students from one country, Bolivia for instance, were encouraged (by a fellowship) to attend the course organized in Paraguay.

During the course held in Montevideo (November, 2007) a novel collaborative experience allowed us to fund the participation of one PhD student from Cuba (sponsored by the International Foundation for Science, IFS), and two young researchers from Burkina Faso (sponsored by IPICS through a support to African scientists in the biotechnology area).

During the very short period of existence of LATSOBIO, the outcome from all the network activities points out a high demand for training of young scientists from the biological sciences, in enzyme immobilization/stabilization strategies, as well as in novel protein purification techniques. These demands come both from countries of the region (Bolivia, Ecuador, Paraguay, Perú, Colombia) and from Uruguay. Particularly in our country, these courses are being considered as requirement for postgraduate degrees in Chemistry, Biochemistry and Pharmaceutical Chemistry at Facultad de Química, and they are also demanded by researchers from the Institut Pasteur de Montevideo.

One major milestone for the success of LATSOBIO as a regional program has been the previous long-term support of IPICS to the group (led by Professor Francisco Batista-Viera), which contributed: (i) to the consolidation of a PhD program in this area, through the theses of five of its members, allowing the formation of a solid research staff participating in the activities of the network; (ii) to develop the infrastructure of the research laboratory necessary to establish a regional training center; (iii) to attract young human resources, thus allowing the growth of the research group.

Another major milestone has been the support of the *Programa para el Desarrollo de las Ciencias Básicas* (PEDECIBA), a national program first financed by PNUD-UNESCO (since 1986) and presently by the government of Uruguay (www.pedeciba.edu.uy). This program has been internationally recognized for the original self-management with high participation of the researchers in the execution of the program. All present members of LATSOBIO are active researchers of the PEDECIBA.

The governmental policies in education in the last five years have also contributed in the consolidation of the LATSOBIO staff: the national government in Uruguay has substantially increased the budged in education and, in particular, in Science and Technology. The policy of the *Universidad de la República Oriental del Uruguay* (UdelaR, the public university) in the last ten years into the promotion of full-time dedications, has also contributed to potentiate the network: *all staff of LATSOBIO have permanent positions at the Biochemistry Department, Facultad de Química, most of them under full-time regime*.

Furthermore, all members of LATSOBIO have been awarded by the ANII (National Agency for Research and Innovation), in the status of active researchers of the National Researchers System. This is the National Organization that unites all of the Uruguayan scientific community, recently created and financed by the Government of Uruguay.

Moreover, the members of LATSOBIO are all participating in different collaborative programs with universities from South and North America and Europe, expanding to new research areas and applications.

We strongly consider that LATSOBIO network must continue, since all the proposed objectives are still in effect. This is a great challenge for both the members of the network and the potential supporting agencies. Based on the short and effective experience, the feasibility of success is promising, since the courses organized by LATSOBIO are ready to be developed in laboratories of Uruguay or other countries, and the network staff is ready to continue and expand these activities, once the network gets financial support. Moreover, to maintain LATSOBIO as an *active regional program* is mostly a matter for the financial agencies interested in contributing to the field of basic sciences.

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The other members of LATSOBIO are Karen Ovsejevi and Carmen Manta; their research field is biotechnological applications of cyclodextrins in the control of enzymatic activity; Cecilia Giacomini; her research field is enzymatic synthesis of galactosides with potential biological activity; Gabriela Irazoqui; research field covalent enzyme immobilization for biotechnological purposes; Beatriz Brena; research field bioanalytical methods for evaluation of environmental contamination.

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The Southern African Biochemistry, Molecular Biology and Biotechnology (SARBIO) Network: Challenges and the way forward

Yogeshkumar S. Naik

1. Background and significance

Many of the problems facing the region arise from, or are related to, agricultural and mining activity. Infectious and parasitic (HIV, HBV, malaria and schistosomiasis) and non-parasitic diseases (hypertension, cancers, etc.) are of significance in human populations. Diseases of livestock (trypanosomiasis, heartwater) and crops (viral) are also of regional importance. Approaches to understanding and even controlling such diseases requires the use of biochemical and molecular biological techniques. The need to improve crop yield also demands the need to use these approaches, e.g., in the study of gene flow and genetically modified organisms. In addition to crop production animal production also uses techniques of biotechnology (tissue culture) for improved yields and varieties.

Currently in sub-Saharan Africa there is a very limited capacity to conduct research on various aspects of importance to the region using the techniques of biochemistry and molecular biology or biotechnology. Due to the unavailability of relevant literature, as well as technology, research has been hampered on aspects of relevance (e.g., food production and disease control) to the region. There is a need to train the relevant young scientists as well as increase awareness amongst them on the various techniques that are available to carry out relevant research. There are very few centres of excellence or competence within the region in the area of biochemistry and molecular biology.

Another challenge faced by sub-Saharan countries is a resource base to attract good and dedicated postgraduate students. While many activities centre on postgraduate training, it is also important to have an awareness at a young age of the potentials of biochemistry and molecular biology.

Keywords: Gene manipulation, parasitic diseases, animal diseases, natural products, pollutants.

2. Past activities

For the reasons mentioned above, the Southern African Regional Cooperation in Biochemistry, Molecular Biology and Biotechnology, SARBIO, was created. Initially the activities involved exchange between labs within the Southern African region. Support was also provided to a limited number of conferences to allow for information exchange. Unsolicited applications for conference attendance were evaluated and supported if found to be deserving. Technicians were also trained through support for relevant regional workshops and training courses. The activities involved exchange within the Southern African region and occasionally between Southern and Eastern Africa.

Short term exchanges (less than two months) for postgraduate and postdoctoral scientists were also sponsored and beneficiaries have published several papers as a direct result of this support.

Collectively over one hundred post graduates and postdoctoral researchers have attended conferences and meetings with SARBIO support. The conferences include meetings of the Federation of African Societies of Biochemistry and Molecular Biology, the Pan African Environmental Mutagen Society, University of Zimbabwe – University of Limpopo Annual Research Day. In addition, five technicians have undergone training for professional development.

3. Recent activity

In the last two years the Board has been expanded to have representation not only from Southern Africa but to also include sub-Saharan Africa. The new members also bring with them a diversity of expertise in various areas of applied biochemistry and biotechnology.

A Board meeting has also been held where progress was reviewed and future activity was planned.

4. Constraints

Support from IPICS has been extremely useful for the various activities proposed by SARBIO over the years and has also usually been sufficient. Lack of efficient electronic communications has hampered progress to an extent. The web-page had been unavailable on a regular basis to prospective applicants.

Difficulties were also faced in trying to evaluate the impact of certain activities. While short-term exchanges could be evaluated easily in the form of outputs such as publications, it was difficult to measure the impact of conference support in many cases.

Most of these issues have been addressed. The electronic communications have improved and the web page is more accessible to applicants. Once it has been linked to the web pages of other (partner) organizations the visibility will be increased. Steps are being taken to have a better evaluation of the impact of conference support.

5. Aim and goals for the future

The aim of SARBIO will continue to be the provision of training for young scientists and to promote interaction between scientists within the region. In the next phase SARBIO will help to train postgraduate students and provide them with appropriate techniques in biochemistry molecular biology and biotechnology through arranging focused and thematic regional workshops. The network will also increase awareness about applied biochemistry and biotechnology amongst the "next generation" of biochemists and biotechnologists through early awareness in these areas of science.

At the end of the granting period there will also be almost 60 scientists that will have been trained in the region in state-of-the-art techniques of biomonitoring, bioinformatics, and biotechnology. The trainees will have come from different countries within the region and will therefore be able to disseminate the knowledge gained upon their return home. This will help develop competence in the specific fields of research that are of relevance to the region, i.e., pollution as well as data mining for application in agriculture, health and biotechnology research.

The training courses will also contribute to the improvement of submitted dissertations of the individual participants. Participants to the training courses will also informally interact with faculty (local and regional) and this will help to establish better networking amongst scientists in the future.

During the next phase, several high school teachers will be trained to increase awareness of the recent advances in applied biochemistry and biotechnology to young potential scientists. These students will be better prepared when they arrive at university to be recruited into undergraduate degree programmes so as to feed the post graduate programme as well.

6. Strategy and Plan

Annually one workshop will be conducted for 30 participants of which 15 will be sponsored by SARBIO and the others will be expected to provide their own funding.

The themes of the workshop will address the regional concerns and these are as follows.

- Biomonitoring: to impart techniques of monitoring water pollutants and their impacts on ecosystems;
- Bioinformatics: to train participants working on problems associated with human parasitic diseases as well as plant diseases on data mining and gathering information;
- Biotechnology: to impart techniques related to all aspects of biotechnology for basic and applied scientists.

Support for short-term exchanges will continue to be provided, but these will be restricted and monitored more closely than in the past. Support will also be provided to applicants who wish to attend courses that are not already offered by SARBIO. Technicians and post graduate students, in particular, will be supported. Annual workshops will be held in countries with IPICS-supported projects (Malawi, Tanzania, and Zimbabwe) for high school teachers. Literature generated for these workshops will be shared with others regionally.

7. Contacts and networking

The Board has been expanded to include five members who have varying expertise as well as their own networks of contacts regionally and internationally.

Two board members now serve on the Executive of the Federation of African Societies of Biochemistry and Molecular Biology (FASBMB) which should assist in expanding the network of contacts further. These contacts will be exploited when arranging workshops and also for the evaluation of applications and reports. Some of the contacts will also be invited to attend the workshops and contribute to the teaching with a view to enhancing the participant's own networks as well.

Recently, valuable collaborations have also been achieved with related IPICS networks (NAPRECA, AFASSA) and the International Foundation for Science in Sweden.

8. Expected financing

While the primary source of funding will come from SARBIO, it is expected that other sources of financing will be identified through SARBIO Board members as well as collaborators. Participants at workshops that are not sponsored by SARBIO will provide additional funds for support.

The salaries of the various board members will be provided by their respective universities. Facilities of the various training course facilitators will be provided from their own respective universities/institutes as well.

9. Expected outcome, impact and dissemination

At the end of the granting period it is expected that there will be more qualified high-school teachers in three different countries in the region. They will help to provide the next generation of biochemists and biotechnologists.

There will also be over fifty postgraduate students trained in some of the state-of-the-art technologies related to their research and these will have returned home to impart their knowledge to others.

There will be several young postgraduate students who will have the opportunity to travel to labs in the region to conduct research and establish new contacts. This latter activity would also likely result in research publications.

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Yogeshkumar S. Naik has also written an article on a proposal for a new network on chemicals management; see page 189. There is also a presentation of him on page 194.

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A regional network devoted to development in Africa: The West African Biotechnologies Network

Alfred S. Traore

Abstract. Since 2001, ten universities and two international institutions of training and research in West Africa decided to create a subregional network of training and research to support sustainable development in Africa. Thus the West-African Biotechnologies Network (*Réseau ouest-africain des Biotechnologies*, R.A.BIOTECH) was created. This network was indeed focused on biotechnologies, which, following the example of ICT, constitute a true scientific revolution in the beginning of this 21st century. The control of biotechnologies brings today most appropriate answers to the challenges of the African continent in its combat for a sustainable development. Through this network, training and research are thus organized to face the challenges below and from which Africa, more particularly West Africa, is suffering from:

- Problems underlying public health;
- Lack of the quantity and quality in the agricultural production;
- Lack of food technologies and processing;
- The insufficiency of the teaching staff, due to its weak renewal rate within the universities;
- The absence of a critical mass of researchers for the animation of the national research centres;
- Lack of hygiene and the low the nutritional value of food.

The network executes a modular teaching of Master level extending over two years. After the Master, three years of doctoral cycle training is organized and sanctioned by a PhD degree.

Three options of biotechnologies were identified like belonging to the priority bases for the development in West Africa in comparison with the challenges announced above:

- Microbial and cellular biotechnologies;
- Plant biotechnologies;
- Animal biotechnologies.

Every year, 25 to 30 students are recruited on the basis of excellence criteria. More than 50 % of the students are recorded in the option *Microbial and Cellular Biotechnologies*. These students originate in the majority from the countries of West and Central Africa. The research topics on the Master or PhD levels concentrate in the following fields.

- Characterization and use of biomolecules extracted from plants and intended for several uses (medical, industrial purposes);
- Valorization of the medicinal plants by the study of their oxidizing, pest-destroying and antimicrobial properties;
- Physiological and molecular characterization of the micro-organisms implicated in the food processing;
- Molecular characterization of the viruses of the AIDS: screening of bio molecules strengthening the immunity of the patients of the AIDS;
- Improvement of the plant production: study of the resistance of the plants to the drought; identification of the genotypes and varieties resistant to the infections of the predatory;
- Improvement of the livestock productions by genetic way;
- Production of food proteins, using micro-organisms and the algae;
- Bio fuels technology.

Since the creation of the network in 2001–2002, the teaching staff comes from the universities of several countries of the South (Benin, Burkina Faso, Côte d'Ivoire, Niger, Mali, Togo, Senegal, etc.) and of the North (Belgium, France). Thus until now, approximately 160 students have been trained at Master level and forty students at level PhD level. After they got their degrees these students are employed mainly in the universities as teachers-researchers, in the ministries for health and agriculture, in the national research centres, in the food industries and international organizations (UNICEF, WHO).

1. Introduction

Today, biotechnology in its multiple facets is essential as a very useful tool for the development, while bringing answers to the problems of hunger, health and with the maintenance of an environmental and ecological balance durable. In "Mosanto Imagine" one can read the following appreciation.

> biotechnology is a 21st century tool for the service of the consumers eager to combine abundance, quality, safety and taste, concerned farmers of productivity and profitability, governments and organizations which have the role of suppress the hunger in the world, to protect the environment and the biodiversity, to promote a healthy and sure food for all.

Mr. Hassan Adamu, former minister for Agriculture and the rural Development of Nigeria specified:

> From the million Africans, whose majority are the children, suffer from malnutrition and hunger. The biotechnology implemented to agriculture is a remedy for this suffering.

Mr. Jacques Diouf, Director of the United Nations for the food and agriculture (FAO) in one of his statements emphasized the importance of the role of biotechnologies in these terms:

> It is now largely recognized that we entered one era of green post-revolution and that in terms of output of the cultures, the conventional selection reached a ceiling. Biotechnologies and the genetic engineering could help to solve this problem by increasing the output to a significant degree.

In view of this report, the teachers and researchers of several universities of West Africa decided to create a subregional network of biotechnologies, under the name of *Réseau ouest-africain des Biotechnologies*, R.A.BIOTECH. This network, by setting up a regional doctoral school of the biotechnologies, approaches this field according to three fundamental directions:

- Microbial and cellular biotechnologies
- Plant biotechnologies
- Animal biotechnologies

In all Africa and in West Africa in particular, the strong increase in the population is accompanied by an explosion of the requirements in terms of food, nutrition and health. The agricultural resources of the developing countries of this area are limited. The food conservation and processing techniques are not optimal. The improvement of the quality of life of the populations allows them a greater participation in the development of demands and access to food safety. In particular, an improvement of the current technique used in the conservation and processing of agro-resources is essential in order to ensure the provision of food of good nutritional and medical quality.

Accordingly, R.A.BIOTECH proposed the professional training in biotechnologies, animated by the nationals of ten universities of West Africa in order to undertake industrial research and innovating projects, targeted on local problems. Very strong partnerships have been developed with several universities of the North.

2. Presentation of R.A.BIOTECH

R.A.BIOTECH was constituted on the basis of will expressed by several universities of West Africa to pool their means and human resources with a view to ensure a training of quality. Thus these universities intended to take an active part in the construction of the African countries and in the fighting against the large plagues which the populations experience daily.

2.1. Objectives of the Network

This network sets up as main lines of action the training and shared multi-field research in order to consolidate the general basis of socio-economic development of Africa, particularly West and Central Africa, by producing the human resources adapted to the challenges of development. To reach that point, it has the following specific aims.

- To educate professionals with high qualifications in Biotechnology (Master 2 and PhD);
- To strengthen the cooperation between academics for the search of excellence in higher education in Africa by supporting the mobility of the teachers and the students;
- To educate professionals to ensure renewal of the teaching staffs in the universities of the South which face several challenges daily, among which lack of a qualified teaching staff and insufficient quantity within the concerned universities;
- To contribute to the popularization of the results of appropriate research for the needs of the communities and the stakeholders;
- To contribute to the increase of the scientific role of Africa on the international chess-board by a reduction of the brain drain.

2.2. The creation of R.A.BIOTECH

The network held its constitutive assembly in 2002 at the Research Centre in Biological, Food and Nutritional Sciences (CRSBAN) of the University of Ouagadougou. The universities or other organizations of training and research below participated to the constitutive assembly:

1. University of Ouagadougou, hosting now the network (Burkina Faso);
2. Polytechnical University of Bobo-Dioulasso (Burkina Faso);
3. University of Lome (Togo);
4. Universities of Cocody and Abobo-Adjamé (Côte d'Ivoire);
5. University of Bamako (Mali);
6. University of Conakry (Guinée);
7. University of Abomey-Calavi, Cotonou (Benin);

8. University of Niamey (Niger);
9. CIRDES of Bobo-Dioulasso (Burkina Faso);
10. EISMV of Dakar (Senégal).

Following the creation of the network, nearly one hundred teachers of the South as well as of the North expressed their interest to take part in the activities of the network by sending their CV as potential lecturers.

2.3. Authorities of R.A.BIOTECH

The network functions thanks to several authorities on the basis of the statutes and rules of procedures, adopted by the General Assembly.

2.3.1. The Permanent Secretariat of R.A.BIOTECH

The Permanent Secretariat is elected by the General Assembly. Placed at the seat, it ensures the daily operation of the network. It includes:

- One president, general coordinator of the network;
- One permanent secretary;
- One associate permanent secretary;
- One financial manager.

2.3.2. Persons in charge of the teaching options

Persons in charge of the teaching options organize the managing staff of the students in the various options. We have three options of biotechnologies. Each option is on the responsibility of one professor:

- A person in charge of the option Microbial and Cellular Biotechnologies;
- A person in charge of the option Vegetable Biotechnologies;
- A person in charge of the option Animal Biotechnologies.

These three people are also placed at the hosting place of the network.

2.3.3. The International Scientific and Teaching Committee

R.A.BIOTECH is led by a committee called the *International Scientific and Teaching Committee* (ISTC). This committee coordinates and takes care of the execution of the work plan decided by the General Meeting of the network. It includes the following.

- One president;
- Three vice-presidents;
- One rapporteur.

Currently, the president is from the University of Ouagadougou (Burkina Faso), the three vice-presidents are respectively from the University of Lome (Togo), University of Bamako (Mali) and the University of Abobo-Adjamey (Côte d'Ivoire). The rapporteur is from the University of Abomey-Calavi (Benin).

2.3.4. National Directors of the focal points of R.A.BIOTECH

R.A.BIOTECH is represented in each country by a focal point, held by a national correspondent or director. These focal points are sheltered by the universities which are members of the network. The national correspondents ensure the promotion of the activities of R.A.BIOTECH in good coordination with the seat. To facilitate the communications and the contacts with the hosting country of the network, they are equipped with means of communication like computers, printers, faxes.

The representatives in the focal points are charged with:

- to disseminate information relating to the activities of the network in each country;
- to chair the local assemblies for the selection of candidates;
- to raise the accession with the network of the local and international researchers;
- to give to the possible candidates information relating to the conditions of recruitment.

Each university or structure, members of R.A.BIOTECH, proposes the correspondent of his focal point which is then confirmed by the ISTC.

3. Activities of R.A.BIOTECH

The principal activity of R.A.BIOTECH consists of the education by teaching and research of qualified professionals of high level which the states concerned need for their economies.

This is why it is held in two phases: a theoretical phase, consisting of lectures; and a phase of research in laboratory concerned with a set of themes considered to be significant for development.

3.1. The theoretical phase or lectures of Master of Biotechnologies

The programme of teaching in Masters of Biotechnologies was conceived by a multi-field team coming from the various universities-members of R.A.BIOTECH.

This program is regularly revised at the request of the International Scientific and Teaching Committee. It covers a 670 hour volume of annual courses thus distributed:

- Common courses to the three options of biotechnologies: 200 hours;
- Specific courses suitable for each of the three options of biotechnology;
- Microbial and Cellular Biotechnologies option: 160 hours;
- Plant Biotechnologies option: 150 hours;
- Animal Biotechnologies option: 160 hours.

Every year, about thirty high level teachers, regional or originating in the North, come to ensure the theoretical lectures over one period from three to four months.

3.2. The phase of research in laboratory

After the theoretical phase, the students are accommodated according to the topics chosen in the various laboratories, where the professors carry out their research tasks. The phase of research lasts approximately eight months.

The research topics in a laboratory with a view to drafting the report of Masters are proposed by the teaching staff taking part in the animation of the education. These topics are strongly inspired by the local problems, so that the results obtained can be used to support development. Indeed, they relate to the challenges to attain a sustainable development. These results consists, for this reason, of excellent data banks for the political decision makers during the execution of the national develpment plans.

Usually, the students having successfully obtained a master continue to the preparation of their PhD according to opportunities which are offered to them in terms of employment and grants.

4. Impact of R.A.BIOTECH on the socio-economic development of the countries of West and Central Africa

The impact of R.A.BIOTECH in the development is appreciable not only by the importance and the diversity of the sets of themes studied within the framework of its activities, but also by the number and quality of the human resources educated by the network.

4.1. Education of human resources

The students of R.A.BIOTECH are recruited on criteria of academic excellence. Each promotion includes on the average 25 to 30 students. Since the installation of R.A.BIOTECH until the academic year 2008-2009, eight generations of students could thus be recruited. The table on page 135 gives their distribution according to country, gender and option.

Over the period considered, the following indicators of performance were recorded:

- Rate of abandonment or failure before obtaining a Master: 14/200 = 7 %. It concerns especially students who for lack of financial support preferred to stop their education;
- Rate of abandonment after obtaining Master: 3/200 = 1,5 %. That means that approximately 98 % of the students who succeed in Master 2 continue in the preparation of their PhD;
- In 8 years of operation, R.A.BIOTECH injected into the development more 100 qualified persons in the field of biotechnologies, the remainder of the students still continuing the preparation of their Masters or PhD;
- 75 % of the students are directed to the option *Microbial and Cellular Biotechnologies*. The problems approached by this option cover a very wide field: energy, problems of public health (fight against the VIH, malaria, etc.), safeguard of the environment, quality of food and nutrition, etc.;
- 57 % of the students of R.A.BIOTECH are local. That is explained of course by the conditions of reception of these students in terms of inscription and lodging, because the local students benefit from better condition than foreign ones;
- Approximately 43 % of the students come from another country than Burkina Faso. It is the mark of the regional character of our regional doctoral school of biotechnologies. Otherwise, in general the rate from abroad in our universities does not exceed 5 to 10 % of the total enrollment of students;
- 32 % of the students of R.A.BIOTECH are female. That is remarkable, because in general, in the scientific disciplines, on the levels Masters and PhD, the participation of women still remain weak in the majority of the universities of West Africa, which count a rate of women in the teaching staff of about 10 %.

4.2. Sectors of development where graduates from R.A.BIOTECH find jobs

The students graduating from of R.A.BIOTECH find themselves in several fields of development:

- Public health, as responsible of the research laboratories in public health public;
- The agro-sylvo-pastoral sector, for an improvement of the agricultural, plant and animal production;
- Food and nutrition, for an improvement of the hygienic quality of food on the level of the households and food industries;
- Universities and the national centres of research which profit today from the contribution of the formations of R.A.BIOTECH for a renovation of their teaching staffs and research;
- NGOs, international non-governmental organizations (UNICEF, WHO, FAO, etc.) In addition to its participation in the development through the formation of human resources, R.A.BIOTECH delivers a great number of scientific publications on the research and development. This repertory is available for the actors of development and for the international community.

5. Conclusion

Through the quality of the human resources that it trains, R.A.BIOTECH proves to be an effective instrument of regional cooperation. The immense majority of the students come from West and Central Africa. None of the universities of Africa in this subregion would be able to educate alone so many students in such a short time and in disciplines lately introduced into these universities, like biotechnology. But this cooperation requires materials and financial means that the beneficiary countries cannot provide without the assistance of the international community. This is the place to greet the World Bank, which allowed the installation of this network. The Francophone Agency of Universities (FAU), the West African Economic and Monetary Union (UEMOA) and the International Science Programme ISP/IPICS (Sweden) supported the costs of functioning of R.A.BIOTECH since its creation. With the support of the university partners of the North, a teaching quality has been reinforced in the South with the profit of students locally. Such an operative organization limits the loss of professionals qualified for the African economy.

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Alfred S. Traore has also written an article on difficulties on regional cooperation; see page 127, followed by a presentation of him on page 137.

The Eastern African Universities Mathematics Programme: Origin, operation, achievements, and the future

John M. Mango

Abstract. We describe the Eastern African Universities Mathematics Programme; present its origin and scope of operation, objectives, coordination structure, activities, achievements, challenges, and desires for the future.

1. Introduction

In June 1995, Sida/SAREC and Uppsala University organized a Conference on *Donor support to development oriented research in Basic Sciences*. This took place in Uppsala, Sweden. In March 1999 a conference in Arusha, Tanzania on *Basic Sciences* was organized by ISP. In 2001 ISP with the Sida/SAREC sponsorship organized the first *International conference in Mathematics in Africa south of Sahara*. This took place in Tanzania. During this conference, the poor state of mathematics in the Eastern African region was noted. This gave birth to the Eastern African Universities Mathematics Programme, EAUMP, in 2002.

The key people who participated in the initial ideas to start this network in 2001/2002 were:

Dr. Leif Abrahamson, Uppsala University in Sweden;
Dr. C. Baruka Alphonce, University of Dar es-Salaam;
Professor V. Masanja, University of Dar es-Salaam;
Professor John W. Odhiambo, University of Nairobi;
Professor Wandera Ogana, University of Nairobi;
Dr. Vincent Ssembatya, Makerere University;
Professor Livingstone Luboobi, Makerere University;
Dr. F. Nabugoomu, Makerere University.

2. Objectives of the network

- Enhancement of postgraduate training with special emphasis on PhD training;
- Establishing and strengthening collaborative research in Mathematics;

- Strengthening the collaborating Mathematics departments;
- Development of resources for the collaborating Mathematics Departments.

3. Membership of the network

- University of Dar es-Saalam, Tanzania;
- Makerere University, Uganda;
- University of Nairobi, Kenya;
- National University of Rwanda (NUR) and Kigali Institute of Science and Technology (KIST), joined in August 2008;
- University of Zambia joined in April 2009.

Dr. Leif Abrahamsson is the Director of the *International Programme in the Mathematical Sciences*, IPMS, at the at the *International Science Programme*, ISP, in Uppsala, Sweden.

The Coordinating Centre of EAUMP is at Makerere University, Uganda, with Overall Coordinator John Mango.

4. Funding of the network

- The EAUMP network is sponsored by the International Science Programme (ISP), based at Uppsala University, Sweden. On the average, ISP funds EAUMP activities to a tune of about 1.3 MSEK (approximately 150,000 USD) per year;
- The network has also secured significant funding from ICTP in Italy. However, in the recent past, we have been getting on the average 10,000–15,000 EUR per year;
- Other notable sponsors are IMU, CDC, LMS, and AMMSI;
- The other sources of sponsorship are the local universities. However, this is basically in terms of infrastructure.

5. Network activities

- Capacity building through PhD and MSc training in Mathematics;
- Regional schools/conferences for graduate students and researchers/ lecturers;
- Research projects;
- Acquisition of books and journals;
- Staff exchange in the region;
- Research visits by cooperating scientists.

6. Major Achievements of the Network since 2002

- PhD training (4 completed and 11 ongoing);
- MSc training (more than 30 have benefited);
- Staff exchange in the region;
- Visits by Cooperating Scientists;
- Equipment;
- Books and Journals;
- Publications;
- Conferences/Workshops/Schools.

7. Challenges

- Low funding;
- Insufficient local manpower;
- Understaffing in Departments of member universities;
- Low interest of PhD students in Pure Mathematics.

8. Why the need to continue funding EAUMP Network?

The poor state of mathematics in the region, now improved by ISP intervention. This state needs to be improved further.

There is great need for more capacity building in the member Departments through PhD and MSc training. This is also one of the NEPAD strategies on Human Resources Development for Africa. Time has come to expand this Network to other universities in the region. There are smaller universities in the region where capacity building is of urgent need.

We need to use the Network to help reduce the problem of brain drain. This is in line with the NEPAD document on Human Resources Development for Africa. From the experience we now have, students who register in their local universities for their graduate training under the sandwich mode, tend to settle, teach/work in their local/regional Universities.

We need to continue developing capacity in the areas of Algebra, Geometry, Combinatorics, Analysis, etc.

There is need for continued collaboration of the region with the International Science Programme (ISP), the New Partnership for Africa's Development (NEPAD), the London Mathematical Society (LMS), and the International Centre for Theoretical Physics (ICTP).

We need to continue sharing human resource in graduate training in Mathematics where the region is most disadvantaged.

Ongoing Postgraduate students (MSc and PhD) need support.

Postdoctoral research requirement. We need our PhD products to carry on Postdoctoral research with their PhD advisers.

EAUMP conference. After all these achievements we plan to organize a big conference where our students, staff and people outside the region will gather to share their research experiences through paper presentations. We need continued funding to support such a conference.

Joint MSc and PhD programmes. After this length of time for this regional cooperation, it has been felt necessary that the region needs to run joint programmes at graduate level (MSc and PhD). We need funding for this important activity.

After about 8 years of regional cooperation by the member Departments under the sponsorship of ISP, the Network has decided that in the future operation; we will start a journal of mathematics for Eastern Africa. This will be key in the dissemination of research findings in mathematics in the region.

We are now set to start inter-network cooperation.

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John M. Mango was born in 1966 in Uganda, obtained a PhD Degree in Mathematics (Numerical Analysis) in 2001. He is a Deputy Dean, Academic Affairs, Faculty of Science, Makerere University, Uganda. He headed the Department of Mathematics, Makerere University from March 2006 to Jan 2009. He is also a Senior Lecturer in the same department. He has been lecturing at university level for the last 17 years. He is the Overall Coordinator of the Eastern African Universities Mathematics Programme, which is sponsored by the International Science Programme (ISP) is Sweden. He has also had other international assignments with the World Bank, UNESCO as reviewer, and others. He is a member of the AMI-Net Council, Cape Town in South Africa, representing Eastern Africa. He was appointed by the World Bank and served as coordinator for Mathematics on the World Bank pilot stage of the African Virtual University (AVU) project 1998−1999. His current research area in mathematics is in numerical partial differential equations.

Genesis of a new network: African Materials Science and Engineering Network (AMSEN)

Lesley A. Cornish, Frank P. L. Kavishe, and Tanya Capecchi

Abstract. In 2008, the DST/NRF Centre of Excellence in Strong Materials (CoE-SM) was part of a successful consortium selected for funding as a Carnegie-IAS Regional Initiative in Science and Education (RISE) network to run for an initial 2.5 years. The aims of the Carnegie-RISE networks are to develop and retain Faculty Members through research and collaboration. The network was initiated as the African Materials Science and Engineering Network (AMSEN), and the nodes are: CoE-SM, which is hosted by the University of the Witwatersrand (Wits), South Africa; the University of Nairobi, Kenya; the University of Namibia, Namibia; the Federal University of Technology, Akure, (FUTA), Nigeria; and the University of Botswana, Botswana. As well as the plans for AMSEN, the success of the award is attributed to the success of the CoE-SM. In the five years that the CoE-SM has existed, over 90 postgraduate students have been involved, 152 papers published, 11 patents granted and a new and successful group was established. There have been students from 19 different countries, mainly from Africa.

Although building on the same success, AMSEN is judged differently. AMSEN is extending areas where research is sustained into other nodes. AMSEN students have access to extra courses given at their universities. Research teams have been established, where at least two nodes (preferably more) participate in a Research Team. As well as supervising postgraduate students, the purpose of the Research Teams is to mentor younger and less experienced staff, and enable them to access equipment which is not available at their home university. A high proportion of the students are expected to become Faculty Members after the completion of their higher degrees. Fifteen higher degrees are expected to be nearly complete within the 2.5 years of funding, and to enable this, four students were sought for each node. Most of these students are already in place, although certain nodes had difficulty enrolling suitable students.

AMSEN is only in its first year, but 18 out of 20 targeted students are already in place. One of the remaining students has been identified and will be enrolled soon, and the last student is yet to be identified. Most of the students at all the nodes have presented their proposals, attended courses and at least five students have submitted abstracts for one of two conferences in December 2009. An AMSEN Workshop is planned for January 2010.

1. Background

The DST/NRF Centre of Excellence in Strong Materials (CoE-SM) was established in 2004 after a call for Centres of Excellence in South Africa from the (government) Department of Science and Technology through the National Research Foundation (NRF), and became one of six, and later seven, such centres. The Centres had to be virtual centres, involving several institutions, based on a major discipline. The theme of Strong Materials is the development of applied materials that need good mechanical properties, usually in aggressive environments, such as: temperature extremes, high pressure, corrosion and radiation. It was envisaged that the CoE-SM would be industry driven, but would also allow the necessary underlying fundamental research. The DST and the NRF stipulated five Key Performance Areas: Research; Education and Training; Information Brokerage; and Networking and Service Rendering. With these in mind, the CoE-SM formed six Focus Areas based on the existing expertise and relationships of the founder members. These were: Carbon Nanotubes and Strong Composites; Ceramics; Diamond, Thin Hard Films and Related Materials; Hardmetals; New Ultrahard Materials; and Strong Metallic Alloys. The CoE-SM comprised groups based in five South African Universities: the University of the Witwatersrand (Wits), the University of Johannesburg, Nelson Mandela Metropolitan University, the University of Kwa-Zulu-Natal, and the University of Limpopo. Additionally, there were also representatives from two parastatal institutions: Mining Council of South Africa (Mintek) and the National Energy Corporation of South Africa (NECSA). Wits is the main component, and hosts the CoE-SM, provides the Director, as well as the three staff in the Secretariat: Administrative Manager, Secretary and Book-keeper. At Wits, the CoE-SM is spread across four schools in two faculties. Within the CoE-SM, the researchers are actually employed by a university or a research council and so are effectively part time, with many other commitments. The CoE-SM already had many successful researchers and good outputs, and the grouping allowed many more collaborations to grow, for example the nanotechnology group at the University of Johannesburg. Currently, there are collaborations in over 12 countries.

The success of the CoE-SM can be attributed to sufficient critical mass, a collegiate environment, and reasonably common research goals. An important feature is the CoE-SM's own Secretariat, comprising an Administrative Manager, Secretariat and Book-keeper, and these persons ensure that the day-to-day functions are smoothly carried out, and also interface between the researchers and the Universities' administration. Benefits of sufficient critical mass include: access to students, access to essential equipment (through the CoE-SM itself, and also through the collaborators), increased awareness, collaborations and also the capability to leverage for other funds. Indicators of the CoE-SM's success include: good throughput of students: at least 44 graduated since 2004, from at least 10 different countries; increased postdoctoral fellow numbers; good journal papers throughput (at least 40 annually); good conference paper output (at least 30 annually); patents; raising at least 100 % more funding than provided by the NRF; good networking and collaboration, and the fact that most of the graduates find employment in industry.

2. Establishment of AMSEN

In 2008, Carnegie-IAS Regional Initiative in Science and Education issued a call for proposals for networks in sub-Saharan Africa to build up and retain faculty members through research and postgraduate training in several fields including Materials. The closing date for the first round was March 2008, and the CoE-SM's contacts and the web were accessed to devise a network on based on Materials. The nodes were CoE-SM which is hosted by the University of the Witwatersrand (Wits), South Africa; the University of Nairobi, Kenya; the University of Namibia, Namibia; the Federal University of Technology, Akure, (FUTA), Nigeria; and the University of Botswana, Botswana. The Director is at Wits, the secretariat at Namibia, and the Deputy Director at the University of Nairobi. The African Materials Science and Engineering Network (AMSEN) was proposed, and became one of the five funded networks from an initial pool of 48 applicants, with notification in July 2008.

The main aims are: research; training and mentoring; capacity building of faculty members; and to encourage Intra-Africa cooperation among the five node universities by sharing of both manpower and equipment. The respective strengths of the individual partner institutions will be exploited for the collective benefit. Mentoring of less experienced staff is accomplished by co-supervision of students with more experienced staff within the nodes. The exposure of the selected students is widened by multiple supervision and travel between the nodes. Three Key Performance Areas have been chosen for AMSEN: Research; Education and Training; and Networking. It was decided that both fundamental and applied research would be supported, but industrial participation would be strongly encouraged, both for additional funding, and to provide relevant projects for the students. A good balance between fundamental and applied research is targeted. RISE rules precluded that both the Director and the Secretariat could be in South Africa, and so the latter was set up in the University of Namibia, but with support from the CoE-SM.

Other aspects of the research plan was the building of strong Research Teams of researchers in related fields of materials to supervise the students, after assessing the expertise and experience of the researchers in the network. The overall research areas were those of the available faculty members at the nodes, and the students would be with the most suited supervisor. Individual student projects were devised, using a team of supervisors in the different universities, such that the members complement each other. Where possible, existing postdoctorate fellows are being used to undertake research and help students, and will be paid a small stipend (since their funding is from elsewhere). It was preferred that funding was spent on more student bursaries, rather than on postdoctorate fellows, because that would ultimately mean increased manpower. In order to comply with university regulations, each student has a home university, but will spend time in at least one other university, depending on each project. There are small groups of students within each team, which allows for high quality supervision and good communication with their peers. Presentations at conferences and workshops are strongly encouraged, as well as publication in journals. This teaches the students to communicate effectively, as does the mandatory requirement to submit three research reports, and give at least one presentation annually (even if not at a conference). The conferences could be discipline specific, depending on the time and availability of a suitable conference, or more general, for example, the biannual African Materials Research Society (AMRS) or annual South African Institute of Physics (SAIP) conferences. The Microscopy Society of Southern Africa (MSSA) Conference is suitable for most materials students, since microscopy is one of the major tools. An AMSEN Workshop is scheduled to occur alternately with AMRS, and the first will be in Namibia, 27–29 January 2010. This will enable all (if not most) of the students to present their work, and the supervisors to meet. It will also allow contact between the different Research Teams.

For supervision, contact between the students and the non-nodal supervisors is mainly by e-mail, with periodic visits, by either the students, or the other supervisors, depending on convenience. Three reports are required annually: by the ends of May, September and December. The very first report was the project proposal required by all the universities, which included at least a literature survey, project background and rationale, and a plan of work. The aim of the reports is to train the students in writing as they proceed in their research. This makes submission to conferences and papers easier, and also achieves much of the editorial work for the final thesis or dissertation.

Networking will be facilitated by the e-mail contact, and occasional visits. It is envisaged that the collaborations will grow, as different researchers have the opportunity to build on each other's collaborations. Although there is a RISE website, the building of a Network Webpage was a RISE requirement. This is currently under development by CoE-SM, Wits, and each node will have a link. The pages have been sent out for information, and the site will contain information of the projects, supervisors, students, achievements, and available equipment.

RISE stipulated the submission of reports at designated times, which includes all the achievements, progress and problems, as well as a financial report. Additionally, monthly updates for the RISE webpage are required, which are usually informal. It has also been decided since most of the collaborating nodal coordinators have to produce an Annual Report of their activities to their universities, AMSEN would also do so. The CoE-SM found that the Annual Report is an extremely useful tool to monitor and compare progress, and encourages self-evaluation.

Contribution by all nodes is ensured by the structure of AMSEN, and the fact that the nodal coordinators are responsible for their node within the network. Also, contributions from all nodes are guaranteed by ensuring that the personnel are part of at least some of the Research Teams. Where expertise is limited, researchers are be mentored during the supervision of students, and is occurring at the Universities of Nairobi, Witwatersrand, and FUTA. Students have already started to access to equipment not at the home university by visits, and both students and staff are recommended, where possible, to make external applications for travel grants for this. All nodes have been encouraged to have active contacts with relevant local industries, to ensure that their work can be useful and beneficial.

Academic retention is a major concern, together with the development of new faculty members through PhD and MSc training. Much of the difficulty in retention is due to poor remuneration, and although AMSEN cannot remedy the low salaries, there are plans to alleviate the situation. These include a scheme for supplementation, which is occurring for the University of Nairobi and the University of Botswana. Other AMSEN support includes rewarding researchers for papers published and students being supervised and graduated. AMSEN is also providing support for conference attendance (where a paper is presented) and for academic visits, funds for equipment, and training of the involved academics. Other non-financial benefits include exposure to other workers and other ideas. There are some actions which could alleviate the retention problem that can only be undertaken if the partner universities are willing. These include supplementation from industry, allowing staff to be seconded to industry for short time periods, allowing consultation work and providing academic staff sufficient time to undertake research.

3. Progress to date

Eight Research Teams have been established with at least three researchers from three different nodes, and at least twenty faculty members are involved. More staff members are expected to join, especially from the University of Namibia as the university expands in the establishment of its graduate programme. The Research Teams are currently: Corrosion, Alloy Development, Phase diagram Research, Nanotechnology, Composites Research, Ceramics, Polymers, and Concrete. Eighteen of the targeted students have been recruited into the scheme. Each node was allowed to acquire and admit its students independently because local university requirements have to be met in order to allow the students to graduate from that university. Of the remaining students, one has been identified at the University of Namibia, and Kenya has yet to identify its fourth student. Unfortunately, one candidate declined the offered bursary; this was particularly sad, since that candidate was female. At the outset, no gender targets were made because of the great difficulty in both finding and attracting females, since there are few females with BSc and MSc physical science or engineering degrees, although a better gender balance would be preferred. Most of the students were selected because they were either staff members or potential staff members at the AMSEN universities. Thus, Wits is hosting 3 personnel from FUTA and one from the University of Nairobi. FUTA is hosting its own staff, and the University of Nairobi is hosting one faculty member, one part-time staff member (not counted as faculty), and one faculty member from Jomo Kenyatta University. All of the University of Namibia's students have expressed interest in becoming faculty members. The University of Botswana has had the most difficulty in attracting students. One is an existing faculty member, and the others have been recruited from outside. Unlike for the other students within the AMSEN scheme, these last three students cannot be forced to join the Faculty, although they are being targeted as future faculty members. However, as well as servicing the node universities, AMSEN is also helping students and a faculty member from outside, and thus spreading the benefit.

Most of the students started their work in January/February 2009 (Wits and FUTA), with one late-comer at Wits starting in August 2009. Students at the University of Nairobi started in stages: one in April 2009 and two in October 2009, of whom one will under the necessary course work initially. The the University of Namibia students are enrolled at Wits since the postgraduate program is under development there. Should there be subsequent rounds of funding, it is envisaged that the next batch of students will be registered at the University of Namibia. Due to the University of Botswana having a northern hemisphere timetable, the students were only enrolled in August 2009. The University of Botswana has also established a Bursary Grant Committee and AMSEN Interest Group.

Student progress has been good. Research proposals and research reports have been submitted timeously, and the research is proceeding well. Two students presented at the Advanced Metals Initiative in July 2009 in South Africa. Although not directly part of the initiative, the students benefit from access to equipment and loan of certain raw materials. At least five conference abstracts were submitted, and to date two were accepted. The students are encouraged to participate in courses offered, and at Wits, the following have been attended by at least one AMSEN student in 2009: E-Resources for Engineering Workshop, Abstract Writing, Writing a Technical Report for Engineers, Project Proposal, Supervision Practices and Entitlements, Atomic Force Microscopy, and Thermodynamics of Phase Equilibria of Materials.

There have already been some visits between the nodes to discuss AMSEN matters and for student supervision. In order to save money, visits are usually arranged to coincide with other meetings. Thus, Professor Kavishe (the University of Namibia) visited Wits (thrice) and the University of Nairobi (twice); Professor Cornish visited the University of Nairobi (twice) and the University of Botswana once; and Professor Jain has visited the University of Namibia once. There have also been visits from Carnegie RISE, and one visit of the student and supervisors to Zambia to study a copper refinery.

In order to keep abreast of other developments, a number of networking conferences have been attended, mainly by the Director. These include: the yearly RISE meetings, in Nairobi, September 2008 and 2009, and an Africa Networking Meeting, Stellenbosch, October 2008, as well as this conference, and the TWAS Meeting in Durban, South Africa, October 2009.

4. Challenges

Although AMSEN is running well, there have been some problems. Communication is very difficult at times, especially with Nigeria, because of the dearth of reliable electricity in Nigeria, although communication is good between the other nodes. There has also been a strike at FUTA since June 2009. The university infrastructure is not always as good as might be expected. There have been problems with transferring money from the disbursing node (Wits) to the others. This was due to the way the university accounts are established and the accompanying draconian rules. It took nearly a year to set up the AMSEN account so that all the necessary financial transactions could actually take place. (Meanwhile, the Director is patiently waiting to be reimbursed for mileage.) Different levels of agreement between Wits and FUTA led to the delay of nearly six months for one student to join the scheme, and other university rules have needed careful navigating! There was difficulty in finding administrative staff for the Secretariat in the University of Namibia, and the person found had to have extensive training, which was provided by the CoE-SM Secretariat. The University of Botswana had difficulty in finding students, and it took some time to get the students in the programme.

5. Future plans

Obviously the communication problems with FUTA need to be addressed, and this has been done to an extent by the use of cellular telephone communication and couriering. Faculty staff members from the Universities of Zambia and Addis Ababa have expressed interest to join AMSEN. However, before this can be done, extra funding is needed, since the RISE funds are already committed. Recent discussions have indicated that potential funding for non-South African Faculty by TWAS or Sida exists.

The AMSEN meeting in January 2010 is expected to cement many of the good intentions and increase the collegiate environment. The possibility of using video-conferencing will be explored, but might prove difficult because of communication and band-width problems.

Since the RISE funding is designed for 2.5 years, the search for more sustainable funding has started. Additionally, plans are being made to accommodate the students currently registered so that they can be accommodated as faculty members. As well as the simple employment issues, plans are needed to allow them some contact time with the universities where they trained, in order to facilitate their establishment as productive researchers.

6. Acknowledgements

The Carnegie-IAS Regional Initiative in Science and Education, the African Academy of Science (AAS) and the Science Initiative Group (SIG) are thanked for giving the opportunity to build AMSEN.

Lesley Cornish has been deriving experimental phase diagrams of alloys related to the Platinum Group Metals (PGMs) and undertaking alloy development work for nearly 20 years, and this was also the topic of her PhD. Apart from 4 years working at the UKAEA and six years as a Section Head at Mintek, she has spent most of her working life at the University of the Witwatersrand. She has lectured to all years and postgraduate students on Physical Metallurgy and supervised over 32 postgraduate students, of whom 24 have already graduated and have gone to work in research. She has also worked with steels, WC-VC-Co hardmetals, aluminium alloys. She has written over 70 papers in journals, one provisional patent and is instrumental for the development of a thermodynamic computer database for Pt-based superalloys. These alloys are based on Pt-Al and are being developed for application at elevated temperatures in highly corrosive environments. She has been working with Materials Science International for 10 years, and contributed to 7 books on phase diagrams, a chapter in the ASM Handbook on Metallography, 2004. She was invited to take and is presently the Director of the DST/NRF Centre of Excellence in Strong Materials, and was instrumental in the establishment of the African Materials Science and Engineering Network (AMSEN) in 2008. She is also presently Deputy Dean of Research in the Faculty of Engineering at Wits. Additionally, she won the Vice-Chancellors Teaching Award (Wits) in 1998.

DST/NRF Centre of Excellence in Strong Materials, hosted by the University of the Witwatersrand, Johannesburg, South Africa; School of Chemical and Metallurgical Engineering, the University of the Witwatersrand, Johannesburg, South Africa; African Materials Science and Engineering Network (AMSEN).

Frank P. L. Kavishe is the Founding Dean of the Faculty of Engineering and Information Technology, the University of Namibia (UNAM) and co-founder and Head of Secretariat of the African Materials Science and Engineering Network (AMSEN), which is one of the five networks funded by the Carnegie Corporation of New York under the auspices of the Regional Initiative for Science and Education (RISE). Professor Kavishe is also a founding member of the Africa Materials Research Society (Africa-MRS), which was initiated with financial support from the American National Science Foundation (NSF). He has authored 46 scientific publications, several consultancy reports, two textbooks, one on fracture mechanics and another on ultrasonic testing of materials; and two manuscripts, one on materials science and engineering and another on mechanics of materials. In the past ten years he has conducted a number of joint research activities such as the study of mechanical properties of Nickel-based micro electro-mechanical systems (MEMS) in collaboration with Princeton University in the USA, production, characterization and application of carbon nano-tubes and carbon nano-balls with the University of the Witwatersrand (Wits) in South Africa and the behavior of sugar cane waste fiber ash as a cementing material with the University of Nairobi in Kenya. He is also a co-supervisor of MSc and PhD students at UNAM, Wits and Nairobi universities.

Faculty of Engineering and IT, the University of Namibia, Namibia; African Materials Science and Engineering Network (AMSEN).

Tanya Capecchi has a PhD in Chemistry, and has been involved in Research Administration at Wits since 2001. She worked on Contract Research Management from 2001 to 2005, and was involved in a number of applications for government funding related to the contract research. In 2005, she joined the DST/NRF Centre of Excellence in Strong Materials as the Administrative Manager. In this role, she deals with numerous tasks, including Financial, Customer Service, HR, as well as dealing with postgraduate students and postdoctoral fellows. She performs the same role for AMSEN.

DST/NRF Centre of Excellence in Strong Materials, hosted by the University of the Witwatersrand, Johannesburg, South Africa; African Materials Science and Engineering Network (AMSEN).

The network Partial Differential Equations, Modelling and Control: Major achievements 1999–2009

Hamidou Touré

1. Summary of network research activities

The network *Partial Differential Equations, Modelling and Control* (PDEMC) was constituted in May 1999. It gathers researchers in mathematics from Senegal, Mauritania and Burkina Faso. These researchers belong to the Computer Science and Numerical Analysis Laboratory (LANI) of Saint-Louis in Senegal; the Mathematical Analysis Laboratory of Equations (LAME), Ouagadougou in Burkina; and the Group of Research on Differential Equations (GRED) of Nouakchott in Mauritania. Professor Adou Kablan Jerome of the research group on fluid mechanics of Université d'Abidjan Cocody in Côte d'Ivoire joined the Network. The network was made up in order to promote a subregional critical mass of active mathematics researchers in the field of Partial Differential Equations, Modelling and Control, and maintains very good links to the international scientific community. It contributes to intensify the doctoral programme in applied mathematics, which still exists now, in the universities of Saint-Louis and Ouagadougou. It maintains a very good management of young researchers in that area. Our aim is also to keep in the sub-Saharan region very active scientists, to overcome their isolation and to fight against brain drain. In order to develop a regional tradition of research in the university part of this programme, we organize schools and annual meetings (workshops). Each year we may organize workshops, regional meetings, conferences and doctoral school of researchers within the region.

The network has operated with the financial and scientific support of the following organizations: Université de Ouagadougou, Université de Nouakchott, Université Gaston Berger, Université de Cocody, Abdus Salam Centre for Theoretical Physics (ICTP), Centre International de Mathématiques Pures et Appliquées, CIMPA (International Center for Pure and Applied Mathematics, ICPAM), International Science Programme (ISP, Uppsala), Support for Research Activities in Data Processing and Mathematics in Africa (SARIMA).

We intend to train more students in doctoral programmes in Saint-Louis (Senegal) and Ouagadougou (Burkina Faso). We are starting a new master and doctoral training in Nouakchott. For that purpose, we need to support postgraduate students and involve them in research-training programmes in activities of the network throughout the region. Our aim is to build research capacity in our universities in applied mathematics. The aim is also to arrange short visits of scientist participating in the network or outside it, in the laboratories that are members of the network, and abroad. The visiting scientists give doctoral courses, seminars and contribute to the training of researchers.

Since its foundation in 1999, our network has had administrative assistance and local facilities from our universities, University Gaston Berger, Ouagadougou University, and Nouakchott University. The management of these universities, Vice-Chancellors, Deans of Faculty and Heads of Mathematics Departments give us local facilities. They are strongly involved in supporting activities when they are organized in their universities. We begin to have a little support from the private sector in Senegal.

In 2003 we organized in Saint-Louis the first International Conference on Mathematics and Applications to Development Problems in Sahel. The second International Conference on this topic took place in Ouagadougou, Burkina Faso, from 27 November to 2 December 2006. Our goal is to have such international conferences every three years so as to give opportunities to researchers in the network and in the region to present their results.

The research carried out in the network mainly concerns the following areas.

- Nonlinear partial differential equations (degenerate, critical power);
- Singularities (domains with corners, etc.);
- Control of systems;
- Modelling advanced salted bevel and digital simulation;
- Ground water pollution starting from irrigated perimeters and urban centres;
- Polluted water discharge;
- Mathematical models of ecology and epidemiology;
- Modelling human infections with mycobacterium (tuberculosis, malaria, etc.);
- Mathematics of infectious diseases (malaria, Rift valley fever, etc.);
- Demographic models of fish, forest and animal resources.

These subjects are very relevant for the sub-Saharan region of Africa.

2. Doctoral programme and research training

Activity of research training within the network has been intensified. It gathers each year successively more students, PhD students and researchers. By taking as a starting point the problems of development of sub-Saharan Africa, the network Partial Differential Equations, Modeling and Control is devoted to patiently building capacity in active and dynamic research.

The network supports local PhD training and sandwich PhD programmes. From 1999 to August 2009, 29 PhD theses have been defended, of these 3 habilitations, 4 in local training, and 22 sandwich programmes. According to the list of publications (see details on pages 276–280), 59 articles have been published in international journals, 3 in regional journals, 3 in national journals; that is, a total of 65 publications.

From the sessions of the African Council for Tertiary Education (CAMES), which evaluate the teachers of most African Francophone Countries, the members of the network got the following qualifications: 2 full professors, 8 professors, 15 assistant professors. All the assistant professors and six of the professors defended their PhD during this period within the network.

3. Workshops and conferences

We organize each year workshops involving members of the network and colleagues within the region. We also organize conferences with partners involving researchers in the continent, lectures and participants from elsewhere. We will outline in the sequel workshops and conferences organized during the last three years by the network with different partnerships.

- *CIMPA School*, 11–24 July 2005, Nouadhibou (Mauritania) on Modelling and Mathematical Tools for Fishery Regulation. (For details see the full report on CIMPA's website.)
- *Mathematical Models and Data-Processing of Water and Sand* (MOMIES), Saint-Louis, 20–24 March 2006: Burkina Faso, Côte d'Ivoire, Cameroon, Benin, Mali, Mauritania, Senegal, France.
- *Celebration of Water world day and open doors of the LANI*, Wednesday March 22, 2006, in the Chambre de Commerce of Saint-Louis
- *Workshop digital simulation*, Ouagadougou, November 22–24, 2006.
- *The second Conference on Mathematics and Applications to development problems in the Sahel*, from 27 November to 2 December 2006, Ouagadougou, Burkina Faso. A total of twenty-seven lectures of forty to fifty minutes were given, covering the following scientific topics: Control and stabilization, Numerical analysis and simulation, Mathematical modelling (in biology, water re-

sources management, environment, etc.), Mechanical of the polyphases mediums. All these fields utilized ordinary differential equations or partial differential equations, which constituted the central topic of the conference. A few lectures were related to mathematical finance and statistics. The talks were at a very high scientific level. They were the subject of animated scientific discussions.

• *Workshop on Mathematical Models and Data Processing of Water and Sand (MOMIES); International Workshop on Scientific Computation*, March 19–22, 2007. The lecturers and participants came from several countries: Burkina Faso (3), Côte d'Ivoire (2), France (3), Mauritania (3) and Senegal (30). The Senegalese participation included in particular academics of the University Sheick Anta Diop, University Gaston Berger of Saint-Louis, Thiès University, and SAED Company. The participants were PhD students, teachers, researchers and workers.

• *Conference in honour of Professor Claude Lobry*, Université Gaston Berger de Saint-Louis; 10–14 September 2007. This scientific conference was inspired by the scientific contributions of Claude Lobry. The main topics presented, during about forty communications, reflected the contributions of Claude Lobry, which were multiform and in various fields. He was often a nonconformist precursor in a number of activities:

- Control theory;
- Mathematics and control theory;
- Singular perturbations in bifurcation, non-standard analysis;
- Interactions between biology, mathematics and computer science;
- Population dynamics, ecology and environment;
- Modelling, Epistemology, Philosophy of Sciences.

Some talks were related to partial differential equations, complex analysis and financial mathematics. More than eighty participants with a keen interest followed the lectures. Many of these gave a description of the state of art in the concerned fields. More than fifty participants came from abroad, from Europe (Belgium, France, Poland, Portugal, Sweden, Switzerland), from Africa (Benin, Burkina, Cameroon, Congo Brazaville, Gabon, Morocco, Mauritania, Niger, Chad, Tunisia), and from Japan. The remainder was coming from the host country Senegal. That is in direct connexion with the excellent relations maintained by Professor Claude Lobry in the international scientific community, on all continents and in all countries, particularly in Africa. The conference in honour of Professor Claude Lobry was at the same time a high level scientific conference and a meeting of friendship and fraternity.

• *The first African Research Conference in Applied Mathematics*, Ouagadougou, 12–17 November 2007. CARMA is a biannual forum for the promotion of applied mathematics in Africa. It concerns the mathematicians working on questions of development and those interested in the promotion of the use of mathematics for solving such problem

The inaugural lecture was given by Dr. Souley Kane from Gaston Berger University of Saint-Louis on "Model of porous media deformable environments ". It is noted that the lecturer is one of the doctors trained within the network. No less than twenty-three lectures of thirty to forty minutes were given. These lectures covered a wide spread of scientific topics like: control and stabilization, numerical analysis and digital simulation, mathematical modeling (in biology, management of water, environment, etc.), dynamical systems, optimization, mechanics of the polyphazes media. Some lectures were related to operational research and complex analyses. Six lectures were given by young researchers who had just finished their theses and got a fixed position in Africa. Eight presentations were given by PhDs. The talks were at a very high scientific level. They gave an occasion for animated scientific discussions and going to the bottom of the problems raised. The conference was followed by around fifty participants, including eighteen lecturers from abroad, namely: Benin (1), Cameroun (2), Côte d'Ivoire (1), France (2), Antilles (1), Mali (1), Morocco (3), Niger (1), Senegal (4), Togo (1), and Tunisia (1).

• *Workshop on Nonlinear Analysis and Partial Differential Equations*, Nouakchott, 4–14 August 2008. Nouakchott, Mauritania. The topics covered were:

- Functional analysis by Professors Mohamed Oudadess (Morocco) and Ahmed Ould Bahya (Nouakchott);
- Theory of partial differential equations by Professors A. Sene (Senegal) and Isselkou Ould Ahmed Izid Bih (Nouakchott);
- Morse theory and applications to PDE by Hicham Chtoui (Tunisia);
- Evolution equations by Professors S. Ouaro (Burkina) and K. Ezzinbi (Morocco);
- Scientific computing by Mohamed Ould Henoune (Nouakchott);
- Minimax method and variational calculus by Mohameden Ould Ahmedou (Germany).

The workshop was attended by 31 participants coming mainly from Burkina, Mauritania, Senegal, Morocco and Tunisia. Participants gave a total of nine shorts talk about their research result. It was very successful.

It seems to us that the quality of the scientific contents of the conferences represents the emergence of an active mathematical community in our region, particularly in the field of partial differential equations and their applications to problems of development in the Sahel.

4. West African Training School – École doctorale ouest-africaine

The West African Training School (WATS) has just completed its three-year cycle on 30 September 2005 in Saint-Louis. Eighteen students followed a 24-week training of 360 hours courses and 240 hours of tutorials during eight weeks, each year from September to August since 2003. This training was in four sets of fields: real analysis; functional analysis; ordinary differential equations (ODE); partial differential equations (PDE), optimization and digital simulation.

WATS was set up by Professor F. K. A. Allotey, SAPAM President, Director of the Math Institute, Ghana; Professor Hamidou Touré, Network Coordinator; Professor Charles Chidume; and Professor Claude Lobry.

WATS students could reinforce their training in the wide field of analysis directed towards differential equations and associated areas of control and numerical methods. The courses started on the basis of the level of master degree (Master 1) until it reached the level of PhD and research training the last year. Thanks to this training school formation, WATS students have a good background to hold classes at university level and to carry out their own research in view to obtain their PhD thesis.

These three years were mainly devoted to building a strong culture of analysis for young universities teachers coming from French-speaking and English-speaking countries of West Africa.

This experience enables us to consider the next steps of WATS in a more flexible form. The duration of WATS will be shorter and the training is especially completely directed on research bases. It is a question of gathering students of Africa south of the Sahara during four weeks on a set of research subjects, on which they work or plan to work. The training will supplement their knowledge in these research fields, bring support and a methodological follow-up to them. It will also put them in relationships and synergy with active researchers in theses fields within Africa and outside Africa.

4.1. Organization of WATS

Each year a topic is defined in the fields of real analysis, functional analysis, ordinary differential equations, partial differential equations, modelling, optimization and control, mathematical economy, numerical methods, scientific computation and digital simulation, theoretical data processing and more generally of applied mathematics.

WATS will take place during four weeks, divided into two periods of two weeks each. During each period, there will be given twenty hours of courses and fifteen hours of workshops. During the four weeks the participant will prepare and give talks of one hour each, which makes fifteen hours of talks at a rate of one hour per students. Home work is evaluated at 80 hours per students.

Courses: two specialists deliver each one a course of ten hours.

Workshops: Students will be divided into five small groups of three students; each group carries out a small research project with the follow-up of an African researcher specialist in the field. Theses small projects will be supervised by two specialists.

Talks: Each student will give one presentation on the results obtained in the projects, in each group.

Home work: During the four weeks detailed attention will be paid to the share of personal work which each student must make.

The WATS will include 24 participants:

- Fifteen students whose subjects of PhD thesis are in the set of fields or wishing to work in those fields;
- Five African researchers having their PhD in the set of subjects able to follow-up the students in the realization of a project;
- Four specialists on an international level, who will work together during each period – they will supervise the workshops; and the five young African researchers in the field.

4.1.1. Objectives

- To develop and reinforce capacity of research of the PhD students;
- To develop the capacities of research training;
- To develop team spirit and the aptitudes of working in groups;
- To support networking of African researchers and the constitution of research working groups in some applied mathematics subjects;
- To increase the number of African researchers publications of international level in the field.

5. West African Training School: Original format

1. Aim : To produce a critical mass of young mathematicians at high level in the broad area of Analysis (Nonlinear Analysis, Differential Equations, Control Theory, etc.).
2. Method: Three years of training programme (two consecutive months every year). All training will take place at the Mathematics Department, University Gaston Berger, Saint-Louis, Senegal.
3. The Programme
   3a. We have selected 20 young students registered for the PhD degree in universities in the West African subregion.

3b. We have competent and dedicated staff (see sections 5.1 and 5.2).
3c. The same students will be invited for those three years. Basically the same courses will be repeated at a higher level every successive year.
3d. Starting with a modest background in the first year, lectures during the second and third years will be at the appropriate advanced levels.
3e. Three lectures of one and a half hours duration each will be given per day for five days a week. Each day, assistants will be available in designated offices to assist the students.
3f. At the end of the training, each year, examinations will be given to the students.

4. PhD thesis supervision. The current PhD theses supervisors of all the students selected are involved in this programme. Consequently, joint supervision of students will be encouraged.
5. Proposed standard courses in Analysis
   5a. Real Analysis
   – Measure Theory I: Finite-dimensional case;
   – Measure Theory II: Lebesgue Measure and Integration;
   – Real Analysis: Rudin's Book.

   5b. Functional Analysis
   – Linear Functional Analysis;
   – Spectral Theory, Nonlinear Functional Analysis;
   – Degree Theory, Sobolev Spaces.

   5c. Partial Differential Equations and Control Theory
   – Linear PDE;
   – Nonlinear PDE;
   – Control Theory;
   – Asymptotic method for PDE.

   5d. Ordinary Differential Equations
   – Linear ODE;
   – Nonlinear ODE;
   – Boundary Value Problem's;
   – Asymptotic method for ODE.
6. Sample syllabus. We give below a sketch of a sample of the courses proposed in Functional Analysis for the three years.

   First year: 2003
   Linear Functional Analysis: Hahn–Banach Theorem (Analytic and Geometric Forms); Uniform Boundedness Principle; Banach–Steinhaus Theorem; Open Mapping and Closed Graph Theorems; Weak Topology; Banach–Alaoglu Theorem; Kakutani's Characterization of Reflexive spaces; Eberlein–Smul'yan Theorem; Applications.

Second year: 2004
Geometric Properties of Banach Spaces and Elements of Nonlinear, Functional Analysis; Spectral Theory of Operators; Introduction to Banach Algebras.

Third year: 2005
Independent study of the following two topics as preparation for the study of differential equations (ODE and PDE): (i) Sobolev Spaces; (ii) DegreeTheory.

5.1. Academic staff

Functional analysis

Professor C. E. Chidume (ICTP, Nigeria)
Professor Hamidou Touré (Burkina Faso, ICTP Associate)

Real analysis

Dr. Diaraf Seck (Senegal)
Professor C. H. Morales (Hunstsville, Alabama)

Differential equations

Professor Gauthier Sallet (Metz, France)
Professor Hamidou Touré (Burkina Faso, ICTP Associate)
Professor Isselkou (Mauritania, ICTP Associate)

Control theory

Professor Claude Lobry (France)
Professor Mary Theuw Niane (Senegal, ICTP Associate)
Professor Abdou Sène (Senegal)

5.2. Assistants

Dr. H. Zegeye, Ethiopian, Former DICTP (Math.)
Dr. Ouaro Stanislas, Burkina Faso
Dr. Djitte, Senegal, Former DICTP (Math.)
Dr. F. I. Njoku, Nigerian, ICTP Regular Associate
Dr. Bonzi Bernard, Burkina Faso

PhD Theses defended 1999 – August 2009

Defence 1999

1. Abdou Sène, *Analyse asymptotique des plaques piezo-electriques et contrôlabilité exacte*. Co-direction Mary Teuw Niane et Annie Raoult, Grenoble 1, Joseph Fourier. Soutenue en janvier 1999.

Defence 2001

2. Ouaro Stanislas, *Étude de problèmes elliptique paraboliques non linéaires en une dimension d'espace*. Université de Ouagadougou, 29/11/2001 (Doctorat Unique). Direction Hamidou Touré.
3. Abdoulaye Sène, *Calcul de singularité pour l'équation de la chaleur et contrôlabilité exacte de l'équation des plaques pour des données peu régulières*. Université de Saint-Louis, 26/07/2001 (Doctorat de 3ème Cycle). Direction Mary Teuw Niane.
4. Mohamed Maliki, *Solutions faibles pour des problèmes paraboliques fortement dégénérés*. Université de Rabat, 07/07/2001 (Doctorat d'État).

Defence 2002

5. Idrissa Ly, *Résultat d'existence en optimisation de forme et étude d'un problème extérieur à frontière libre : cas du p-Laplacien*. Université de Saint-Louis, 2002 (Doctorat de 3ème Cycle). Direction Mary Teuw Niane.

Defence 2003

6. Mamadou Sy, *Paramétrisation en Mécanique des fluides : Analyse Mathématiques de quelques modèles.* Doctorat de Troisième Cycle de Mathématiques Appliquées. Université Gaston Berger, Saint-Louis, soutenu le 15 Décembre 2003. Co-direction Mary Teuw Niane et Didier Bresch.
7. Cheikh Talibouya Diop, *Étude et mise en œuvre des aspects itératifs de l'extraction des règles d'association dans une base de données.* Doctorat d'Informatique de l'Université de Tours, soutenu le 8 Décembre 2003.
8. Mamadou Abdoul Diop, *Équations aux dérivées partielles stochastiques et homogénisation*. Doctorat de Mathématiques de l'Université Aix-Marseille I, soutenu le 6 Octobre 2003. Direction Mary Teuw Niane.
9. Ayitchéou Judicael Deguenon, *Observateurs des systèmes anti-adjoints de dimension infinie et applications*. Doctorat de l'Université de Metz, soutenu le 20 Octobre 2003. Co-direction Hamidou Touré et Cheng-Zhong Xu.

Defence 2004

10. Abdoua Tchousso, *Étude de la stabilité asymptotique de quelques modèles de transfert de chaleur*. Doctorat de l'Université Claude Bernard Lyon I, soutenu le 24 Juin 2004. Codirection Hamidou Touré et Cheng-Zhong Xu.
11. Ngalla Djitte, *Systèmes différentiels extérieurs et applications aux problèmes inverses*. Doctorat de l'Université Paris IX-Dauphine, soutenu le 12 juillet 2004. Co-direction Mary Teuw Niane et Ivar Ekeland.

Defence 2005

12. Mamadou Sy, *Effets des termes diffusifs sur des modèles diphasiques et un modèle géophysique.* Université Blaise Pascal, Clermont-Ferrand, 2005. Codirection Mary Teuw Niane et Didier Bresch.

13. Soulèye Khane, *Analyse Mathématique et simulation numérique de modèles découlement de fluides incompressibles en surface libre et milieux poreux déformable*, 2005. Université de Neuchâtel. Codirection Mary Teuw Niane et Olivier Besson.

14. Abdou Khadry Dramé, *Modélisation et analyse de procédés biologiques : application à la dépollution des eaux. Théorie des systèmes asymptotiquement autonomes*, 2005. Université de Montpellier II, Codirection Mary Teuw Niane et Claude Lobry.

Defence 2006

15. Abdoulaye Sène (These d'État), *Stabilization of a thermoelastic system, exact controllability of wave equations*. Université de Dakar, February 18, 2006.

16. Papa Ibrahima Ndiaye, *Modelling dynamics of mosquitos Aedes in Sahelian region. Example of Aedes vexans arabiensis, vector of rift valley fever*. University of Metz, December 2006. Codirection Mary Teuw Niane et Dominique Bicout-Gauthier Sallet.

Defence 2007

17. David Célestin Faye, *Médiation de données sémantique dans SenPeer, un système pair à partir de gestion de données*. 22 Octobre 2007, Université de Nantes.

18. Ousmane Thiare, *Exclusion mutuelle de groupes dans les systèmes distribués : application aux réseaux mobiles ad hoc*. 25 juin 2007, Université de Cergy Pontoise.

19. Mariama N'Diaye Diakhaby, *Contrôle et Stabilisation dans les canaux d'irrigation avec ou sans prélèvements.* Université Gaston Berger de Saint-Louis, 2007.

20. Oumar Diop, *Détection de nuages de poussière dans les images Météosat à l'aide des attributs de textures et de la fusion de segmentations : application à la zone sahélienne du continent africain*. Université de Rennes.

21. Oumar Niang, *Décomposition Modale Empirique : Contribution à la modélisation et applications en traitement du signal et de l'image*. Université de Paris XII. Codirection Mary Teuw Niane et J. Lemoine.

22. H. Okou, *Analyse asymptotique des ondes inertielles d'un fluide en rotation rapide dans un tore*. Thèse de Doctorat de l'Université de Cocody, Abidjan, soutenue le 7 Novembre 2007. Direction Adou Kablan Jérome.

23. N. A. Konan, *Modélisation numérique stochastique des rebonds des particules sur parois rugueuses*. Thèse de Doctorat de l'Institut National Polytechnique de Toulouse, soutenue le 9 Décembre 2007.

24. Idrissa Ly, *Problèmes à phases et spectraux en optimisation de forme*. Thèse d'État, Université Cheick Anta Diop de Dakar, 15 décembre 2007.

Defence 2008

25. Diène Ngom, *Observation et régulation de certains modèles discrets d'ecosystèmes*. Soutenue le 15 décembre 2008 à Saint Louis. Codirection Abdérahmane Iggidr et Mary Teuw Niane.

26. Zabsonre Jean de Dieu, *Modèles visqueux en sédimentation et stratification : obtention formelle, stabilité théorique et schémas volumes finis bien équilibrés*. 24 Juillet 2008, Université de Savoie. Codirection D. Bresch, E. Fernandez-Nieto et Hamidou Touré.

Defence until August 2009

27. Aboudramane Guiro, *Sur quelques problèmes d'observateurs : Applications à certains modèles d'écosystème aquatique*. 12 Mars 2009. Codirection Hamidou Touré et Abderrahman Iggidr, INRIA − Université de Metz, France.

28. Adama Ouedraogo, *Solutions renormalisées pour des problèmes paraboliques fortement dégénérés : cas isotrope et non isotrope*. 14 Mars 2009. Codirection Hamidou Touré et Mohamed Maliki, Université Hassan II de Mohammedia, Maroc.
29. Fatou Kamara épouse Sangare. Doctorat de l'Université Gaston Berger de Saint-Louis soutenue le 4 février 2009.

List of Publications 2001 – August 2009

Publications 2001

1. Abdou Sène (2001). Modelling of piezoelectric static thin plates. *Asymptotic Anal.* **25**, no. 1, 1−20.
2. Idrissa Ly; Diaraf Seck (2001). Étude d'un problème à frontière libre pour le p-Laplacien. *C. R. Acad. Sci. Paris*, **332**, Série I, 899−902.
3. Ould Ahmed Izid-Bih Isselkou (2001). Critical boundary constants and Pohozaev identity. *Ann. Fac. Sci. Toulouse Math.* (6) **10**, no. 2, 347−359.
4. Mohamed Maliki; Hamidou Touré (2001). Dépendance continue de solutions généralisées locales. *Ann. Fac. Sci. Toulouse* **10**, No. 4, 701−711.

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Hamidou Touré has also written an article on ten years' experience of this network; see page 165, where there is also a presentation of him, page 171.

Five years of materials science and solar energy for Eastern and Southern Africa

Joseph Buchweishaija, Margaret Samiji, and Tom Otiti

Contents

1. Background

1.1. Establishment

The network with the acronym MSSEESA was formally established on 9 October 2004 in a meeting held at Makerere University and attended by delegates from all materials science and solar energy research groups in the Eastern and Southern African subregion with the exception of Addis Ababa University.

1.2. Membership

Membership is open to materials-science and solar-energy research groups in the region. Currently the network has five nodes, from four chapters:

- University of Dar es-Salaam (Departments of Physics and Chemistry), Tanzania Chapter;
- Moi University (Department of Physics), Kenya Chapter;
- University of Nairobi (Department of Physics), Kenya Chapter;
- Makerere University (Department of Physics), Uganda Chapter;
- University of Zambia (Department of Physics and Chemistry), Zambia Chapter.

2. Rationale/Justification

The Eastern and Southern Africa region has several university departments that are engaged in teaching and research activities in materials science and solar energy appliances among other fields.

These departments through their respective research groups already had informal cooperation through the coordination of IPPS, Uppsala, Sweden.

Situational analysis revealed the following common issues.

- Shortage of Academic Staff to conduct postgraduate training, supervision and research;
- Lack of sustainability of research activities after donor-funded projects have come to an end;
- Inadequate funding from government that has affected performance in research activities;
- Poor gender balance amongst students and staff in science disciplines.

The network could be used to address the common weaknesses in the subregion and act as a platform for strengthening of:

- Sharing of research facilities;
- Joint offering of courses/programmes;
- Student/staff exchange;
- Joint supervision of postgraduate students;
- Information exchange and provision;
- Organization of conferences, workshops, colleges, etc.

3. Mission and vision

The network is an international partnership aiming at enhancing the development and application of science in the area of materials science and solar energy in the Eastern and Southern Africa region and to foster efficient and effective use of human and infrastructure capacity in advanced research in these areas as well as promoting socio-economic and industrial development in the subregion.

The vision of the network is that MSSEESA becomes a laboratory of ideas and a think-tank to assist member institutions in formulating strategies and directions regarding materials science and solar energy research and related activities in the subregion.

4. Objectives

4.1. General objectives

To enhance human and infrastructure capacity in advanced research in materials science and solar energy. Thus MSSEESA aims at strengthening the research facilities and activities and postgraduate training programmes by complementing activities of materials science and solar energy in the various institutions of the subregion.

4.2. Specific objectives

> To assist countries in the subregion to build and sustain a critical mass of credible scientists through postgraduate training and research in the areas of materials science and solar energy that are of critical importance of sustainable socio-economic development;
>
> To coordinate activities of materials sciences and solar energy in the various universities in the subregion;
>
> To attract talent and induce competent young scientists with an equal gender distribution to work in their own countries;
>
> To provide avenues for international cooperation and links in the areas of Materials Science and Solar energy;
>
> To promote joint research ventures amongst the members of the network;
>
> To assist in the dissemination and exchange of information;
>
> To implement cost effective utilization of available resources in the subregion.

To achieve the objectives of the network the following strategic developmental issues have been identified.

> To strengthen joint postgraduate training and expanding MSc and PhD programmes. Thus collaborating institutions are to harmonize the postgraduate curricula as well as policies related to the development and approval of postgraduate programmes;
>
> To establish regular and flexible technical training courses linked with equipment manufacturers. It may be cost-effective to conduct collective training rather than to sponsor several individual trainings at scattered different locations;

To broaden intake of participants, the scope and duration of subregional courses (e.g., Thin Film Technology College) to cover other related topics;

To audit the resources that can be shared, in terms of equipment, exposure, experience, personnel and research interests/activities. This can be facilitated through exchange of students/ researchers in the region. This fact also addresses the shortage of academic staff;

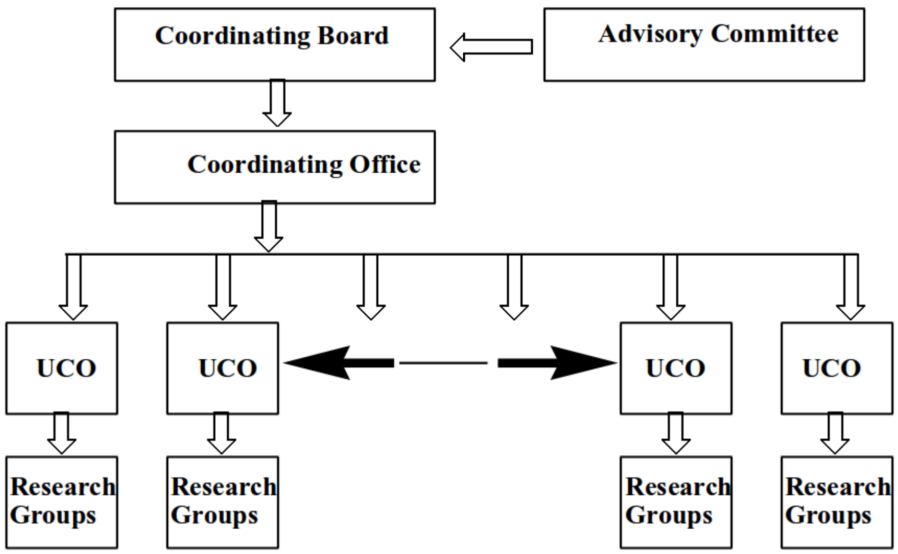
To establish a platform for dissemination of information amongst those working in the field of Materials Science and Solar Energy in the region;

To introduce tailor-made multi-disciplinary MSc and PhD programmes.

5. Strategic plan development

The network has already prepared its five-year strategic plan which will guide the network's activities.

6. Organizational structure



7. Activities for the past five years

7.1. Registration of MSSEESA chapters

MSSEESA Tanzania Chapter officially registered by the Tanzanian Registrar of Societies on 11 May 2006 and launched on 24 July 2006.

MSSEESA Zambia Chapter officially registered on 16 November 2006 and Launched on 23 March 2007.

MSSEESA Kenya Chapter and MSSEESA Uganda Chapter are in the final stages of registration at the time of writing.

Registered chapters have already signed MOU with their universities.

7.2. College on thin film

MSSEESA Tanzania chapter conducted the 9th College on Thin Film Technology from 24 July to 4 August 2006.

The college attracted participants from all nodes including others Universities from Rwanda, Lesotho, and Malawi.

This activity was funded by University of Dar es-Salaam, ISP, Uppsala University, Sweden, and ICTP.

7.3. Inform workshop

MSSEESA organized a four-day Training Workshop on literature search for young scientists in Physics and Mathematics at University of Dar es-Salaam, Tanzania, from 6 to 10 August 2007. Facilitated by experts from Uppsala University, Sweden. The workshop training attracted participants from Tanzania, Kenya, Uganda, Ethiopia, Rwanda and Zambia. Financed by ISP.

7.4. Research proposal writing

The network submitted a grant proposal to Carnegie-IAS Regional Initiative in Science and Education (RISE) in 2008. It was not funded.

The network also submitted a grant application proposal to IPPS for funding, which was presented to the ISP Reference Group meeting in Addis Ababa, October 2008. It was granted 200,000 SEK for the year 2009.

7.5. Network meetings

The network held its first Annual Coordinating Board meeting on 4 April 2009 in Dar es-Salaam, Tanzania as per constitution.

The meeting endorsed establishment of the first Coordinating office under the Tanzania chapter and Professor R. T. Kivaisi was endorsed as a chief coordinator of the network for the triennium starting 1 January 2009.

7.6. Harmonization of postgraduate programmes

The network undertook a harmonization of Masters programmes in Physics as the first budgetary activity for year 2009. Committee Members met in Nairobi for 2 days in July 2009. This activity is in progress and the outcome will be presented at the next extraordinary meeting, scheduled in October 2009.

7.7. International conference

The network will hold a conference in materials science and solar energy in October 2009, between the 13th and 15th. Preparation is in the advanced stage. The conference will attract about 60 participants from the region.

8. Experiences and challenges

Funding Problem:

Currently we have enough candidates for postgraduate studies but no funds to support training.

Change of Sida policy: some chapters like Tanzania and Uganda no longer get support to sustain research activities.

9. Conclusions

Future development:

Development of research proposals to attract funding;
Implementation of the network's strategic plan;
Development of outreach programmes.

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Natural products research network for Eastern and Central Africa (NAPRECA)

Jacob O. Midiwo

The mandate of NAPRECA is mobilization of scientists in the Eastern and Central Africa subregion to contribute effectively in the development of science of natural products. It is also to promote Natural Products research and utilization in the subregion. NAPRECA is run by individual scientists according to its constitution. It therefore precludes and avoids government bureaucracy and inertia.

1. History

NAPRECA, Natural Products Research Network for Eastern and Central Africa, was conceived in July 1984 by African chemists attending the Fourteenth IUPAC International Symposium on the Chemistry of Natural Products. They realized that Africa is rich in biodiversity but poor in research and development in the Natural Products field. Those chemists came from Eastern and Central African region – Ethiopia, Kenya, Sudan and Zimbabwe. They founded the organization following the model of ASOMPS, which operates in South East Asia. It was affiliated to UNESCO as one of its network programmes in November 1987, and has been implementing its mandate since 1988. NAPRECA branches were established in the following order: Ethiopia, July 1984; Sudan, October 1984; Tanzania, November 1984; Kenya, May 1985; Rwanda, April 1988, Zimbabwe, December 1988; Uganda, June 1989; Madagascar, October 1990; Botswana, 1991; D. R. Congo, 1999; Cameroon, 2005. The first NAPRECA office was coordinated by Professor Ermias Dagne, assisted by Professor Berhanu Abegaz and Mr. Hailu Guadey, in Addis Ababa from 1988 to 1996. The next office had Professor Mayunga Nkunya as the Executive Secretary assisted by Professor Michael Kishimba and Professor Cosam Joseph in Dar es-Salaam, 1996 to 2005. The current office is at the University of Nairobi led by Professor Jacob O. Midiwo assisted by Professor Abiy Yenesew and Professor Caroline Langat.

2. Aims and objectives

- To initiate, develop and promote research in the area of natural products in the Eastern and Central African subregion;
- To coordinate and maintain inter- and intra-regional links among different research groups;
- To disseminate information pertaining to natural products research;
- To foster and maintain research links with scientists in other parts of the world who are actively involved in specific areas of natural products that are pertinent to Africa.

3. NAPRECA structure

Supreme body is the NAPRECA Coordinating Board, which consists of the following: the Executive Secretary, Assistant Secretary/Treasurer, one National Point of Contact (NPC) from each NAPRECA branch, an ex-officio representative of UNESCO, a Program Officer of NAPRECA coordinating office (ex-officio).

4. Activities of NAPRECA

NAPRECA branches and coordinating office act to fulfill its mandate. The co-ordinating office performs the following activities: organizing of symposia and workshops referred to as Summer Schools and pre-symposium workshops, processing the NAPRECA / DAAD scholarships, sending out newsletters, soliciting and publishing monographs on specific natural products topics, publication of NAPRECA Symposia proceedings and managing exchange of researchers scheme.

NAPRECA has held 13 Natural Product symposia so far: Addis Ababa 1988, Nairobi 1988, Arusha 1989, Addis Ababa 1991, Antananarivo 1993, Kampala 1995, Dar es-Salaam 1997, Gaborone 1999, Nairobi 2001, Addis Ababa 2003, Antananarivo 2005, and Kampala 2007. The Thirteenth Symposium took place in Kinshasa, DRC Congo, in August 2009.

NAPRECA postgraduate scholarships are provided by German Academic Exchange Service (DAAD) and has been in place since 1988. The programme has benefited to more than 90 students in the region. Studies usually lead to acquisition of MSc and PhD degrees. These are third party scholarships that are provided by Germany, and NAPRECA gives them to students in one NAPRECA country to pursue scholarship in another NAPRECA country; in this way they encourage regional understanding, if not contributing to integration. Some NAPRECA countries have benefited more than others; NPCs are encouraged to make sure that their graduating young people are made aware of this activity. NAPRECA stages two types of workshops: Summer schools and pre-symposium workshops. The workshops that are designed for young scientists are virtually annual events. The last summer school was held in September 2006 in Gaborone, Botswana, and the last pre-symposium workshop was held during the 12th NAPRECA Symposium in Kampala, Uganda, July 2007. The next summer school is going to be held August 31 to September 7 2008 at the Department of Chemistry, Addis Ababa University, Ethiopia. The next pre-symposium workshop will be held in Congo Kinshasa before the Thirteenth Natural Product Symposium.

NAPRECA is intent on producing a Newsletter which will shortly start featuring at its website at www.napreca.net. NPCs should normally alert members and stake holders about these notices but this could also be done from the coordinating office. NAPRECA has the exchange of researchers scheme. If any member is interested in visiting another member laboratory for a period of one week to two months then he/she can request the coordinating office to include this in the budget for the next year. It is also possible to go for the visit in the same year if there happens to be excess funds.

To fulfill all its mandate, NAPRECA should be involved in multi-disciplinary national and multi-national research projects aimed at solving Africa's intermittent problems. This activity would develop Natural Products research capacity through training and equipment acquisition. It would also create networked centres of excellence in order to maximise research capability. NAPRECA members are encouraged to form national and or international groups to pursue thematic research around Africa's vexing problems: Malaria, leshmaniasis, HIV/AIDS, tuberculosis, development of cheap and safe agrochemicals for protection of crop in the field and in storage, etc. The coordinating office pledges to be involved in locating potential funding agencies for such efforts.

5. Funding

NAPRECA sponsors are mainly the International Program in Chemical Sciences (IPICS) Sweden, the German Academic Exchange Service (DAAD), the International Foundation of Sciences (IFS), Sweden, UNESCO, the Organization for the Prohibition of Chemical Weapons (OPCW), and membership fees at branch level. The Coordinating office can provide branches with some funding but they are required to send requests for their activities for the following year to the coordinating office so that it is included in the budget. We are grateful to all agencies who provide funds for the varied NAPRECA activities.

Jacob O. Midiwo undertook his PhD studies in Organic Chemistry at the University of Maryland, College Park, USA, studying fungal mycotoxins, which had potential in cancer chemotherapy. He graduated from that university in 1981 and took up a lectureship position at his Alma Mater, the University of Nairobi, where he has risen through the ranks to full professor. He became the NAPRECA Executive Secretary in 2005 after being chairman of NAPRECA-Kenya for four years.

Professor Midiwo has done research on the secondary metabolites of popular Kenyan medicinal plants from a range of plant families, especially, the Myrsinaceae, Polygonaceae, Papilionacea, Compositae, Rutaceae and Sapindaceae. He has published over one hundred papers in refereed international journals describing the structures and bioactivity of compounds with various bioassay models − anti-plasmodial, mosquito larvicidal, insect antifeedant and other biocide effects and their capacity as anti-oxidants − in search of their potential application.

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Linking laboratories in five neighbouring African countries: ALNAP

Ermias Dagne

1. Origin and History

ALNAP, founded in 1997, is an acronym for the *African Laboratory for Natural Products*, which is a closely knit network of laboratories found in five neighbouring countries of east and central Africa, namely Uganda (Department of Chemistry, Makerere University, and Ministry of Health), Rwanda (Institute for Scientific and Technological Research, IRST), Ethiopia (Department of Chemistry, Addis Ababa University), Congo DRC (Faculty of Pharmaceutical Sciences) and Burundi (Department of Chemistry, Burundi University). The logo of ALNAP shows the map of the above-mentioned five member countries:

ALNAP is established in order to accelerate the development of the science of natural products in the region in order to harness quality products from nature for the benefit of the people. The members are committed to assist each other by making both human and material resources at each others laboratory at the disposal of the other. Such arrangements are particularly attractive to young researchers and postgraduate students, who often suffer from dire shortages and limitations. Although much is said of African Unity at the political level, it is rare to find situations that give opportunities to African students or researchers so that they are able to study or do research in a country other than their own. In most instances students and young staff are discouraged even to visit another African country due to expensive air travel costs, requirements of visa, payments in foreign exchange, etc. It is therefore critical to have Pan-African programmes and networks that enable exchange visits, resource sharing, etc. Such arrangements make it possible for researchers to tap into resources and facilities available nearby.

In the first proposal submitted to the Swedish organization the International Programme in the Chemical Sciences at Uppsala University (IPICS) in 1997, it was stated that

> the main mission of ALNAP is to contribute to the development of the science of Natural Products of interest to medicine, industry and agriculture. This involves implementing programmes such as training of research and laboratory assistants, organizing short courses and workshops, hosting visiting researchers, dissemination of scientific information, provision of analytical services and coordinating activities in the maintenance of scientific equipment.

The positive response from IPICS assured sustained flow of grants over the past 12 years that has enabled ALNAP to implement the above activities without facing serious impediments and constraints. We are therefore very much indebted to IPICS for this generous financial and logistics support.

2. Project Description and Implementation

2.1. Workshops

The first ALNAP Workshop was organized in Uganda in the Natural Chemotherapeutics Research Laboratory (NCRL) in July 2007. Over 30 participants from different institutions in Uganda, three from Burundi, and two from Ethiopia took part. Professor Ermias Dagne (Ethiopia) and Dr. Norbert Arnold (Germany) served as resource persons. Dr. Peter Sundin, Director of IPICS, observed the workshop and made valuable contributions. The lectures emphasised how to conduct research in the various disciplines of natural products science. Dr. Arnold focused on product development from fungi and related microorganisms. A one-day excursion to a Medicinal Plant farm at Mubende about fifty miles from Kampala gave participants ample opportunities not only to observe the rich flora of Uganda but also to visit the garden of one of the most well-known traditional healers of the country. Table 1 on page 295 shows that so far eight workshops have been organized for a total of 120 participants (30 % female) from eight African countries.

2.2. Comments by participants of workshops

1. *Nalika Nusula, NCRL, Uganda:* I am an ethnobotanist and a researcher at the Natural Chemotherapeutics Research Laboratory, Ministry of Health. The second ALNAP workshop was well organized. I have been exposed to the use

Participants of the First ALNAP Workshop in Kampala, Uganda, held 22–22 July 2007 at the Natural Chemotherapeutics Research Laboratory of the Ministry of Health.

of various instruments for extraction, separation, identification and quantification of phyto compounds. I was also taken through the process of documentation of scientific literature and record keeping. The knowledge I acquired in all areas of training will contribute a lot to the improvement of Natural Products Research at NCRL. I thank Professor Ermias Dagne for organizing the workshop, IPICS for the funding, and the Director of NCRL, Dr. Grace Nambatya Kyeyune, for support with regard to the incidental expenses.

2. *Jean Claude Tomani, IRST, Rwanda:* I have a BSc in bio-organic chemistry and I am a researcher in plant medicines at the Institute of Scientific and Technological Research (IRST) in Rwanda. The third ALNAP Workshop was really fantastic: to learn how to use the sophisticated instruments of analysis such as GC, NMR, HPLC, HPTLC, etc. Moreover, as a young researcher, it was with a great pleasure to learn from an experienced and internationally recognized researcher, Professor Ermias Dagne. I will be back to my country, to introduce the information gathering system and database of ALNAP.

3. *Gemechu Tafa, Mekelle University, Ethiopia:* I am a lecturer in Mekelle University, Ethiopia, and currently I am a PhD student at the Chemistry Department, University of the Negev, Israel. The 4th ALNAP workshop was so

interesting and educative. The experience acquired in the field at the medicinal plants gardens, the pressing of plants for herbarium identification followed by the visit to the national herbarium, the discussions, the two weekend excursions, the hands-on experience on some instruments, the glassblowing session, and even watching support staff on action in harmony was fascinating. I personally want to thank all the support staff and Professor Ermias Dagne for their determination to make things go right.

2.3. Exchange of Researchers

This scheme helps young staff to spend some time in collaborating laboratories in the region. This programme is extremely important because it gives to our young colleagues a chance to visit another African country for the first time in their life.

2.4. Analytical services

This is by far the most popular component of all our programmes. The Laboratory in Makerere University is in good position to give gc-ms services. The Laboratory of Professor Kalenda in the DRC has excellent HPLC facilities. IRST in Rwanda has experience on large scale production of bio-ethanol and essential oils.

A 400 MHz NMR instrument in Addis Ababa was purchased and installed in the year 2000 through a major Sida-SAREC grant. Keeping such state-of-the-art equipment in operation is indeed a challenge not only for a laboratory in a third-world country but even in advanced countries. IPICS has made contributions through the ALNAP grants towards upgrading, maintenance and running costs. The instrument is still in good working condition. NMR spectral services are given to local and regional parties upon request. Modest fees are charged for the services, and a fraction of the received fees (45 %) is shared among the two professors in charge and three other operators while 55 % remains in the account of the Department of Chemistry. Another unique facility acquired some years back through IPICS grant is the CAMAG Analytical HPTLC equipment, which is an invaluable tool for quality control of natural products. The research group in Addis Ababa also has working HPLC, GC, freeze drier, Separao-MPLC, chromatotron, polarimeter, UV-VIS spectrophotometer, distillation set up for solvent recovery, etc. These and the other basic laboratory facilities, and the glass blowing workshop enables the Addis Ababa Research Group to smoothly conduct training workshops and exchange programmes.

Table 1: Workshops organized by ALNAP

Theme *Period*	*Participants country / number / gender*	*Location*
1. How to Conduct Research in Natural Products 2007-07-20−22	Total 30: Uganda (25), Burundi (3), Ethiopia (2). Female participants: 14	NCRL, Uganda
2. Chromatographic and spectroscopic methods 2008-07-20−08-01 (Group 1) NAPRECA Summer School 2008-09-01−08 (Group 2)	Total 11: Uganda (3), Burundi (1), Ethiopia (7) Female: 2 Total 13: Uganda (3) Tanzania (2), Sudan (1), Rwanda (1), Kenya (2), Ethiopia (4). Female: 3	AUU, Ethiopia
3. Extraction and Separation Technologies for MAPs 2009-02-16−22	Total 6: Uganda (2), Rwanda (1), Ethiopia (3)	AAU, Ethiopia
4. Research Methods in Natural Products: Presymposium Workshop; 13th NAPRECA Symposium 2009-08-08	Total 25: DRC (20), Kenya (5), Uganda (2), Female: 7	Dept. of Pharmaceutical Science, Kinshasa Univ. DRC
5. Laboratory skill upgrading 2009-08-27−09-10	Total 6: Uganda (1), Ethiopia (5)	AAU, Ethiopia
6. Phytomedicine Product Development and Quality Control 2009-09-28−30	Total 28 Uganda (1), Ethiopia (1) Rwanda (26). Female: 11.	IRST, Rwanda
7. Laboratory skill upgrading 2009-12-21−27	Total 2: Ethiopia (2)	AAU, Ethiopia

Professor Ermias Dagne with a participant at the 400 MHz Nuclear NMR Instrument, purchased by a Sida-SAREC grant and installed in 2000.

Table 2: Exchange Scheme implemented

Topic *Dates*	*Fellow name / Institution / Country / Gender*	*Location*
1. Product development and quality control from shea butter and *Prunus Africana* 2006-12-05 – 2007-01-05	Patrick Ogwang / NCRL / Uganda / Male	AAU, Ethiopia
2. Finger print of antimalarial product developed from lemongrass and *Artmeisia annua* 2009-06-01 – 15	Patrick Ogwang and Geresom Mugisha / NCRL / Uganda / Male	AAU, Ethiopia
3. Essential oil analysis using GC and other methods; Method development for avocado analysis 2009-10-28 – 11-10	Murenzi Raymond / Rwanda, Bureau of Standards (RBS) / Rwanda / Male	AAU, Ethiopia

2.5. Data bases

There are many databases that compile information on natural products and medicinal plants. However, a large body of knowledge that is generated in Africa is not included in these databases. The main aim of the ALNAP Database is therefore to scan and enter information from scientific journals, proceedings, monographs, books, dissertations, etc. that deal with the biology, chemistry, ethnobotany and pharmacology of African plants. The information, when needed, is generated through a quick search, which can be saved, printed or sent by e-mail. The entries in this literature database now exceed 26,000. Another contribution of ALNAP is NADA (Natural Database), Version 1.0 of which has just been released on CDROM. The ultimate goal of NADA is to enable a user to get quickly basic information on African plants with species, family name, brief description, uses, chemistry and in some cases with pictures of the plant.

3. ALNAP Internship Programme

This is a new programme initiated in 2009. Under this programme young graduates (BSc) are recruited to work for a maximum period of 2 years in an ALNAP-affiliated laboratory so that they get hands-on experience. Yehaulashet Belete, age 22, BSc chemistry, is the first ALNAP Intern who started to work in the laboratory in Addis Ababa in September 2009. A modest allowance is paid to interns.

4. Acknowledgments

Since its inception ALNAP has benefited from generous grants from IPICS-ISP with total of over 2 million SEK and an average of SEK 200,000 per year. Without this support none of the above activities could have been implemented. We would therefore like to express our deep gratitude to IPICS-ISP and to the Swedish People and Government. At the personal level we would like to thank the three consecutive directors of IPICS, namely Professors Rune Liminga, Malin Åkerblom and Peter Sundin.

We also like to acknowledge the active and positive participation of the leaders of the member laboratories, namely: Uganda (Professor B. Kiremire, Makerere University, and Dr. Grace Nambatya, NCRL Ministry of Health of Uganda); Rwanda (Dr. J. B. Nduwyezu and Justin Kabera, IRST); DR Congo (Professor D. T. Kalenda, University of Kinshasa) and Burundi (Dr. J. Bukuru, University of Burundi).

Some of the participants of the Second ALNAP Workshop. From left to right: Jeremie Ngezahayo (Burundi), Yoseph Atilaw (Ethiopia), Nalika Nusula, and Kabonesa Dora (Uganda).

Ermias Dagne, born on 8 June 1944 in Hararge Province, Ethiopia, is Director of *The African Laboratory for Natural Products* (ALNAP) based at the Chemistry Department of the Addis Ababa University, Ethiopia. He is also a founding member of the Natural Products Research Network for Eastern and Central Africa (NAPRECA).

His main research is in the area of natural products chemistry, with publications now exceeding 90, dealing mainly with the isolation and structure elucidation of natural compounds. His research was supported by grants from the International Foundation for Science, ISP-IPICS and Sida-SAREC.

He received Alexander von Humboldt Fellowship in 1982 (FRG) and Fulbright (USA) in 1992. He was elected in 2008 as fellow of TWAS, the Academy of Sciences for the Developing World. His scientific contributions were recognized by international awards, IFS/DANIDA (1997) and IOCD Pierre Crabbé (2003). With his wife Tadelech Tadesse he manages a natural products business known as Ariti Herbal.

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Asian Network of Research on Anti-Diabetic Plants

Mohammed Mosihuzzaman

1. Formation of ANRAP

Collaborative research between the Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders (BIRDEM), Dhaka, and the Department of Chemistry, University of Dhaka, on anti-diabetic plant materials developed during 1989–1994 with support from IPICS. Following a successful workshop in 1992, an international seminar was held on 8–10 January 1994. During the seminar it was realized that a multidisciplinary concerted move for finding out remedy from plant materials of an incurable disease like diabetes should be made. Recommendation for the formation of ANRAP followed. A draft proposal for setting up this network was discussed at the ACGC meeting in Melaka, Malaysia, in June 1994, where representatives of ISP, IFS, UNESCO, and FACS were present. (ACGC stands for the Asian Coordinating Group for Chemistry.) The proposal was unanimously approved, and ANRAP was formally launched in a meeting of the Ad-Committee in its meeting in Dhaka on 7–8 January 2005.

The draft constitution of ANRAP was approved and accordingly the first ANRAP Board was elected at the meeting with Professor Mohammed Mosihuzzaman (Bangladesh) as the Chairman, Professor A. K. Azad Khan (Bangladesh) as General Secretary, and Professor Avijit Banerjee (India) and Professor Eric H. Karunanayake (Sri Lanka) as Members. In its next international seminar (2nd ANRAP International Seminar) the number of persons in the Board was increased to five as given in the constitution.

The current (2007–2009) Board members are Professor Mohammed Mosihuzzaman (Bangladesh; Chairman), Professor A. K. Azad Khan (Bangladesh; General Secretary) and Professor Nordin Hj. Lajis (Malaysia), Professor Biswapati Mukherjee (India), and Professor M. Iqbal Choudhary (Pakistan), Members.

2. Objectives of ANRAP

- To develop close cooperation between the scientists working in the field of anti-diabetic plant research;
- To compile information on the anti-diabetic plant materials reported in the scientific literature and reputed in the folkloric use;
- To exchange views, experiences, and information among the research workers in the field;
- To make a concerted effort in finding out pure active anti-diabetic principles from plant sources;
- To scientifically evaluate the formulations prepared from one or more plants and used in traditional medical systems;
- To make facilities available in the field in one laboratory to the workers in other laboratories;
- To train junior workers, especially postgraduate students, at laboratories where proper facilities are available;
- To arrange exchange visits by scientists working in the field;
- To organize seminars on plant materials as a source of anti-diabetic agents;
- To cooperate with scientists working in various fields of natural products involving other plants or disease areas.

3. Fellowship Program

The Fellowship Program is a key activity of ANRAP. The network provides airfare and subsistence, and the host laboratory provides working facilities. So far, 23 Fellows from 8 countries have availed this opportunity. Most of the Fellows used the combination of working facilities in biological (BIRDEM) and chemical (DU) fields in Dhaka. Anti-diabetic rat models developed in BIRDEM was the main tool for biological testing. In Pakistan, the Fellows utilized the excellent spectroscopy facilities at the HEJ Research Institute of Chemistry, University of Karachi.

Out of the 23 Fellows, 14 were postgraduate students at various levels of their MSc, MPhil or PhD studies. Among them 9 have completed their PhD degree, and others have either finished MSc or MPhil. Five Fellows were Scientific Officers in Research Organizations in their respective countries. Five of the Fellows were relatively senior having already secured their PhD degree. They came to Dhaka for shorter terms to learn specific techniques and discuss possible research cooperation. The Fellowship period lasted between 1 and 12 months. It was quite incidental that there was a nice gender balance among the ANRAP Fellows, 12 being male and 11 being female.

Table 1. List of ANRAP Fellows.

Name	*Country of Origin*	*Host Country*	*Fellowship period (months) and year*	*Degree acquired*
Shahinul Haque Khan (M)	Bangladesh	Thailand	4 (1997)	PhD
Tuhin Kanti Biswas (M)	India	Bangladesh	5 (1998)	PhD
Anjuman Ara Begum (F)	Bangladesh	Pakistan	3 (1998)	PhD
M. Nur-e-Alam (M)	Bangladesh	Pakistan	6 (1999)	PhD
Sarat Baba Amatya (M)	Nepal	Bangladesh	4 (1999)	
Dr. Rehana Rashid (F)	Pakistan	Bangladesh	3 (1999)	
Dr. R P Nandi (M)	India	Bangladesh	0.5 (2000)	
Sadhana Amatya (F)	Nepal	Bangladesh	4 (2000)	
Selestin D. Sokeng (M)	Cameroon	Bangladesh	12 (2000-2001 and 2004)	PhD
Mohammad Mostafa (M)	Bangladesh	Pakistan	6 (2001)	PhD
Shrabana Chakraborti (F)	India	Bangladesh	6 (2001)	PhD
Balmukunda Regmi (M)	Nepal	Bangladesh	3 (2001)	PhD
Baikuntha Rajbhandari (M)	Nepal	Bangladesh	9 (2002-2003)	
Dr. Ashok Purohit (M)	India	Bangladesh	2 (2002)	
Dr. Meenakshi Bhagat (F)	India	Bangladesh	6 (2003-2004)	
S. P. Binti M Bohari (F)	Malaysia	Bangladesh	4 (2005)	MSc
Dr. B. P. Sarma (M)	India	Bangladesh	2 (2006)	
Swarnali Sarma (F)	India	Bangladesh	12 (2006-2007)	MSc
Thushari Bhandara (F)	Sri Lanka	Bangladesh	7 (2006-2007)	MPhil
Suad Naheed (F)	Pakistan	Bangladesh	1 (2007)	PhD
Huneza Khanam (F)	Pakistan	Bangladesh	1 (2007)	
Monisha Das (F)	India	Bangladesh	8 (2008-2009)	
Ivan L Lawag (M)	Philippines	Pakistan	1 (2008)	

Of the 23 Fellows, 18 were hosted by the Dhaka Group (BIRDEM & DU), 4 were hosted by the HEJ Research Institute of Chemistry (Pakistan) and one Fellow from Bangladesh was hosted by Mahidol University, Bangkok, Thailand. Out of the 4 Fellows going to Karachi, 3 were PhD students from the Dhaka Group who used the excellent spectroscopy facilities at HEJ. One postgraduate student from the Philippines has spent one month in Karachi to learn some bioassay techniques developed during the author's stay in Karachi.

By hosting 18 ANRAP Fellows from six different countries (Cameroon, India, Malaysia, Nepal, Pakistan, and Sri Lanka) the Dhaka laboratories got enriched both in developing research culture, competitive working habit and producing good results. The Fellows got trained and the host laboratories (BIRDEM and DU) got connected with various laboratories in the region, some of which have started work on anti-diabetic plants and entered into long-term collaboration, especially with BIRDEM. As the DU laboratory has switched its concentration from natural products to organic pollutants, BIRDEM and more specifically BIHS (Bangladesh Institute of Health Science), another organ of the Bangladesh Diabetic Association, is fast developing its chemistry wing to cater to the research needs of plant materials. Coincidentally the ANRAP Chairman, after retiring from DU and spending about 2 years at HEJ, has joined the BIHS with the goal of establishing an International Centre of Natural Product Research (ICNPR) and is now looking after ANRAP activities more closely than ever before.

The ANRAP Fellows from various laboratories at home abroad have not only got training and research degrees but have also published a good number of articles in national and international refereed journals. ANRAP Secretariat is now in the process of compiling those publications and hopefully in its future report list of such publications will be made available. A consolidated list of ANRAP Fellows (1997 – August 2009) is given in Table 1 on page 301.

4. Organizing Seminars/Symposia

4.1. International Seminars

1. The 1st ANRAP International Seminar was held in BIRDEM, Dhaka, on 8–10 January 1994. A total of 200 Participants from India, Pakistan, Philippines, Japan, France, UK, Sweden, Kenya, Cameroon, Australia, Malaysia and Bangladesh attended.
2. The 2nd ANRAP International Seminar was held in Dhaka on 6–8 December 1997. A total of 250 Participants from India, Pakistan, Philippines, France, UK, Sweden, Kenya, Australia, Malaysia, Bangladesh, Indonesia, Thailand, Germany, Norway, Sri Lanka, Bhutan, USA, Nepal and New Zealand attended.
3. The 3rd ANRAP International Seminar was held in Dhaka on 16–17 November 2000. A total of 400 local and 27 foreign participants from India, Pakistan, Nepal, Sri Lanka, Iran, Sweden and Australia attended.
4. The 4th ANRAP International Seminar was held in Kolkata, India, on 16–18 January 2004. A total of 350 participants from India, Nepal, UK, France, USA and Bangladesh attended.
5. The 5th ANRAP International Seminar was held in Kuala Lumpur, Malaysia on 8–10 November 2006. A total of 320 participants from India, Bangladesh, Pakistan, Mauritius, Philippines, Japan, France, UK, Sweden, Kenya, Cameroon, New Zealand, Australia, and Malaysia attended.
6. The 6th ANRAP International Seminar was held in Dhaka, Bangladesh during 15–17 January 2010.

4.2. ANRAP Bangladesh National Seminars

Place	*Period*	*# of* participants
Dhaka	April 2000	250
Chittagong	February 2002	150
Dhaka	October 2003	250
Dhaka	April 2005	300
Dhaka	June 2006	250
Dhaka	March 2008	300

4.3. Regional ANRAP Seminars

Place	*Period*	*# of* participants
Jorhat, Assam, India	November 2007	350
Kathmandu, Nepal	June 2009	250

4.4. ANRAP Regional Workshops

Place	*Period*	*# of* participants
Kuala Lumpur, Malaysia	January 2005	150

5. Support for Attendance to International Seminars/ Conferences

Young research workers, ANRAP Fellows and senior scientists working on plant materials reported to have anti-diabetic activities were supported either partly or fully to attend Seminars, Symposia, and Conferences. ANRAP Board members were also supported in some cases. Participation in the International Symposium on Natural Products (Pakistan), annual meetings of EASD (European Association for the Study of Diabetes), IDF (International Diabetic Federation) meetings, and National, Regional and International Symposia organized by ANRAP were considered important. Twenty-nine such supports, of which about 50 % were partial supports, have been undertaken by ANRAP.

6. ANRAP Board Meetings

Number	*Place*	*Date*	*Members present*
1−4	Dhaka	1995−1998	M. Mosihuzzaman, Avijit Banerjee, and A. K. Azad Khan
5	Dhaka	1999-01-31	M. Mosihuzzaman, Avijit Banerjee, and A. K. Azad Khan. Malin Åkerblom by invitation
6	Dhaka	2000-04-07	M. Mosihuzzaman, Avijit Banerjee, A. K. Azad Khan, and M Iqbal Choudhary
7	Dhaka	2000-11-17	M. Mosihuzzaman, Avijit Banerjee, and A. K. Azad Khan
8	Chittagong	2002-02-11	M. Mosihuzzaman, A. K. Azad Khan, M. Iqbal Choudhary, and Biswapati Mukherjee
9	Dhaka	2003-01-11	M. Mosihuzzaman, A. K. Azad Khan, M. Iqbal Choudhary, and Biswapati Mukherjee
10	Kolkata	2004-01-18	M. Mosihuzzaman, A. K. Azad Khan, M. Iqbal Choudhary, and Biswapati Mukherjee
11	Kolkata	2004-01-18	M. Mosihuzzaman, A. K. Azad Khan, M. Iqbal Choudhary, and Biswapati Mukherjee
12	Kuala Lumpur	2005-01-11	M. Mosihuzzaman, A. K. Azad Khan, Biswapati Mukherjee, and Nordin Hj Lajis
13	Karachi	2006-01-07	M. Mosihuzzaman, A. K. Azad Khan, M. Iqbal Choudhary, Biswapati Mukherjee, and Nordin Hj Lajis
14	Kuala Lumpur	2006-11-09	M. Mosihuzzaman, A. K. Azad Khan, M. Iqbal Choudhary, Biswapati Mukherjee, and Nordin Hj Lajis
15	Kuala Lumpur	2006-11-09	M. Mosihuzzaman, A. K. Azad Khan, M. Iqbal Choudhary, Biswapati Mukherjee, and Nordin Hj Lajis
16	Dhaka	2008-03-15	M. Mosihuzzaman, A. K. Azad Khan, M. Iqbal Choudhary, Biswapati Mukherjee, and Nordin Hj Lajis

7. Major Achievements

- Created awareness among the natural product scientists of the Asian Region on the importance of research on anti-diabetic plants;
- Trained a good number of postgraduate students and young scientists in the field of natural products chemistry in general and anti-diabetic plants in particular;

- Trained quite a few researchers on the development of diabetic model rats and using them for biological evaluation of plant extracts, fractions and pure compounds;
- Generated new research centres working on anti-diabetic plant materials;
- Created better facilities in Bangladesh for research on plant materials reported to have anti-diabetic properties.

Mohammed Mosihuzzaman has also authored an article on the importance of collaboration and networking; see page 79. There is a presentation of him on 85.

Challenges and Constraints in South-South collaboration: The experience of AFASSA

Vijaya Kumar

The importance of regional and interregional cooperation in the South has been realized by most of the perceptive scientific thinkers involved in the promotion of science in developing countries. It has been promoted by the International Science Programme for more than 25 years, initially through the efforts the Director of the International Programme in the Chemical Sciences (IPICS), Professor Rune Liminga made in persuading scientists to collaborate within the region and extend their facilities for scientists from less well endowed institutions in their region. In fact, I became the first regional fellow of IPICS when I visited Mahidol University and worked with Vichai Reutrakul and Manat Pohmakotr with the main idea of accessing the mass spectroscopic facilities available at Mahidol. I was working in a good developing country laboratory and during my stay I was able to not only identify many activities which could be replicated in Sri Lanka and improve our laboratories and research programmes but also understand the challenges facing such laboratories and how they could be surmounted. In fact during most of my first month at Mahidol the mass spectrometer was non-functional. My stay at Mahidol made me rethink my own research direction and strategy and plan on concentrating future research on bioactive natural products rather than essential oils.

With the need to introduce bioactivity directed fractionation in our natural product research, which had by then become focused on the development of botanicals with potential for crop protection, one of the first problems we faced was the development of suitable bioassays. We sent Harshani Bulumulle (M.Phil., 1991) to the Bhabha Atomic Research Centre, Mumbai, on a IPICS Regional Fellowship to work with Ashok Banerjee in order to transfer the bioassay techniques used by his group to Peradeniya. Although we embarked on a bioassay-directed fractionation programme based on the *Aedes egyptii* bioassay used in Mumbai, we had problems in maintaining the insect culture and in the reliability of the results. Subsequently I too spent three months on an IPICS Regional Fellowship at Mumbai, and on my return we were able to sort out the problems and establish a routine *Aedes egyptii* bioassay and use it as the initial bioassay to determine the activity of an extract and for the fractionation of extracts. Through the regional fellowship, we had successfully transferred basic bioassay technology from Mumbai to Peradeniya.

We however realized that the few bioassays we could carry out at Peradeniya were insufficient if we were to develop into a significant group in the field. We were able to send Premaratne Bandara (PhD, 1993) to the International Centre for Insect Physiology and Entomology (ICIPE), Kenya, on an IPICS Interregional Fellowship to work with Ramesh Saxena on the insecticidal activity of some Sri Lankan plant extracts and to be trained in insect bioassays as part of a sandwich degree. On his return, we were able to convince IPICS to provide us support to build an insectory in the Department. It was largely due to his training at ICIPE that we were able to establish and develop a number of bioassays in subsequent years and build up a strong botanicals/biopesticide group at Peradeniya.

We too subsequently hosted scientists at our laboratories, two from Nepal, Professor Mangala Manandhar and a student of hers who visited us and were trained on bioassay development.

This is why we have become convinced of the usefulness of regional and interregional cooperation. It provides not only novel insights to a young researcher which can mould his/her research thinking and strategy, but also facilities not available at the home laboratory and training in new techniques which could be adapted for use at home. Moreover it provides exposure to constraints and pitfalls one would face while working in a developing country laboratory and possible strategies that could be used to overcome them. Problems could affect research by making instruments not available through delays in the repair, by the lack of urgently required chemicals and by poor access to literature and even non-scientific problems that crop up in developing countries like difficulties in obtaining a visa, finding suitable accommodation at reasonable rates and in some countries political problems which affect security of stay.

Regional and interregional cooperation gave our group access to more funding from SAREC and from a company involved in crop protection, largely because our initial work which was developed through cooperation assured funding agencies of our capabilities. We were able to improve our capacity both in human resources through training both in Sri Lanka and abroad and in research infrastructure through investment in equipment and instruments. We established extensive bioassay facilities and developed field testing and formulation capability. Although one of our products was developed until the penultimate stage for production as a commercial pesticide by the company, the project had to be finally abandoned due its poor photostability in international field testing. We have however made products for the local farmer, including a protein bait for fruit and melon flies which is presently being manufactured and sold in Sri Lanka and an improved neem-based pesticide, which is now ready for production.

This type of experience underlining the usefulness of regional and interregional cooperation is not unique to us. It has been the experience of many groups which have developed over the years to provide leadership in many research areas, particularly in Natural Products Chemistry in the third world. Although regional cooperation is easy to organize, there has been very little interregional cooperation and it was this realization that prompted Federico Dajas of Uruguay and Rune Liminga to propose the formation of AFASSA, an acronym for *Africa Asia South America*, which would coordinate the activities of several networks in Natural Products Chemistry and promote interregional cooperation in the field.

The rationale for the formation of AFASSA was the realization that there were many advanced laboratories in Chemistry and Biology in the South, some specialized in niche areas and most well equipped but South-South collaboration had not taken place to a significant extent largely because there was no mechanism to promote such collaboration. South-South collaboration would permit research to be directed on problems of the South and the groups involved would gain from the synergism generated by such collaboration. Furthermore it would facilitate the training of young scientists in the best laboratories in the South at cheaper cost, in a research environment similar to that at home and in the organization of symposia and meetings which would bring together scientists from the South, encouraging further collaboration.

AFASSA activities were mainly to be centred on studentships for the training of young scientists in laboratories belonging to the network and other advanced laboratories in the South. This year we were able to provide partial travel support to facilitate the travel of Moses Akanmu from Ile-Ife, Nigeria to Montevideo to be trained in Federico Dajas' Neurochemistry group. AFASSA has organized several symposia over the years, usually held in association with other symposia, largely due to funding considerations. The last symposium was held in 2008 at Kasane, Botswana, with the IOCD-ISDNP Symposium held there at that time. A post-ASOMPS Symposium planned in Sri Lanka when the Asian Symposium on Medicinal Plants, Spices and Other Natural products (ASOMPS) is held at Karachi in 2010 is awaiting confirmation of the date of the Karachi Symposium. AFASSA usually funds the participation of young scientists at these symposia.

However AFASSA has faced several challenges and constraints in its work. The main constraint has been that of funding. Although AFASSA's plans have been ambitious, it has not been able to generate the kind of funding necessary to implement these plans. It has also been observed that students prefer training in the North to that in the South. There could be several reasons for this, including the risk of non-functional instruments even in well-equipped laboratories, although the turn-around time for repairs of instruments in the better equipped laboratories is now much less and delays in access to materials and chemicals, particularly when a student is undertaking a “home” research problem and requires further material from the home laboratory. Apart from these, there are several logistic problems in organizing interregional collaboration. Reasonable accommodation for foreigners, even students, in developing country cities is often expensive and it may be difficult to find affordable student accommodation in relation to the stipend received. However many campuses have recently been able to build guest houses to cater for visitors and this has gone a long way to solve this problem. Public transport in many developing countries is often not well developed and always over-crowded, restricting their use by students. Visas are sometimes difficult to obtain for visitors coming from countries which do not have regular visitors to the host countries. An AFASSA student from Cameroon planning to work in Dhaka, Bangladesh, was prevented entry at Dhaka airport due to visa problems and returned home, wasting the scarce travel funds available to AFASSA. Obtaining a visa and sanction for the visit is often hindered or delayed by government and institutional bureaucracy and financial regulations of the host country. Furthermore many developing countries are unable to assure the student of a safe and secure environment due to political problems, making many students vary of working in the country, however much the institution confirms it to be safe. Another problem which faced AFASSA has been the lack of awareness among scientists of the existence of such programmes.

In order to face these challenges, AFASSA planned several strategies. Among them were an increase in publicity for the organization through a better web-site and dissemination of AFASSA literature. This website, at www.afassa.org, is now fully functional and a brochure on AFASSA has been printed and distributed through the networks and also at important natural products symposia in the three continents. Information on the laboratories and facilities available has been disseminated. It was also decided to create a new individual membership of AFASSA, mainly as a means to improving awareness and to obtain firmer commitment to the concept among third world natural products scientists. It was also decided that training programmes should be planned carefully so that potential problems are resolved before the studentship began, and that new sources of funding should be explored which would enable AFASSA to undertake and expand its activities.

There was also a suggestion which came from the organizers of the ASOMPS Symposium, which is held once every three years in Asia, noting that similar conferences are held in Africa and South America by the regional networks of NAPRECA and LANBIO. Their suggestion is that the meaning of the acronym ASOMPS be changed so that the A refers not to Asia but to Asian, African, American and that the Symposium be held once every year moving from continent to continent, so that there will be a Symposium in each continent once every three years. Such symposia will attract scientists from all three continents and thus promote interregional cooperation. AFASSA was asked to facilitate this suggestion, and the AFASSA Coordinating Group has accepted it in principle.

Our conclusions are that regional and interregional cooperation is of immense value and should be encouraged. It will lead to more relevant research, especially in terms of impact on society. However this requires new and larger sources of funding, possibly from inter-governmental groups like the European Union for instance. In order to overcome constraints it may be necessary to evolve a new mechanism involving South-South-North cooperation rather than South-South cooperation alone. However, the logistics will then have to be organized at least initially by an established funding agency. The involvement of a North partner or a North funding agency would help in sorting out Visa problems and facilitating quick resolutions to constraints faced during the studentship such as instrument and chemicals problems.

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Networking to build regional capacity in Africa: The efforts of NABSA

Berhanu Abegaz

Abstract. This paper presents the efforts made by the Network for Analytical and Bioassay Services in Africa (NABSA) to build regional capacity in the chemical sciences, particularly in the area of natural products, through three main activities: (1) providing spectral services to scientists in facility constrained institutions; (2) short-term research visits, principally to the research group of the Network Coordinator in Gaborone; and (3) dissemination of information through subregional symposia, and publications. Besides presenting the unique aspects of the activities and their implications, verifiable indicators and quantitative data are provided in terms of publications and trained scientists. IPICS' support in terms of finances, guidance and facilitation to interact regionally; the synergetistic support obtained from other organizations like TWAS, OPCW, UNESCO, etc., have been crucial to realize NABSA's achievements. This paper also gives two examples of successful research cooperation among scientists in the region. The paper concludes with an effort made to form regional multidisciplinary groups to address regional problems and also to secure financial support from larger funding agencies.

1. Introduction

Many scientists in Africa, including those returning after completing PhD training outside Africa, often seek collaboration with their former mentors or other North-based scientists who offer services of scientific instrumentation and joint publications in return for access to African biological resources. There are excellent cases of this type of collaborations that have made contributions to capacity building in terms of human resource development for African institutions. Many scientists often mention the difficulties they encounter due to the lack of suitable research environments in their own countries to allow them to initiate relevant and active research programmes. Many young scientists are frustrated due to scientific isolation and lack of access to equipment, scientific information, research funds, etc. It is in this regard that NABSA has, during the last decade or so, played a small part in providing a viable means of collaboration among a small but significant number of African scientists to produce a reasonable quantity of research output and in the process contribute to capacity building in the area of natural product sciences.

The purpose of the NABSA programme is to develop regional cooperation among selected scientists and research groups in Africa. The key factors in this programme are: (1) the availability of excellent facilities in the Department of Chemistry of the University of Botswana (UB), and the willingness of the institution to share these resources; (2) the record of good performance of the Natural Products Research group of the Network Coordinator; (3) the network of collaborating scientists from Cameroon, Democratic Republic of Congo, Ethiopia, Ghana, Kenya, Nigeria, South Africa, Tanzania and Zimbabwe that have established excellent working relationships with the research group in Gaborone; (4) recent efforts by multidisciplinary groups formed by scientists from these countries who are focusing attention on neglected diseases relevant to the region; and (5) the synergy derived through the participation of other organizations (TWAS, OPCW, ANSTI, GIBEX, etc.) in supporting the NABSA activities

2. NABSA's spectral services programme

One of the main contributions of NABSA has been the provision of analytical services, particularly NMR and mass spectral services. The two major lines of instrumentation available at UB are: (a) NMR (a High field 600 MHz instrument which is hyphenated to an HPLC system, and a 300 MHz spectrometer fitted with full automation for uninterrupted running of samples using a 64 sample robotic system; and (b) a High Resolution Mass Spectrometer capable of undertaking exact mass measurements and hyphenated GC-, and LC-MS systems, fitted with EI as well as a range of soft ionization techniques. Two experts, Dr. M. T. Bezabih, and Dr. K. Sichilongo are heading the two NMR and MS laboratories, respectively. Table 1 shows the yearly services rendered by NABSA to scientists in Africa and also the total number of NMR spectra determined for scientists in eleven countries during the last eleven years. Obviously scientists from Cameroon have benefited most, followed by Tanzania with those in Kenya and Nigeria coming distant third and fourth. We have also successfully set up two remote NMR workstations in Dar es-Salaam and Cameroon. These stations are able to access the NMR server computer in Gaborone directly (although recently firewalls set up at institutions are making remote access difficult; consequently we are reverting to burning FIDs on CDs and sending these to be processed at the remote workstations). Many theses written in the Universities of Dar es-Salaam, Nairobi, Dschang, and Yaoundé clearly display NMR and mass spectra determined in the University of Botswana. Numerous papers and theses published from Tanzania and Cameroon acknowledge such assistance from NABSA. An article published in *Analytical Chemistry* (2003, 75(5) 106A–113A) refers to the NABSA services as a fine example of regional cooperation in spectroscopic services.

Table 1. Spectral services from the NMR and MS facilities of the University of Botswana.

Year	*NMB*	*MS*	*Country*	*NMR Spectra 1998–2009-09*
1998	236	80	Cameroon	4,840
1999	476	124	DRC	192
2000	844	296	Egypt	55
2001	967	294	Kenya	925
2002	1,025	337	Nigeria	989
2003	1,138	389	Senegal	16
2004	1,902	234	South Africa	463
2005	1,672	27	Sudan	1,049
2006	539	168	Tanzania	2,796
2007	905	28	Zambia	63
2008	1,912	125	Zimbabwe	535
2009-01–09	209	56		
Total	11,825	2,158		11,923

2.1. NABSA's short-term visits

This programme allows the visit of a researcher, who may be a postgraduate student or a senior researcher, to visit for a period of up to three months. In some special cases, this visit may be for a maximum of six months. The scheme allows for intensive cooperation between the host scientist in Gaborone and the visitor from the region. Multiple visits are possible to allow interaction between the host at the NABSA center and a research group under the guidance of a senior professor. Typically, different students come to Gaborone and occasional visits are arranged for the leader of the client group in order to allow overall discussions between the two research leaders, to review past achievements, define the scope of future collaboration, and to write papers for publications. Seven research groups are currently collaborating with us (see below). In 2002, TWAS recognized the Natural Products Research Groups in the University of Botswana as a South Center of Excellence and approved a scheme that allows for up to ten scientists (identified as Associate Fellows) to come to Botswana for a period of three months on a cost-shared basis. Accordingly, TWAS pays for travel and incidental expenses and the host at UB pays for maintenance and research costs. OPCW and ANSTI also provide fellowships for staff to undertake research visits in other member institutions. These fellowships pay for the travel as well as maintenance costs of the visitor. The host institution is required to provide facilities for research. Three fellows have so far succeeded in getting such a grant. All in all, NABSA's Short-Term Visit scheme has enabled 34 visitors to come our laboratories:

from Burkina Faso, Dr. G. Yonli (1 visitor);
from Cameroon, research groups of Professor B. T. Ngadjui, Professor Tane, Drs. G. F. Kapche, J. Vardamidies, F. Ngandeu, and their students (11 visitors);
from Nigeria, from the research group of Professor A. Ogundaini (3 visitors);
from Ethiopia, research groups of Professor E. Dagne, W. Mammo (1 visitor);
from Kenya, Professor J. Midiwo (2 visitors);
from Congo, Professor V. Mudogo (2 visitors);
from South Africa, Professor K. Eloff, Dr. G. Matsabisa (4 visitors);
from Sudan, Professor S. A. Khalid, Dr. S Yagi (2 visitors);
from Tanzania, Professor Nkunya, Dr. Magadula (3 visitors); and
from Zimbabwe, Dr. S. Mukanganyam (5 visitors).

Indeed much has been achieved through these visits: 20 PhD and 5 MSc theses and 58 papers have been written and published.

Table 2. Publications based on short-term visits of reseachers to the NABSA Coordinator's Research Group in Gaborone.

Peer-reviewed journal	*Country / Institution*						
	Ethiopia	*Dschang*	*Tanzania*	*Yaoundé*	*Douala*	*Zimbabwe*	*Total*
Biochemical Systematics and Ecology		2			1		3
Bulletin of Chemical Society of Ethiopia	2	1		3			6
Journal of Ethopharmacol.				3			3
Nat. Prod. Com.		1					1
Phytochemistry	6	1	2	11	1		21
Pure & Appl. Chem.				2			2
Others	6	1		13		2	22
Total	14	6	2	32	2	2	58

2.2. Subregional postgraduate students' symposia

This is an activity that brings together postgraduate students from three universities of the region to one of the institutions in order to make oral and poster presentations of their research. The symposium is often started with a plenary lecture by a senior staff from the host university, and thereafter it is devoted to the students. This activity is important to build peer contact and critique, and also to build the confidence and morale of the students. Seven such symposia have been held so far.

3. Two examples of successful research regional cooperation

3.1. The *Dicoma* project

In 2002 a delegation from the Medical Research Council (MRC) of South Africa approached the NABSA Coordinator and requested assistance in elucidating the structures of a series of dimeric sesquiterpenoid lactones detected from a south African plant (*Dicoma anomala*) that had been found out to possess anti-plasmodial properties. LC-NMR experiments had been conducted on the active extract of the plant and the molelcular masses of 500, 502, 504 and 506 recorded for these lactones. A provisonal patent had been applied for and it was important that more scientific data be generated. Cooperation with the MRC began after MOU and confidentiality agreements were signed. NMR spectra measured on samples received from the MRC demonstrated the dimeric sesquiterpene nature of the compounds but the spectra were not clean enough to elucidate the structures. A Sudanese student on a one-semester visit to UB was assigned to isolate the active compounds from 300 g of plant material received from the MRC. She was able to isolate 20 mg of the major active ingredient from the South African plant and 22 mg of a closely related sesquiterpene dimer from the locally collected *Dicoma*. At this time (2003) the Network Coordinator was on a sabbatical leave in Addis and he teamed up with a host colleague in Addis and the structure of both compounds were fully elucidated. Antiplasmodial and cytotocicity data were measured at the Medical Research Council laboratories in Cape Town, and the results were indeed promising (Table 3). A full patent was applied by the MRC lawyers and subsequently secured. As a follow up of the foregoing results it became important for our MRC collaborators to get large quantities of these active compounds to conduct in-vivo antimalarial experiments on animals and also to assess mammalian toxicity. This was achieved through the participation of a Cameroonian scientist who worked with us at UB and successfully isolated sufficient quantities of these sesquiterpene dimers. The purified compound was couriered to the MRC where animal experiments are currently going on and we are informed that this substances do confer protection against malaria for the animals under investigation.

Table 3. Antiplasmodial and cytotoxicity data for natural products and reference compounds.

Compound	*Source*	*Antiplasmodial activity*	*Cytotoxicity* $IC_{50}\mu g/Ml$
BW-484	Botswana	0.04 μM	6.4
RSA-500	South Africa	0.06 μM	1.1
Chloroquine	Commercial	0.03 μM	—
Emetine	Commercial	—	0.05

This project has benefited from the contributions of students and senior scientists from five countries: Botswana, Cameroon, Ethiopia, South Africa and Sudan.

3.2. The *Rhus* project

Rhus pyroides has potentially the same kind of history, and hopefully end, as that of the neem tree. The discovery of neem is attributed to Heinrich Schmutterer, who observed that swarming desert locusts in Sudan defoliated almost all local flora except the neem trees.[1] Likewise in the mid-eighties chemists in Botswana were informed by local farmers that the notorious crop pest, the corn cricket, voraciously eats most green plants but avoids the leaves of the indigenous plant, *Rhus pyroides*. It then became a departmental project for a while and the NABSA coordinator became involved in 1997 when a Motswana student enrolled to do a MSc degree in natural products. The student isolated one novel bichalcone of unusual structure. The natural product was named rhuschalcone I.[2] We sought the help of Kenyan scientists to assess the effect of rhuschalcone I on insects. They were not able to test for activity on the corn cricket, since this insect was not available to them. They were, however, able to determine that the compound showed poor anti-feedant but toxic to *Locust migratoria*. It was neither toxic nor anti-feedant to *Schistocerca gregaria*. Subsequently, a Tanzanian PhD student investigated the same plant and was able to isolate five more bichalcones, which were named Rhuschalcone II–VI. These compounds had two structural types based on the linkage of the two chalcone moieties. Rhuschalcone I–IV showed two chalcone moieties that were linked through oxygen, while Rhuschalcones V and VI had Bi-chalcone C-C linkages. The Tanzanian student was not only able to isolate and identify

[1] National Research Council, 1992. *Neem. A Tree for Solving Global Problems*. Washington, DC: Natl. Acad. Press, 141 pp.

[2] I. B. Masesane, S. O. Yeboah, J. Liebscher, C. Muegge, and B. M. Abegaz (1999). A Bichalcone from the twigs of *Rhus pyroides*. *Phytochemistry* **53**, 1005–1008.

the chalcones, but was also able to synthesize one of the bi-aryl ether bichalcones.[3]

More recently a Congolese PhD student has developed a general synthetic methodology that is applicable for the synthesis of C-C linked bichalcones. This methodology was developed through a joint cooperation with a senior professor from Addis Ababa University. While the overall synthetic methodology was designed in Gaborone, the key step of the method employed what is known to us as the Suzuki coupling reaction. This key step was optimized for the synthesis of bichalcones under the guidance and supervision of Professor W. Mammo of Addis Ababa University. The general applicability of the method was demonstrated by synthesizing a total of nine bichalcones. This has paved the way for undertaking a thorough biological evaluation of these class of compounds, which have shown a wide array of biological activities.

The most exciting conclusion of the *Rhus* story would be to conduct tests of the isolated compounds on the corn cricket itself, and this is exactly what we intend to do when the insect emerges in December 2009 – January 2010. In summary, this project has served as an example of a successful multidisciplinary regional project involving students and senior scientists from Botswana, the DRC, and Ethiopia.

4. Efforts to establish regional multidisciplinary research teams and seek larger funding

The NABSA experience has gone through evolutionary phases: initially the focus was the provision of analytical services. Emphasis then shifted from indiscriminate running of spectra for everyone to engaging those interested in establishing research cooperation and joint publications. Efforts during the last five years have been focused to establish multidisciplinary research groups among like-minded scientists in the region. The two projects mentioned in Section 4, were examples of the early stages of the effort to form regional multidisciplinary groups addressing regional problems. The Dicoma project was successful in getting a regional grant of 600,000 ZAR from the South African Department of Science and Technology.

Our efforts to submit research proposals for larger funding have not always been successful. In 2006, a joint application on antimalarials (entitled Control of Malaria in Africa with Natural Products Grown Under Agroforestry, and Integration into Local Economies) with scientists from Botswana, Cameroon, Ethiopia, Madagascar, Zimbabwe, together with scientists from Oregon State

[3] Ladislaus K. Mdee, Samuel O. Yeboah, and Berhanu M. Abegaz (2003). Rhuschalcones II−VI, Five New Bichalcones from the Root Bark of *Rhus pyroides*. *J. Nat. Prod.* 66(5), 599−604.

University to the Melinda and Bill Gates Foundation was rejected during the first round of screening. In 2008, a regional project submitted to RISE was selected during the first round of short-listing for the best projects, but failed during the final round. However, a third application (to screen African natural products for a new broad-spectrum anthelimintics with a low propensity for the development of resistance targeting peptide GPCRS as the core basis for the screen) with scientists from McGill University to Melinda and Bill Gates Foundation was successful in getting a grant development funding of 100,000 USD for a period of two years. A major outcome of this funding has been the establishment of the Pan-African Natural Products Library (P-ANPL). An expanded group of 13 scientists (nine from Africa and four from the US and Canada) are now preparing the research proposal targeting 1 MUSD over a two-year period. The NABSA and ALNAP coordinators (B. M. Abegaz from Gaborone and E. Dagne from Addis) have also teamed with Professor Kelly Chibale of Cape Town and B. Nyasse of Cameroon and submitted a proposal concept to the Welcome Trust which has passed the first level of selection for a more detailed proposal.

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Network of Instrument Technical Personnel and User Scientists of Bangladesh (NITUB)

Altaf Hussain

Abstract. The Network of Instrument Technical Personnel and User Scientists of Bangladesh (NITUB), established in 1994, is a learned society dedicated to scientific education and research in Bangladesh. The primary mission of NITUB is to create a nucleus of skilled manpower in Bangladesh to assure proper use, maintenance and trouble-shooting of scientific equipment so that scientific activities do not suffer due to non-functioning equipment. To fulfill this mission, NITUB conducts training programs on specific groups of scientific instruments for user scientists and technical personnel to update their knowledge. NITUB also runs training programs on common laboratory equipment and medical equipment for technicians, science teachers of university colleges and medical personnel. So far, NITUB has trained 499 scientists and technical personnel of Bangladesh through its 36 training programs. Another program of NITUB is the Instrument Repair Program, through which non-functioning scientific equipment is being repaired. NITUB has already repaired 859 non-functioning scientific instruments of public and private organizations of Bangladesh. It is observed that NITUB spent very little money, about 1 % of the value of the instruments, to repair them. Other than these activities, NITUB also helps different educational and research organizations of Bangladesh to install their equipment, provide experts services to buy equipment, etc. Recently, NITUB has also started programs on a regional basis, which hopefully will strengthen scientific ties between neighbouring countries.

Introduction

Scientific research and education in Bangladesh, like in other third-world countries, are suffering mainly due to the fact that proper care of scientific equipment, including its installation, maintenance and repair, are missing. Scientists are also complaining that costly scientific equipment cannot be procured owing to fund constraints, for which research activities suffer. Ironically, whatever instruments there are, they remain non-functional in many cases. This is due to insufficient technical knowledge of the scientists and scarcity of properly trained technical personnel in the country. The difficulties in maintaining and repairing scientific instruments faced by the fellows of the International Program in the Chemical Sciences (IPICS) and the grantees of the International Foundation for Science (IFS) were discussed.

On behalf of IPICS fellows and IFS grantees, Professor M. Mosihuzzaman raised the issue with the officials of IPICS and IFS and solicited their support. To improve the capability of scientists and technical personnel to use, maintain and repair scientific instruments properly, a week-long *Workshop on Instrument Maintenance and Repair* was organized in 1991 by the IFS grantees and IPICS fellows of Bangladesh at the Department of Chemistry, University of Dhaka, with the financial support of IPICS and IFS. The positive impact of the workshop led to the suggestion of conducting another National Workshop with longer duration, in which user scientists and technicians of Bangladesh working in the field of chemical and agricultural sciences could participate.

This National Workshop on Instrument Maintenance and Repair was held on 12–25 January 1994 and its practical sessions were held at Chittagong, Dhaka, and Mymensingh simultaneously. The workshop was attended by 40 scientists and technical personnel from different educational and research organizations of Bangladesh and was conducted by 6 foreign experts from the International Centre for Advanced Technology (ICAT), Luton College, UK, and 8 local resource persons. The main sponsor of the National Workshop was IFS, with some contributions from a few other national and international organizations. A post-workshop meeting attended by the resource persons, organizers, IFS and IPICS representatives was held in Dhaka, which was presided by Professor M. Shamsul Haq, Chairman, UGC. It was recommended at the meeting that a network be formed in Bangladesh to address the issue of proper use, maintenance and repair of scientific equipment. Later, this proposal was placed before the Asian Coordinating Group of Chemistry (ACGC) in a meeting held on 18 June 1994 in Melaka, Malaysia, during the Asian Symposium on Medicinal Plants, Spices and Other Natural Products (ASOMPS VIII) by Professors M. Mosihuzzaman and Nilufar Nahar of the Department of Chemistry, University of Dhaka. The proposal was supported by IFS, IPICS, UNESCO and the Federation of Asian Chemical Societies (FACS) representatives present in the meeting. ACGC took a resolution in its meeting supporting the formation of the Network of Instrument Technical Personnel and User Scientists of Bangladesh (NITUB). The network was formally launched on 19 July 1994. NITUB is a voluntary, non-profit, non-political learned society dedicated to scientific education and research in Bangladesh. NITUB has been registered as a learned society with registration number S 7887 (1077)08.

Professor Nilufar Nahar delivering a lecture in a regional training program of NITUB.

Aims and objectives

The main aims and objectives of NITUB are:

I. to improve upon the capabilities of the technical personnel and user scientists in handling, maintaining, trouble-shooting and repairing of scientific instruments;

II. to conduct training courses for the technical personnel and user scientists on different types of scientific instrument;

III. to repair instruments and offer technical services to different educational and research institutions of Bangladesh by the technical personnel from the pool of NITUB and, if necessary, to procure the services of foreign technical experts;

IV. to maintain a directory of technical personnel who can offer technical assistance to NITUB;

V. to create a stock of spare parts and accessories required for repair of instruments on a routine basis and make them available to various institutions as and when necessary;

VI. to maintain an inventory of available scientific instruments in Bangladesh.

Goal of NITUB

The goal of NITUB is to see to it that all the scientific instruments of Bangladesh are functioning properly and the user scientists do not have to face problems in running their equipment.

Activities of NITUB

Training Program

NITUB organizes training programs on the use, maintenance and troubleshooting of specific groups of scientific equipment such as IR & UV-VIS, GC, GC-MS, HPLC, AAS, X-ray and NMR Spectroscopy. Beside that, NITUB also organizes workshops on common laboratory equipment, common medical equipment mainly for university college teachers, technical and medical personnel. Training programs are generally limited to 15–20 participants, run for 5–6 days, and include both theoretical and practical sessions. So far, NITUB has conducted 36 such training programs, through which 499 scientists, young faculty members, graduate students and technical personnel have been trained. NITUB is asked to conduct such training programs more frequently to train more scientists and technical personnel of Bangladesh, which will enhance the standard of scientific education and research. The details of the already conducted training programs are given in Table 1 on page 328. The participants attended in these training programs are shown category-wise in Table 2 on page 333.

Instrument Repair Program

User scientists were facing problems with their non-functioning scientific instruments. To address this problem, NITUB started the *Instrument Repair Program* in the year 1996. This program of NITUB runs throughout the year. The concerned scientist sends a request on a prescribed form of NITUB to repair his/her non-functioning instrument. Technical experts of NITUB go to the institution to find the fault of the particular instrument. In many cases, the instrument is repaired on the spot; if not, the technical experts give a report specifying the fault. If any spare parts are needed and if they cost more than 1000 BDT, the institution is requested to procure the spare parts. NITUB experts then go back and fix the instrument. The success of the technical experts of NITUB in repairing non-functioning scientific equipment made this program a very popular one among the scientists of Bangladesh. So far, NITUB has repaired 859 scientific instruments of different organizations throughout Bangladesh. Table 3 on page 333 shows the number of non-functioning instruments repaired by NITUB since 1996 and its value.

In the year 2008, three technical experts of NITUB attended a workshop on Instrument Maintenance and Repair in Nepal as resource persons. During the workshop, the technical experts repaired 50 non-functioning scientific equipment of two public universities of Nepal. Scientists of Nepal plan to launch similar type of program there too.

The different institutions who took the service of NITUB to repair their non-functioning equipment are given below:

I. Many departments of Dhaka University, Jahangirnagar University, Rajshahi University, Shahjalal University of Science and Technology, Bangladesh University of Engineering and Technology, Bangladesh Agricultural University;

II. Bangladesh Sheikh Mujib Medical University, Medical Colleges, Public Health Organization;

III. Research Organizations like Bangladesh Council of Scientific and Industrial Research, Atomic Energy Commission, Geological Survey of Bangladesh, Forest Institute, Bangladesh Institute of Nuclear Agriculture;

IV. Private Pharmaceutical Companies.

Installation

During the last few years, NITUB has also received requests for installation of equipment from different research and educational organizations. The instruments were not installed due to lack of expertise available in the concerned institution. In response to these requests, NITUB experts installed a large number of scientific instruments such as AAS, HPLC, IR, X-ray generators and GC of different organizations.

The engineers and technical experts of NITUB have not only installed the equipment but also trained user scientists and technical personnel of the respective organization to run the equipment.

A decade of NITUB

NITUB organized a one-day symposium, *A Decade of NITUB*, in 2004 to assess its strength and weakness. The symposium was attended by administrators, senior faculty members, senior scientists and participants of all previous training programs of NITUB. The participants expressed their views on the results of their experiences with respect to the training that they had received. The participants were very positive about the different training programs of NITUB and expressed their satisfaction that NITUB was at hand to help them when necessary.

Contract Service

By conducting training programs and repairing non-functioning instruments, NITUB has generated awareness among the scientific community. This achievement of NITUB has created interest both in public and private sectors, asking NITUB to sign contracts to repair their non-functioning scientific equipment on a yearly basis by different organizations. Bangladesh Petroleum Exploration and Production Company Limited (BAPEX), Government of Bangladesh, is in agreement with NITUB for maintenance and repair of their laboratory instruments. Novartis has just sent a request for such contractual service for their HPLC machines. Discussions with more organizations are going on for similar contracts with NITUB.

MOU with IFS

NITUB has signed an MOU with IFS stating that the IFS grantees (national and regional) are welcome to participate in NITUB's programs. NITUB will also repair the non-functioning equipment of IFS grantees if asked for. IFS has agreed to provide financial support to these events for its grantees. IFS has allocated a fund of 11,000 USD for the year 2008.

Regional cooperation

Following the example of NITUB, Professor Mangala Manandhar of the Central Department of Chemistry, Tribhuban University, Nepal, took an initiative to form the Network of Instrument Technical Personnel and User Scientists of Nepal (NITUN). The network is getting active support from IFS to run their activities. For the last few years, scientists and technical personnel of Nepal took part in NITUB's programs getting financial support from IFS or from their own sources. NITUB has also organized a regional training program sponsored by IFS and OPCW, where scientists and technical personnel from Nepal and

Myanmar took part. NITUB hopes to extend its regional collaboration program with other countries of the region, for example with Laos, Vietnam and Cambodia.

Programs of NITUB for the year 2009

NITUB will organize the following training programs in 2009:

I. 37th training program on Common Medical Equipment;
Venue: Gono Bishawbidhalay, Savar;
Date: October / November 2009.

II. 38th training program on the use and maintenance of HPLC;
Venues: Department of Chemistry, DU & BIRDEM;
Date: December 2009.

Future Programs of NITUB

The duration of the training programs of NITUB is generally 5–6 days. Participants frequently request NITUB to organize training programs for longer duration (i.e., 2–3 weeks). Longer duration programs will definitely help participants to be more conversant and confident in handling their instruments. NITUB plans to take up the following programs in the near future along with its usual programs:

I. 2–3 week-long training program on specific groups of instruments;

II. Courses on basic electronics;

III. Preparation of training manual of different types of instrument;

IV. Follow-up program for participants who attended any earlier NITUB programs.

Acknowledgement

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(i). The International Science Program (ISP), Uppsala University, Uppsala;

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(iii). The Organization for the Prohibition of Chemical Weapons (OPCW), The Hague, The Netherlands;

(iv). The Ministry of Health and Family Welfare;

(v). The Ministry of Science, Information and Communication Technology, Government of the People's Republic of Bangladesh;

(vi). The University Grants Commission (UGC);

(vii). Universities of Bangladesh;

(viii). The Bangladesh Council of Scientific and Industrial Research (BCSIR);

(ix). The Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders (BIRDEM);

(x). The Bangladesh Institute of Health Science (BIHS);

(xi). The Bangladesh Diabetic Somity (BADAS);

(xii). The Network of Instrument Technical personnel and User scientists of Nepal (NITUN);

(xiii). The Bangladesh Centre for Advanced Studies (BCAS).

Table 1. Training programs of NITUB conducted during 1994–2009

1. *Training Program:* Gas Chromatograph (GC).
   Venue: Department of Chemistry, University of Dhaka.
   Dates: 1994-11-19–24 and 1995-01-21–26.
   Number of Participants: 12 and 11, respectively.
   Resource Persons: Local.
2. *Training Program:* X-Ray Powder Diffraction Technique.
   Venue: Department of Chemistry, University of Dhaka.
   Dates: 1996-11-30–12-04.
   Number of Participants: 7.
   Resource Persons: Local and 1 Foreign.
3. *Training Program:* High Performance Liquid Chromatograph (HPLC).
   Venue: BIRDEM, Dhaka and Department of Chemistry, University of Dhaka.
   Dates: 1996-11-30–12-04.
   Number of Participants: 12.
   Resource Persons: Local and 1 Foreign.
4. *Training Program:* UV-VIS & IR Spectrophotometers.
   Venue: Department of Chemistry, University of Dhaka.
   Dates: 1997-06-01–05.
   Resource Persons: Local.

5. *Training Program:* Gas Chromatographs (2nd).
   Venue: Department of Chemistry, University of Dhaka.
   Dates: 1997-12-20–25.
   Number of Participants: 14.
   Resource Persons: Local.
6. *Training Program:* Atomic Absorption Spectrophotometers (AAS).
   Venue: BCSIR, Dhaka, and Department of Chemistry, University of Dhaka.
   Dates: 1998-06-14–19.
   Number of Participants: 16 and 1 foreign.
   Resource Persons: Local and 1 Foreign.
7. *Training Program:* High Performance Liquid Chromatographs (HPLC) (2nd)
   Venue: BCSIR, Dhaka, and BIRDEM Dhaka.
   Dates: 1998-11-28–12-03.
   Number of Participants: 12.
   Resource Persons: Local and 1 foreign.
8. *Training Program:* Various Common Laboratory Equipment.
   Venue: BCSIR, Dhaka.
   Dates: 1999-05-08–13.
   Number of Participants: 16.
   Resource Persons: Local.
9. *Training Program:* UV-VIS and IR Spectrophotometers (2nd).
   Venue: Department of Chemistry, Jahangirnagar University, Savar, Dhaka.
   Dates: 1999-09-11 and 1999-09-18–22.
   Number of Participants: 16.
   Resource Persons: Local.
10. *Training Program:* Atomic Absorption Spectrophotometers (2nd).
    Venue: ICDDR,B, Geological Survey of Bangladesh (GSB), BCSIR and Chemistry Department, Dhaka University.
    Dates: 2000-02-05–09.
    Number of Participants: 10.
    Resource Persons: Local and 1 foreign.
11. *Training Program:* Various Common Laboratory Equipment (2nd).
    Venue: Dhaka University.
    Dates: 2000-06-17–22.
    Number of Participants: 18.
    Resource Persons: Local and 1 foreign.
12. *Training Program:* Nuclear Magnetic Resource (NMR) spectrometer BCSIR, Dhaka.
    Dates: 2000-11-12–16.
    Number of Participants: 4.
    Resource Persons: Local and 1 foreign.
13. *Training Program:* UV-VIS and IR Spectrophotometers (3rd).
    Venue: Department of Chemistry, University of Rajshahi.
    Dates: 2001-06-23–29.
    Number of Participants: 15.
    Resource Persons: Local.

14. *Training Program:* Various Common Laboratory Equipment (3rd).
Venue: Bangladesh Agricultural University, Mymensingh.
Dates: 2001-10-27−31.
Number of Participants: 24.
Resource Persons: Local.
15. *Training Program:* Gas Chromatographs and Gas Chromatograph-Mass Spectrophotometer (GC and GC-MS).
Venue: Department of Chemistry, University of Dhaka and BCSIR.
Dates: 2001-12-26−31.
Number of Participants: 10.
Resource Persons: Local.
16. *Training Program:* Common Laboratory Equipment (4th).
Venue: BCSIR Laboratories, Chittagong.
Dates: 2001-10-27−31.
Number of Participants: 18.
Resource Persons: Local.
17. *Training Program:* High performance Liquid Chromatography (3rd).
Venue: Department of Chemistry, University of Dhaka, and Animal Nutrition Laboratory, Department of Livestock Services, Farmgate, Dhaka.
Dates: 2001-12-26−31.
Number of Participants: 12.
Resource Persons: Local.
18. *Training Program:* Common Medical Instrument.
Venue: Research Division, BIRDEM, Dhaka.
Dates: 2002-10-26−31.
Number of Participants: 20.
Resource Persons: Local.
19. *Training Program:* Common Laboratory Equipment (5th).
Venue: Science Workshop, DU, Dhaka.
Dates: 2002-10-05-10.
Number of Participants: 13.
Resource Persons: Local.
20. *Training Program:* GC and GC-MS (2nd).
Venue: Department of Chemistry, DU, Dhaka.
Dates: 2003-12-04−07 (scheduled); shifted to 2003-12-24−29.
21. *Training Program:* Regional Workshop on the Use, Maintenance and Trouble-Shooting of Common Laboratory Equipment.
Venue: NITUB Office (14/2, Topkhana Road, Ansari Bhaban,Segunbagicha, Dhaka-1000); Department of Chemistry, University of Dhaka.
Dates: 2004-03-06−11.
Number of Participants: 16, of which 7 from Nepal and Myanmar.
Resource Persons: Local.

22. *Training Program:* Atomic Absorption Spectrophotometers (3rd).
    Venue: Department of Chemistry, University of Dhaka and Atomic Energy Centre, Dhaka.
    Dates: 2004-08-21−26.
    Number of Participants: 11, of which 1 from Nepal.
    Resource Persons: Local.
23. *Training Program:* Gas Chromatograph (3rd).
    Venue: Department of Chemistry, University of Dhaka.
    Dates: 2004-12-27−31.
    Number of Participants: 11.
    Resource Persons: Local.
24. *Training Program:* High Performance Liquid Chromatographs (4th).
    Venue: Department of Chemistry, University of Dhaka, and Research Division, BIRDEM.
    Dates: 2005-03-21−25.
    Number of Participants: 12, of which 1 from Nepal.
    Resource Persons: Local.
25. *Training Program:* UV-VIS and IR Spectrophotometers (4th).
    Venue: Department of Chemistry, Shahjalal University of Science and Technology, Sylhet.
    Dates: 2005-09-10−15
    Number of Participants: 15.
    Resource Persons: Local.
26. *Training Program:* Gas Chromatograph (4th).
    Venue: Department of Chemistry, University of Dhaka.
    Dates: 2006-06-24−29.
    Number of Participants: 7, of which 1 from Nepal.
    Resource Persons: Local.
27. *Training Program:* Common Laboratory Equipment for College Teachers.
    Venue: Eden Mohila College, Azimpur, Dhaka.
    Dates: 2006-09-16−17 and 2006-09-19−20
    Number of Participants: 22.
    Resource Persons: Local.
28. Atomic Absorption Spectrophotometers (4th).
    Venue: Department of Soil, Water and Environment and Department of Geology, University of Dhaka.
    Dates: 2006-12-14−19.
    Number of Participants: 11.
    Resource Persons: Local.
29. *Training Program:* Common Medical Instrument (2nd).
    Venue: Research Division, BIRDEM, Dhaka.
    Dates: 2007-04-21−26.
    Resource Persons: Local.

30. *Training Program:* Common Laboratory Equipment for College Teachers (2nd).
Venue: Chittagong College, Chittagong.
Dates: 2007-08-25−30.
Number of Participants: 16.
Resource Persons: Local.
31. *Training Program:* UV-VIS and IR Spectrophotometers (5th).
Venue: Department of Chemistry, University of Dhaka, and Plasma Plus+ Application and Research Laboratory, Uttara, Dhaka.
Dates: 2007-11-10−15.
Number of Participants: 14.
Resource Persons: Local.
32. *Training Program:* Regional Workshop on the Use and Maintenance of High Performance Liquid Chromatographs (5th).
Venue: Department of Chemistry, University of Dhaka, and Research Division, BIRDEM, Dhaka-1000.
Dates: 2007-12-08−13.
Number of Participants: 16 of which 1 from Nepal.
Resource Persons: Local.
33. *Training Program:* Atomic Absorption Spectrophotometers (5th).
Venue: Department of Soil, Water and Environment and Department of Geology, University of Dhaka.
Dates: 2008-06-03−09.
Number of Participants: 13.
Resource Persons: Local.
34. *Training Program:* Common Medical Instrument (3rd).
Venue: Research Division, BIRDEM and BIHS, Mirpur, Dhaka.
Dates: 2008-10-18−23.
Number of Participants: 16.
Resource Persons: Local.
35. *Training Program:* Gas Chromatograph (5th).
Venue: Department of Chemistry, University of Dhaka and Research Division, BIRDEM, Dhaka-1000.
Dates: 2008-11-29−12-04.
Number of Participants: 11 of which 3 from Nepal.
Resource Persons: Local.
36. *Training Program:* Common Laboratory Equipment for College Teachers.
Venue: Ananda Mohan College, Mymensingh.
Dates: 2009-06-01−05.
Number of Participants: 17.
Resource Persons: Local.

Table 2. Participants having attended the training programs conducted during 1994–2009, category-wise

Categories	*Number*
Faculty members	155
Graduate Students	17
Research scientists	213
Technical personnel	92
Medical technologists	22
Total	499

Table 3. Non-functioning scientific instruments repaired by NITUB during 1996–2009

Year	*No. of instruments repaired*	*Price of the instruments* (USD)	*Expenditure of NITUB to repair the instruments* (USD)
1996	10	42,069	529
1997	28	74,914	826
1998	82	326,948	4,904
1999	76	265,483	4,085
2000	126	610,086	5,225
2001	64	271,224	3,190
2002	73	250,431	2,726
2003	40	150,750	2,182
2004	29	200,750	2,505
2005	40	678,923	1,370
2006	34	385,735	1,132
2007	52	741,457	1,711
2008	70	292,536	1,869
2009	135	179,058	1,736
Total	724	4,470,364	33,990

Altaf Hussain was born in Sylhet, Bangladesh, on 01 July 1948. He completed his MSc in Physical-Inorganic Chemistry from Dhaka University in the year 1969. He is the first IPICS fellow (1973-74) from the newly born Bangladesh. He got a Swedish Institute Fellowship (1974−1977) and completed a Fil.dr degree in Inorganic Chemistry from Stockholm University in the year 1978. Dr. Hussain joined the Department of Chemistry, University of Dhaka, Bangladesh as Assistant Professor in 1978 and he became full Professor in the same Department in the year 1993. Dr. Hussain was an Alexender von Humboldt Foundation Research Fellow (1984-85). He was visiting Professor / Scientist at the University of Christchurch, New Zealand, and at Giessen, Hannover and Bonn Universities in Germany. Professor Hussain is a Council Member of the Asian Crystallographic Association (AsCA), Executive Committee Member of Bangladesh Chemical Society (BCS), and General Secretary of the Network of Instrument Technical Personnel and User Scientists of Bangladesh (NITUB). Professor Hussain works on inorganic materials, especially binary, ternary and quaternary transition metal oxides. He has 35 international publications in different international journals and presented a large number of papers in national, regional and international conferences.

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Mr. A. K. M. Rahmat Ullah is conducting a practical class of an AAS training program.

Dr. Malin Åkerblom, Director of IPICS, attending the inaugural session of the syposium *A Decade of NITUB* and a HPLC training program.

Driving analytical chemistry initiatives in Africa through SEANAC

Nelson Torto

Background

The Southern and Eastern Africa Network for Analytical Chemists (SEANAC) was founded in 2002 at a Sida-funded workshop held in Gaborone, Botswana, by 13 Universities from 11 countries from Eastern and Southern Africa. The workshop was hosted by the Analytical Section of the Department of Chemistry at the University of Botswana. SEANAC has since grown and increased its activities beyond these regions to encompass the African continent as it seeks to address challenges in curricula, research, research training, access to and maintenance of instrumentation/equipment in order to meet some of the MDGs. Despite all these efforts, there is an increasing challenge in a continent where financial limitations are on the increase and motivation to work in academia is on the decline.

It is believed that the foundation for technological advancement, innovation, efforts to alleviate poverty as well as improve health care through environment protection and green practises, lies entirely in the understanding of the basic sciences. Chemistry is one of the core basic sciences which is normally viewed as a composite of mainly Analytical Chemistry, Inorganic Chemistry, Organic Chemistry, and Physical Chemistry. Practising Analytical Chemistry can be rewarding as it impacts on agriculture, environment, food, and health. Because Analytical Chemistry cuts across the chemistry discipline as well as most of the basic and applied sciences and technologies, it poses a challenge not only in terms of its understanding, but also the costs associated with technological aspects as instrumentation use is core in its practise. The use of sophisticated instrumentation and methods of analysis designed by Analytical Chemists means that diagnosis of diseases and poisoning, evaluating the quality of water, food, medicine and air can be achieved.

There are two conflicting characteristics about the African continent; it is the source of most of the global resources but still poverty stricken. It is easy to associate poverty with droughts and poor management of resources by governments. However, fundamentally one can trace all these drawbacks that contribute to poverty to being associated with inadequate investment in basic sciences. There is not enough technical expertise and will to invest in technologies and systems that can prepare the African continent for unseen disasters. SEANAC believes that if an adequate and appropriate level of investment in basic science is maintained, this will impact and improve the quality of lives for many people. This contribution will highlight some of the challenges and review the efforts from SEANAC in order to address them.

Challenges facing nations due to standards and global trade

An excellent book edited by Wilson and Abiola on standards and global trade, a voice for Africa, captures the issues of standards and global trade clearly with illustrations from Kenya, Mozambique, Nigeria, South Africa, and Uganda. Besides advocating for improved production practises, the book also emphasizes the need to improve quality assurance, monitoring, evaluation, and product testing. In all these aspects, analytical chemistry is key. Some of the important commodities in the trade with Africa include; coffee, cotton, cashew, cocoa and cocoa products, flowers, fish and fishery products, fruits and vegetables, peanuts, seeds, forestry, textiles, and several organic produce. For all these products, consumers are demanding more information about chemical content, for instance amount of pesticides in fruits, vegetables or flowers. They also want to know the quality of ingredients used in processes to alleviate scares for example of high metal content in children products. This information should be obtained by trained personnel, using reliable instrumentation to enable trade to take place between suppliers and consumers.

Unfortunately the matrix and composition of samples that have to be handled in laboratories to ensure that standards and quality are met is always complex and changing with consumption trends. Improved knowledge of disease and effect of various chemicals means that the requisite knowledge in the basic sciences should be used to develop analytical methods that will help in diagnosis. The instrument technology also has a huge impact on the quality of instrumentation in terms of its reliability, robustness and the need for maintenance. The instrumental factors are very important because irrespective of the available chemistry knowledge, analysis cannot be achieved if the instrument is not in its functioning state. There is still a large number of Analytical Chemists that return to work in Africa that are trained at institutes in Asia, Europe and the Americas. Starting new research areas or simply starting a laboratory in a place and environment that is different from what one has experienced as a student is rather a daunting task. Chemists in these situations will generally feel isolated and will have no one to share their frustrations, especially when faced with malfunctioning instrumentation and lack of spare parts.

Generally in those parts of the world the maintenance and repair of instrumentation is well covered by service contracts and also there is normally enough funding to avail expertise to carry out any major work. In Africa most of the labaratories are not well equipped, and if they are, most of the quipment is not in working order. It is very difficult to get spares for instrumentation, partly because of the fact that most countries would have very old models that are no longer serviced by manufacturers. It is also not uncommon to find that a lab might have new instrumentation, not commissioned simply because it was donated before the completion of the construction of the laboratary and hence all the warranties expire before it has been commissioned. This is very common with donor supplied instrumentation. Therefore in all these circumtances, there is a need for Analytical Chemists to share expertise, resources and information through a network where common problems can be addressed.

What is SEANAC

SEANAC is the African network of analytical chemists that was formed in Gaborone, Botswana, in 2002. It is an organization affiliated to IUPAC. The table below shows the Universities and countries involved in the founding workshop, which was hosted by the University of Botswana.

Table 1. SEANAC founding member universities and their countries.

University	*Country*	
University of Botswana	Botswana	BW
University of Addis Ababa	Ethiopia	ET
University of Nairobi	Kenya	KE
Egerton University	Kenya	KE
National University of Lesotho	Lesotho	LS
University of Malawi	Malawi	MW
University of Eduardo Mondlane	Mozambique	MZ
University of Swaziland	Swaziland	SZ
University of Dar es-Salaam	Tanzania	TZ
University of Zambia	Zambia	ZM
National University of Science and Technology	Zimbabwe	ZW
University of Zimbabwe	Zimbabwe	ZW

SEANAC has a constitution which allows the registration of SEANAC chapters in the member countries. It has a board that has representation from member countries. The daily activities are managed by a Secretariat that consists of the Secretary General, Treasurer and Program Officers. Since its formation, the SEANAC secretariat has been and is still based at the University of Botswana in Gaborone.

What are the core activities of SEANAC?

SEANAC was founded on the basis of addressing three objectives. SEANAC's first objective is to promote analytical chemistry in Africa through collaboration, research, research training, teaching and information sharing. The network recognizes the approach to be the most efficient and cost effective way of maintaining, developing, and diversifying capacity within the region. The promotion of analytical chemistry will facilitate recognition of the role of this branch of Chemistry such that it may be able to attract support within the continent for its development. Collaboration in research, research training and teaching are considered to be of paramount importance. The network provides a platform for African chemists to be able to share the limited resources particularly as many of the universities and institutions lack a proper support system. In the spirit of sharing of resources, chemists are able to move around the continent where cross-boarder activities enable them to progress with their research without necessarily incurring much in transport costs. In cases where there are less qualified or experienced personnel, a network also helps in sharing of the human resource and in some cases facilitate the development of curricula that will be tailored to address some of Africa's problems.

SEANAC's second objective is to facilitate inventory, access, operation, maintenance and repairs of analytical equipment. One of the challenges Africa faces is slow delivery of spare parts, lack of technical back-up by instrument providers and inadequate service of instrumentation by competent technical people. The idea is that SEANAC intends to continuously develop and update a data base that identifies universities or organizations that have functional equipment. Analytical Chemists who are challenged in terms of availability of instrumentation can then link up with the university so that, through SEANAC or other organizations, support can be given to enable the researcher to conduct their research. The other objective is also to identify instrumentation that cannot be repaired but still good in the sense that some parts could be used to repair other instrumentation in some laboratories. This step requires the identification of technicians which SEANAC will use from time to time to conduct the repair and maintenance work at a reasonable cost. Universities with technical people with complementary competencies can also be encouraged to ensure that there is a free flow of such personnel so as to assist with maintenance and repair of instrumentation. SEANAC encourages that members purchase instrumentation of the same brand so as to increase the knowledge bank as well as the negotiating power when it comes to dealing with instrument manufacturers.

SEANAC's third objective is to collaborate with organizations with similar aims. The network recognizes that some of the identified problems are not unique to Africa, let alone to SEANAC. Therefore SEANAC continuously identifies such organizations and seeks assistance or collaboration to ensure that there is maximization of resources. There have been some networks that were formed post the founding of SEANAC that also do some aspects that SEANAC is grappling to address, for example the African Network for the Chemical Analysis of Pesticides (ANCAP), based in East Africa. This network is focused on pesticides which is indeed an important component in Analytical Chemistry as the main challenge is sample handling. Therefore when there are opportunities to collaborate in workshops or conferences SEANAC takes advantage of the opportunities.

In addition to the three objectives, SEANAC in its program of action realized the need to embark on capacity building by training trainers as well as graduate students who are preferably shared amongst the member countries as the research interest dictate. The need to facilitate networking by bringing together Analytical Chemists in the region so as to encourage collaboration is also realized. SEANAC also encourages the linking-up of universities and support institutions to facilitate capacity building. SEANAC has always seen training of MSc and PhD candidates to be the most practical way to encourage collaboration as well as to increase human capacity in Africa. Various mechanisms have been proposed that mainly involve sandwich programs. The idea is that if chemists are trained in Africa and have the opportunity for research exchange amongst the African Universities, then they are most likely to maintain the relationships in their later stages of their research career. Such links provide a platform to share knowledge, information, experiences and resources.

During the SEANAC founding workshop, it was agreed that research projects that can lead to the award of postgraduate degrees should be based on common research themes. The research themes chosen for this were on research that would address the areas of health, food security, and environment. SEANAC founding members also felt that it was appropriate that SEANAC organizes as many workshops as possible with at least one every year so that members could have the opportunity to upgrade their skills. In order to bring the analytical experts from outside Africa to the continent, the obligation of SEANAC is to identify such experts and ensure that they present their work at SEANAC conferences. It is the view of the network that since most analytical journals are based internationally and that most university libraries in Africa do not have access to them, conference opportunities are ideal as a platform to disseminate research outcomes and generally serve to inform about what other researchers are doing, especially in Africa.

Has SEANAC lived to expectations?

SEANAC's activities have been focused on increasing the platform for networking through conferences and workshops. The network has also supported three-month exchange research visits within Africa and to Europe as well as trained technicians and also conducted needs assessment exercises to Mozambique, Nigeria, and Rwanda.

SEANAC has hosted three international conferences which have attracted some of the best Analytical Chemists in the world. The inaugural conference was held in Gaborone, Botswana, in July 2003. One of the key aspects about the inaugural conference was the collaboration between SEANAC and Professor James Holcombe, which was funded through the National Science foundation (USA). Professor Holcombe, a renowned scientist and journal editor, brought with him three key Analytical Chemists in Professor Sadik, who was the keynote speaker; Professor Gardea-Torresdey; and Professor Lindner as part of the collaboration. Dr. Ron Majors of Agilent Technologies gave workshop on Sample Preparation as part of the pre-symposium workshops. The team of US scientists was involved in mentoring of students as well as a workshop on dissemination of scientific results. One of the highlights of the inaugural conference was the fact that papers presented in the normal sessions were submitted for review and those judged to have scientific merit were published in a special issue of Talanta. All keynote and plenary speakers contributed to a special issue of Pure and Applied Chemistry. The second conference which was preceded by three workshops in, respectively, *Trace elemental analysis of environmental and biological samples* (Professor McCrindle and Dr. Ndung'u); *Remote access and control of a GC-MS* (Professors Fitch, Mavura, and Kishimba); and *Sample preparation with solid phase extraction* (Dr. Majors) was also held in Botswana in 2007. This conference built on the initial success of the inaugural conference and enjoyed participation by many international scientists. The keynote speaker, Professor Tebello Nyokong of Rhodes University, won the UNESCO L'Oreal Award in 2009, demonstrating the strength of some of the participants. The third SEANAC Conference was held in Mbabane Swaziland in July 2009. The Swaziland conference like all other SEANAC conferences was preceded by three workshops which had over 50 participants. The workshops were in *Biosensors for food analysis* (Professor Amine); *Capillary gas chromatography* (Dr. Apps); and *Introduction to solid-phase extraction* (Dr. Majors). SEANAC will join the UNESCO celebrations for the year of Chemistry in 2011 by hosting its next conference in Maputo, Mozambique.

SEANAC was able to successfully launch three-month funded exchange research fellowships for postgraduate students as well as recently graduated PhDs who still had some pending research to do. In 2005 there were 9 funded fellowships and 10 in 2006. These exchange visits were within Africa and in 2007 a PhD student from Egypt was funded for a 3 months research stay in the United Kingdom. In 2008 and 2009, only 3 and 2 were funded for exchange visits, respectively. Generally during the year when a SEANAC conference is taking place, the funding is devoted to supporting the participation by students at the pre-symposium workshops as well as the conference itself. For the second and third SEANAC conference, the International Organization for Chemistry in Development (IOCD) has availed funds to award prizes for the best presentations by postgraduate students.

In order to get a clear understanding of the situation on the ground, SEANAC has conducted some needs assessment trips to Nigeria, Mozambique and Rwanda. Because of Nigeria's population, SEANAC receives more requests from Nigeria for assistance than any other African country. The Secretary General was a guest of the Nigerian Chemical society (Osun Chapter) and used the opportunity to meet with key people as part of SEANAC's objective to collaborate with organizations with similar aims. A team of the secretariat also visited the University of Eduardo Mondlane in Maputo, Mozambique, as well as government laboratories and private industry. A SEANAC representative was also sent to Rwanda at the request of the National University of Rwanda as there was a need for capacity in developing a postgraduate program in Analytical Chemistry.

These examples discussed represent some of SEANAC's main activities. However SEANAC has also been involved in training of technicians, and recently a technician from Mozambique completed a three-month glass blowing course. SEANAC has collaborated with other organizations in hosting conferences, workshops as well as general mentoring of students.

Challenges facing SEANAC after almost seven years of existence

1. African scientists still find it a challenge to support themselves in order to participate at SEANAC conferences;

2. The level of scientific inquiry for both postdoctoral researchers and some experienced scientists is still below the international level for similar rank and experience;

3. SEANAC three-month research stays have not resulted in substantial scientific output;

4. There are limited opportunities for funding that will result in the award of a PhD in Analytical Chemistry;

5. Very few research groups have the capacity to host researchers due to limitations associated with facilities and running costs to purchase the requisite chemicals and reagents;

6. SEANAC funds are limited; hence cannot really address some of the problems that scientists are facing;

7. Reports received from funded fellows can be very uninformative in terms of both the science and achievements;

8. Unreasonable demands in terms of assistance required;

9. Generally quality of research proposals submitted for funding is of low standard;

10. There is generally a big disparity in terms of analytical practice and knowledge between scientists from different parts of the African continent;

11. Visa requirements and red tape between some countries delays the implementation of the SEANAC program.

SEANAC's future agenda for analytical chemistry in Africa

The success of a network normally depends upon its credibility which will directly affect its capacity and ability to attract funding as well as implement its programs. SEANAC has been fortunate as it has received support initially and directly from Sida and eventually from the International program in chemical sciences (IPICS) at Uppsala University. Because of this continued support, SEANAC has to a large extent been able to meet its objectives and in fact do much better than one would expect of a very young network. However, for SEANAC to even make a bigger impact on the needs for basic sciences in Africa it has to continue to aggressively look for other sources of funding as it has already built some credibility through its activities. There is need for funding that will support extended research fellowships from 3 to 6 months as not much is achieved in a shorter time. More PhDs need to be trained in the area of Analytical Chemistry. Indeed, because of the large disparity in knowledge and research capability among the researcher in Africa, SEANAC sees the need to harmonize curricula. Lastly SEANAC will endeavour to assist more in the area of access, repair, and maintenance of instrumentation.

Acknowledgements

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Eight years of ANCAP: Achievements, challenges, and the future

Michael A. Kishimba[1]

Abstract. This paper details the achievements, challenges and the future aspirations of the African Network for the Chemical Analysis of Pesticides (ANCAP, uwww.ancap.org). ANCAP is a legally registered non-governmental, non-political, non-sectarian and non-profit-making scientific body devoted to the study, promotion, and development of the science of all aspects of chemical analysis of pesticides, including residue analyses, degradation, and environmental fate – with the overall objective of not only safeguarding public health and the environment, but also ensuring the safety of African agricultural and aquatic products, thus making them competitive on the world market, thereby significantly contributing to the continent's poverty-eradication endeavours. ANCAP, which was established in July 2002 in Kampala, Uganda, has six member countries, namely Ethiopia, Kenya, Sudan, Tanzania, Uganda, and Zimbabwe. In its almost eight years of existence, ANCAP, which, in collaboration with SETAC Africa, organized a highly successful global conference on the *Use of Pesticides in Developing Countries* in Arusha in October 2006, again joined SETAC Africa in SETAC's 4th Conference in Africa (and 2nd ANCAP-SETAC conference) in November 2009, in Kampala on Environmental Pollution in Africa, had a great impact in the region by effecting, among others, the following: Conducting eight summer schools on Pesticide Chemodynamics and Residue Analysis; holding three Regional (Scientific) Symposia; exchange of several MSc and PhD students amongst universities in the region; enhanced the publication profiles of researchers in pesticide residue analysis and environmental chemistry in the subregion.

Keywords: Pesticides, residue analysis, summer schools, regional symposia.

Introduction

Up to the early 1990s, it was found out that in the Eastern Africa region, analytical laboratories with the capacity and capability to perform pesticide residue analyses in water, food and the environment were scarce. In most of the laboratories that were trying to perform pesticide residue analyses, the equipment – gas and high performance liquid chromatographs (GC and HPLC, respectively) were not working properly, either because they needed repair

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and spare parts or service was not available, or because people were not adequately trained to handle the complicated equipment. The situation changed for the better in the mid- to late 1990s, when, with kind financial assistance from Sida-SAREC, and most dedicated technical and logistic support from the International Programme in Chemical Sciences (IPICS of the ISP), Uppsala University, and the Department of Environmental Assessment, Swedish University of Agricultural Sciences (SLU), Uppsala, through either bilateral or ISP projects assisted Ethiopia, Tanzania, and Uganda in the establishment of research capacity in pesticide residue analysis.

The idea to establish ANCAP dates back to 1997: it was first mooted when the then Head of the Pesticide Section of the Department of Environmental Assessment at SLU visited Dar es-Salaam to plan for the start of the above-mentioned project in Tanzania. The idea was further consolidated in 1998, when a draft constitution of PERENESA (Pesticide Research Network for Eastern and Southern Africa) was written, and launching earmarked for San Jose, Costa Rica, where a conference on the use of pesticides in developing countries was held in February 1998. Unfortunately, the launching failed because the number of African participants was very low – less than ten and from four countries only. The determination did not wane, and in 2001, EANAOP (East African Network for the Analysis of Organic Pollutants) formed in Nairobi with four member countries: Ethiopia, Kenya, Tanzania and Uganda. A year later, EANAOP was changed into ANCAP, and approval of its constitution led to its legal formation in Kampala. Sudan and Zimbabwe joined the network two years later.

The African Network for the Chemical Analysis of Pesticides (ANCAP) is a legally registered non-governmental, non-political, non-sectarian and non-profit-making scientific body devoted to the study, promotion and development of the science of all aspects of chemical analysis of pesticides, including residue analyses, degradation and environmental fate – with the overall objective of not only safeguarding public health and the environment, but also ensuring the safety of African agricultural and aquatic products, thus making them competitive on the world market, thereby significantly contributing to the continent's poverty eradication endeavours.

Advantages of networking – the case of pesticide chemical analysis

The formation of the network was designed to take full advantages of networking, which include the following.

- Coordination of the human resources capacity in chemical analysis of pesticide research within the subregion;

- Creating of an interactive atmosphere among researchers in the subregion and promotion of South-South and North-South collaboration;
- Increasing awareness through publications;
- Creation of opportunities for postgraduate training at MSc and PhD levels, and participation in training workshops within the subregion;
- The regional networking approach in chemical analysis of pesticides research offers many opportunities, among which are the following;
- Facilitating the optimal use of laboratory equipment and other facilities available in the subregion;
- Promoting the regional research approach to solving common problems and fostering intra-regional capacity and capability for the training of both MSc and PhD students. This is contributing towards the development human resources that is needed to solve the subregion's socio-economic environmental problems, management of biodiversity, provision of health care services, enhanced food production and preservation, evolving poverty alleviation strategies, etc.;
- Contribution towards increasing the potential to marshal both decision-makers and political support needed for development and possible exploitation of viable research results.

Achievements

ANCAP has greatly endeavoured to meet its objectives and expectations. In its seven years of existence, ANCAP, which, in collaboration with SETAC Africa organized a highly successful global conference on the *Use of Pesticides in Developing Countries* in Arusha in October 2006 and again joined SETAC Africa in SETAC's 4th Conference (and second ANCAP-SETAC conference) in Africa (November 2009 in Kampala on Environmental Pollution in Africa), has had a great impact in the region by effecting, among others, the following.

- Conducting eight summer schools on Pesticide Chemodynamics and Residue Analysis in Kampala (2002, 2005, 2009), Nairobi (2003), Arusha (2004, 2006), Gaborone (in collaboration with SEANAC, 2007), and Wad Medani (Sudan, 2008);
- Holding three Regional (Scientific) Symposia (Kampala 2002, 2005; Nairobi 2003), one Regional Workshop on DDT (Kampala 2004) and an International Inaugural Conference (Arusha 2004);

- Exchange of researchers amongst the member countries;
- Exchange of several MSc and PhD students amongst universities in the region (so far: Makerere, Nairobi, Dar es-Salaam, and Addis Ababa), facilitating the timely successful completion of their respective degree programmes;
- Enhanced the publication profiles of researchers in pesticide residue analysis and environmental chemistry in the subregion.

ANCAP'S main activities referred to above fall under the following categories: summer schools, exchange of students, regional symposia and international conferences and regional workshops. These are briefly elucidated below.

Summer schools

The summer schools have been so successful and useful to students/young researchers that were it not for shortage of funds they would extend for a full month – as repeatedly demanded by participants. The fourth summer school held at the Department of Chemistry, Makerere University, Kampala, Uganda, from the 11th to the 20th of July 2005, is a typical example of an ideal summer school. The course tutor was Professor Peter Nkedi-Kizza from the University of Florida, FL, USA. The course title was *Sorption of Organic Chemicals on Soils and Sediments*. The students were first of all given a review of properties of organic chemicals with special emphasis on Persistent Organic Pollutants (POPs), and then they set up sorption experiments to demonstrate/research on:

- Effect of soil to solution ratio;
- Effect of Organic Carbon;
- Effect of sorption coefficient;
- Modeling sorption kinetics;
- Apparent sorption coefficient.

Later they studied degradation, volatilization and mineralization of pesticides and POPs; sorption of ionizable organic chemicals; sorption in mixed solvents (solvophobic theory); leaching experiments, templates for data analysis, hysteresis; and their experimental. The participants also studied the following: theory, modeling and set-up of sorption experiments; solvophobic theory, and went for a field trip to Makerere University's Agricultural Research Institute, Kabanyolo (MUARIK).

The popularity of these courses was again highlighted when students/ participants wrote a proposal for its funding to Sida. Unfortunately, there was no response. As already stated above, a total of eight summer schools have been organized so far with four of them being held as pre-conference activities. Efforts are under way to solicit more funds for this activity.

Exchange of students

The opportunity to go and work in another university, not too far from home, has proved to be a very effective method of enabling students to make giant leaps in their research projects. (In Africa, senior students have reached an age where they have a lot of social responsibilities which have to be met alongside their studies.) One beneficiary exemplifies the typical gains which can be accrued from the program as he wrote:

> I would like to take this opportunity to appreciate the support offered to me by the ANCAP in April 2004. Our Thermionic Selectivity Detector (TSD) broke down last year before I completed the analysis of my research samples for organophosphorus pesticide residues. It was a really hard time for me, but when I applied to Dr. Kishimba (ANCAP Executive Secretary), he accepted to accommodate me for 4 weeks, in which I managed to run 127 samples comprising of water, soil, weed and fish samples, and external standards. I have managed to complete my thesis and handed it in for corrections. I hope to donate copies of my work done at Makerere and Dar es-Salaam Universities to the respective labs after approval. God bless you all.

Regional symposia

ANCAP Regional Symposia are held at the end of Summer schools to share research experiences in the region. Presentations and draft publications are presented and discussed. The 3rd Regional Symposium which was held at the University of Makerere in Kampala, Uganda, from the 21st to the 22nd of July 2005 is given as an example. The symposium, which was attended by about thirty participants from five countries, had sixteen presentations of research papers, mostly by young scientists in the region. The symposium also set aside some time to deliberate on the way forward. It was suggested that ANCAP establish one centre of excellence for pesticide analysis with sophisticated equipment whose functions would be as follows.

- Inter-laboratory quality control assessment;
- Analysis with more precise instruments;
- Training of staff and students;
- Development of data bases;
- Promote public education and awareness.

Due to conferences in 2006–2009, there has not been an opportunity to hold another symposium.

International Conferences

Conferences not only provide fora for exchange of research experience and associated benefits but also allow researchers to keep abreast of new technologies and methodologies, provide an opportunity to meet and network with others in the discipline and help elevate a research group or network. ANCAP has so far organized four international conferences, the Inaugural Conference in 2004, two with SETAC Africa (Arusha 2009 and Kampala 2009) and the 1st African Congress on Pesticide and Toxicology Sciences in Wad Medani, Sudan. All these were successful as they met and in some cases exceeded the goals and expectations.

The pinnacle of conferences was the 2006 *International Conference on the Use of Pesticides in Developing Countries* held in Arusha, Tanzania, from the 16th to the 20th of October, 2006. It drew close to 200 participants from almost 30 countries from the continents. The conference, which was opened by the then Minister for Science, Technology and Higher Education, Professor Peter Msola, and closed by the Regional Commissioner for Arusha, Colonel Samuel Ndomba, was also attended by local and foreign dignitaries. The total attendance was about 200 foreign and local participants from various organizations, governmental, non-governmental and industry and over 150 scientific presentations were made, including two special sessions: Dr. Malin Åkerblom's Valedictory Session and another on the risk assessment of locust control insecticides.

After the conference, many congratulatory e-mails were sent to the Coordinating Office by participants expressing their appreciation and describing the conference as a great success.

Regional Workshops

ANCAP organized three regional workshops in 2004 and 2005. The first, in Kampala in 2004, was devoted to DDT: *Is DDT the Only Viable Solution to Malaria in Africa?*, and the other two were held in 2005 in Zanzibar. One was on the *Eco-toxicology of Agrochemicals in the Western Indian Ocean Region* and the other *Training Workshop on Risk Assessment*. All the workshops were well attended with participants from at least ten countries in each.

Challenges

Like any other organization operating in developing countries, ANCAP has a number of challenges, the most serious being financial resources. Unlike other parts of the world, especially developed countries or those whose economies are in transition, organizing any meeting, workshop, conference or short courses involves not only soliciting for funds to take care of the organizational costs: venue, materials, etc.; but also for sponsoring (transport and upkeep) of the participants. Thus having resources to cover all these is a great challenge, and ANCAP is fortunate to have the IPICS sponsorship with the periodic extra funds from other organizations like OPCW, Sida and a number of local micro-grant sponsors.

The other challenge is interaction with society. Due to the educational/technical knowledge gap between researchers in the network and the general population in member countries, interaction is rather limited. Whereas the goal of the network is to serve the masses in the mainly rural communities in African countries which are the main users of pesticides, the gap creates an invisible barrier, which ANCAP has to overcome to gain overall recognition by the general public in the member countries. Thus efforts will be made to hold sensitization seminars, articles and occasional guest programmes in the mass media.

The third and last major challenge is the marshalling of political and decision-maker support, without which any operational measure based on scientific findings would be most difficult. Sometimes, there are contradicting decisions/recommendations between researchers and decision makers, and when that happens, researchers are the natural losers as decision makers have executive power. For example, the re-introduction of DDT for the control of malaria is a very decisive matter between decision makers and researchers. The former see DDT as a "silver bullet" whereas the latter know better! ANCAP involves stakeholders in matters of public interest such as the workshop DDT held in Kampala, in which government leaders and politicians (a minister and members of parliament) were also involved in the deliberations. The endeavours are on-going.

Future plans

The future plans of ANCAP are geared towards meeting the above challenges so that we have the ability to conduct month-long summer schools, hold annual regional symposia and have systematic exchange of students in the form of intra-regional scholarships; have stakeholder recognition and participation and have political and decision-maker cooperation.

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Challenges and accomplishments of the Eastern and Southern Africa Regional Seismological Working Group

Dumisani John Hlatywayo

Abstract. The Eastern and Southern Africa Regional Seismological Working Group (ESARSWG) is a Seismology network of seismic recording stations in nine countries that span the entirety of the East Africa Rift System, from Eritrea / Ethiopia in the north down to Mozambique / Zimbabwe in the south. The major objective at its inception in 1992 was to cooperate in earthquake monitoring and joint production of an earthquake bulletin with improved epicenter locations. As time progressed, the network has advanced into the area of research. Joint research among scientists in the geophysics field who are active in their own countries and rendering support to the main objective of ESARSWG has now been added as a second objective. It is envisaged that data realized from the ESARSWG objective will continue to be resource material for research work in the region in an endeavour to mitigate hazards that may arise from seismic activities as well as enhance research skills in geophysicists who are participating members in ESARSWG countries.

Challenges have been encountered in the sourcing of spare parts to keep the seismic stations up and recording. This is in addition to problems experienced in communication both within individual countries as well as intercountry. The advent of internet has alleviated this problem but not eradicated it all together. To date, ESARSWG has more than 52 seismic stations of which three fifths are up and running at any given time. ESARSWG will continue to strive to attain 100 percent station operation. Apart from challenges, ESARSWG has seen an improvement in the seismic data base in the region with some publications in international journals being realized. ESARSWG successfully participated in the GSHAP programme of the 1990s and is keen to participate in the GEM activities and make a significant contribution. Through the initiative of ESARSWG, scientists have been trained in the region to Masters and PhD levels to enhance research capabilities. Currently, work to map active faults in the Rukwa region of Tanzania is in progress.

Keywords: Capacity, station networks, data analysis, EAR system.

Introduction

The Eastern and Southern Africa Regional Seismological Working Group (ESARSWG) is a seismology networking group which monitors earthquake activity in nine coutries that fall along the East Africa Rift (EAR) system. The Group comprises Eritrea and Ethiopia in the north; Uganda, Kenya, and Tanzania in the central part of the region; Zambia, Malawi, Mozambique, and Zimbabwe in the south (Figure 1). It was formed in 1993 with the sole purpose of collaborating in earthquake monitoring and seismological bulletin preparation in order to improve the accuracy of seismic epicentral data location within the region.

Numerous studies of the EAR system have significantly increased our understanding of rifting processes (Tiercelin et al. 1988; Ring et al. 1992; Debayle et al. 2001; Delvaux, 2001; Maguire et al. 2006). The EAR system remains the best natural laboratory, found nowhere-else on earth except in Africa. Seismic hazard assessments have been carried out in the region (Midzi et al. 1999). These were based on broad seismotectonic data and empirically modified attenuation relations. Calculations have not incorporated active fault data. An inclusion of this data will give more accurate seismic hazard assessment results for the Southern and Eastern Africa region. The region has experienced a number of moderate to large earthquakes over the past century, some of which have caused considerable damage. Furthermore, the region is still developing. The population is increasing rapidly. It is envisaged that vulnerability to earthquakes will increase with time. To date, little attention has been paid to earthquake hazards associated with EAR that have direct social and economic impacts on humanity. This makes the need for proper earthquake mitigation programs to reduce the risk of this reality. Such risk reduction may be achieved through seismic hazard assessment that incorporates in its calculations, accurate earthquake event location, velocity models, attenuation relations and active fault data.

The probabilistic seismic hazard assessment method has been used for the computation of seismic hazard in the region (Midzi et al. 1999). The success of this method depends upon the accuracy of earthquake location, the characteristics of active faults and the attenuation relations for the region. Eastern and Southern Africa lacks data on active faults to which the seismic activity could be directly linked. There is therefore a need to carry out an active fault mapping project in the region. ESARSWG have since 1993 been cooperating in seismic networking in data collation and collection; through workshops, produce bulletins of seismic data for the region; and train personnel required to man National Data Centres. This has produced a substantial amount of seismic data. The results have been profound and encouraging to seismologists in the region and abroad.

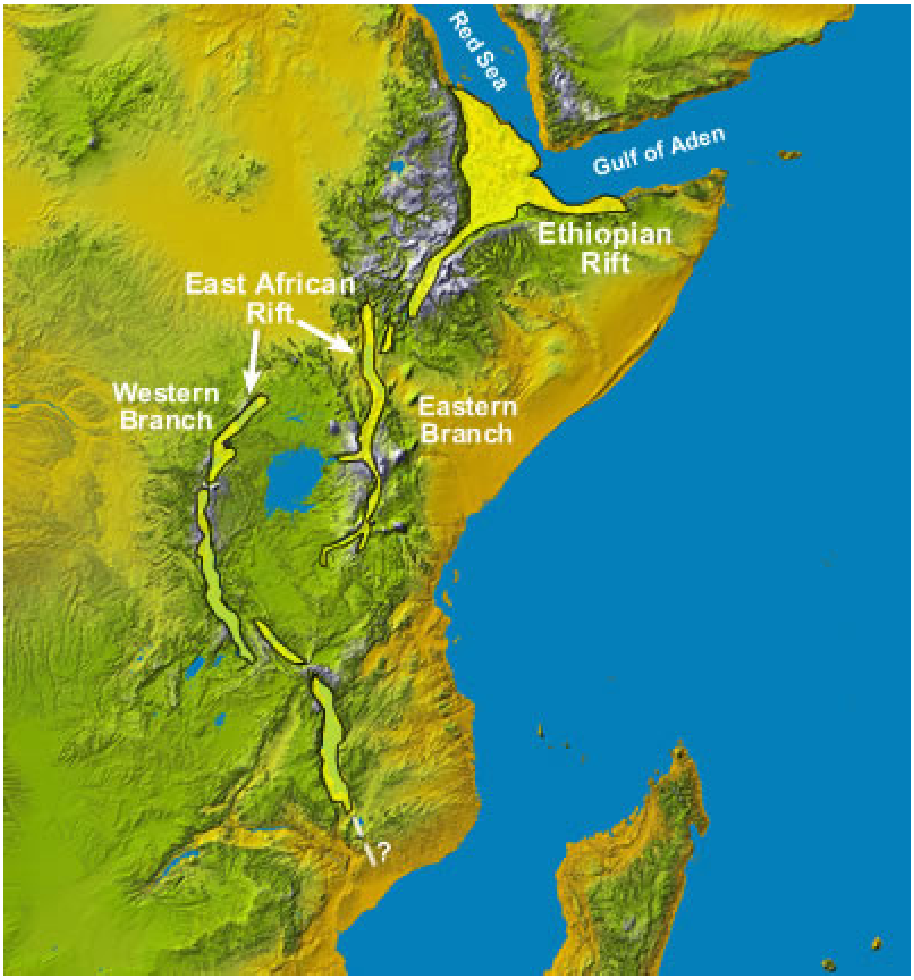

Figure 1. Map of the Eastern and Southern Africa region with the nine countries that are participating in the ESARSWG seismological network. The East Africa rift system extends from Eritrea / Ethiopia in the north through Uganda, Kenya, and Tanzania to Malawi, Zambia, Mozambique, and Zimbabwe in the extreme south. In East Africa, the rift splits into two branches – the Eastern and Western branches. In Zimbabwe and Southern Mozambique, the rift is ill defined, and incipient rifting is identified by earthquake activity. Earthquakes of magnitude in excess of 6.0 have occurred along and over the entirety of the region from the south in Mozambique to Ethiopia in the north.

Composition

The Network comprising of nine countries in the eastern and Southern Africa region brings together Seismological Data Centres and scientists with interest in geophysics-related sciences. These include seismologists, geologists, geophysicists and geodesists who are either working at government institutions like Geology Departments and Geological Survey Departments or in academic institutions like Observatories and University Departments. The aim at its inception was to plan activities and coordinate research amongst countries in the region along the East African rift. The Network embraces four main objectives:

1. To monitor the seismicity of the EAR system through a sustained seismic station operation in the nine countries that comprise ESARSWG;
2. Collectively analyse data to produce Seismological Bulletins for the region;
3. To enhance capacity building in the region in both equipment upgrading and personnel training, to enable seismology related research to be carried out;
4. To plan and conduct joint research programs in the region.

To achieve the Group's objectives, it was realized that the objective at enhancement of capacity building in both equipment and personnel had to be addressed first. The seismic monitoring equipment used in the region varies from country to country, often within the country itself, and heavily depends upon who was influential in starting and building the network. Each country took the responsibility of ensuring acquisition of seismometers. The ESARSWG network currently boasts of at least three stations per country (Table 1). Collaboration in seismic event analysis improves the accuracy of earthquake location.

Training

Training of seismogram analysts began in 1991 in Dar es-Salaam, two years before the formation of the ESARSWG Network. Seven participants from Kenya, Uganda, and Tanzania attended the training workshop which was conducted by two instructors from Tanzania and one from Sweden. The training workshop was followed in 1993 by a Workshop in Dar es-Salaam organized for the region. The ESARSWG Network was borne out of this workshop. It also was the first of its kind to be held in the region to collectively analyse

Table 1. Seismic stations in the ESARSWG Network comprising of National Networks. Stations are not necessarily continuously operational. Some stations may be down for longer periods than others. Of the 52 stations in the region, 32 are currently operational.

Country		*Total number of stations*	*Total stations in operation*
Eritrea	ER	4	2
Ethiopia	ET	6	5
Kenya	KE	6	2
Uganda	UG	5	3
Tanzania	TZ	7	7
Malawi	MW	5	3
Zambia	ZM	8	4
Zimbabwe	ZW	6	3
Mozambique	MZ	5	3

seismic data and produce a seismological bulletin. The operation was overseen by Jens Havskov from University of Bergen. He also provided SEISAN software for seismic event location (Havskov and Utheim, 1992). This software has now been developed into a full seismic data analysis. The adoption of the Seisan software has resulted in a harmonized method of data analysis for the region. The success of the workshop was measured by the publication of a paper in an international journal (Dindi et al. 1995). Since then, a total of 16 workshops for data analysis and bulletin preparation have been held by the ESARSWG network. At three of these workshops, training of seismogram analysts from the National Data Centres was conducted. The overall result is a realization of better analysis skills and techniques that has given rise to an improved epicentre location of events in the region (Figure 2).

Once the data analyst was trained, there was need to train the scientist who would use the data made available. This was achieved through North-South Cooperation, especially with three of the Nordic countries, Sweden, Norway and Finland. A number of countries within the region now have the capacity and capability to train scientists to MSc and PhD levels (Table 2). The first two graduates to be trained to MSc, sponsored under the ESARSWG Network budget received their certification in seismology from Addis Ababa University in 2008.

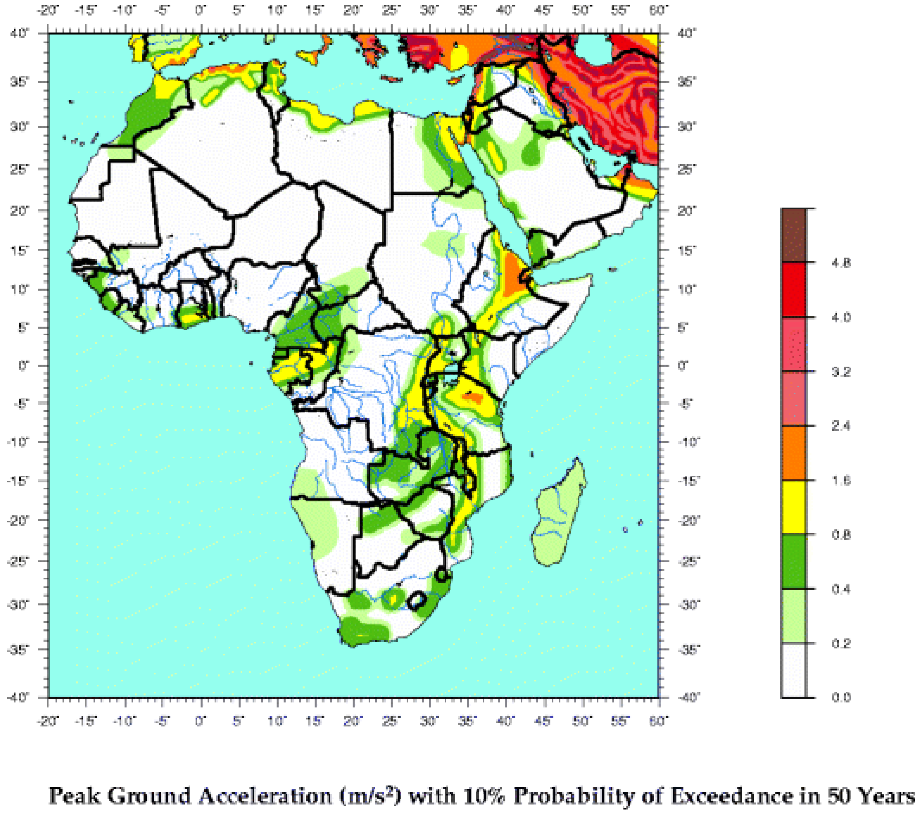

Figure 2. Seismic hazard map of Africa (GSHAP, 1999) showing the areas of possible high vulnerability from earthquakes along the East Africa rift system.

Research

The first form of joint research to be conducted by the Network was in earthquake event monitoring and collective seismological bulletin preparation (Dindi et al. 1995). This has now become routine practice by the Network.

The second endeavour which was equally successful was joint work in seismic hazard mitigation during the Global Seismic Hazard Analysis Program (GSHAP) in the 1990s, that culminated in a seismic hazard map of Eastern and Southern Africa region (Midzi et al. 1999), which was incorporated into the GSHAP map for Africa (Figure 2). Other work included the determination of velocity models for the region by Midzi and Ayele (2006).

Table 2. Capacity building in manpower within the region. At least six persons were trained to PhD and fourteen trained to MSc level. A number of institutions in the region now have the capacity to train scientists in geophysics / seismology.

	Level of personnel training [North-South cooperation]		*Institutions now offering Post-Graduate Programs in Geophysics in region*		
Country	*PhD*	*MPhil/MSc*	*Institution*	*PhD*	*MPhil/MSc*
Zimbabwe	2	2	NUST Univ.	x	x
Zambia		4			
Uganda	1	3	Makerere Univ.		x
Tanzania	1	3	Dar es-Salaam Univ.	x	x
Malawi		2			
Ethiopia	2		Addis Ababa Univ.	x	x
Kenya			Univ. of Nairobi	x	x

Current joint research work focuses on the determination of attenuation relations for the region and active fault mapping in the Tanganyika–Rukwa–Malawi Transform zone. A desk study on faulting in the Rukwa region was carried out at a Workshop held in Dar es-Salaam in August 2009. Results show interesting features and are being prepared for publication in some Journal.

Conclusions

ESARSWG has encountered both challenges and made notable achievements which are given below.

Achievements

There has been significant improvement in the mode of operation of National Networks of seismic stations in the region. Collaborating in data exchange and carrying out data analysis using the same software, calculating the same parameters and collating station data has improved seismic event location. It has been possible to produce seismic bulletins of earthquake data that has harmonized earthquake magnitudes. Scientists in the region have started work in joint regional cooperation in research, writing and publishing papers together in scientific journals. Overall, ESARSWG has achieved notable capacity building in equipment and manpower development.

The activities of the Group since its inception have put it on the spotlight on the African continent. Scientists have begun cooperation in research in geohazards in the region with Africa Array Network of Seismic Stations, ICTP

(Italy) and Global Earthquake Model (GEM) through ICSU-ROA. Also, a number of institutions and organizations, both within the continent and abroad, are now aware of the existence of ESARSWG, with some looking forward to foster collaborative research work in geo-hazards and seismic risk assessment.

Challenges

The Network has developed not without its share of challenges. Despite the availability of internet world-wide, communication has continued to dog the Group with unreliable Internet communication bandwidths and poor ISP provision in some countries. The cost of telephone calls remains prohibitive.

There is generally a high rate of turn-over of scientists to supposedly economically greener pastures. Admittedly, this calls for sustained training of both the scientist and the technician to maintain and care for the equipment and counter the brain-drain.

Although most national governments in the region are now aware of the work of ESARSWG and the need to continue earthquake monitoring in the region, Seismic Networks are not on a high priority list in government budgets. This has led to long delays in repairs to seismic station equipment breakdowns resulting in substantial data loss and gaps in the data base. ESARSWG hopes this scenario will improve in their favour as they engage on a vigorous campaign of seismic hazard and seismic risk awareness to the national governments.

Future perspective

ESARSWG seeks to continue to strengthen seismic event monitoring in the region – event location and bulletin production. It will also continue to carry out joint research – of immediate interest is active fault mapping in the Rukwa region and regional attenuation relation determination. There is also need to sustain personnel training programs at all levels.

The Network is currently putting in place a Constitution so as to be properly constituted. It is hoped that such a document will assist and enable the National Networks to effectively lobby their governments for increased financial support. An Office of the Secretariat will be established. Hopefully, it will improve communication and the way of conducting business amongst the Network members. An Advisory Board will be set up within the requirements of the Constitution. Advisory Board Members will assist in selling the Network and enhance the image of ESARSWG to the scientific community and assist in attracting funds that will enable sustained research work in geophysics (seismology) related work in the region.

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The African Laser Atomic, Molecular and Optical Sciences Network. Activities for the development of optical sciences and their applications in Africa

Ahmadou Wagué

1. Presentation of the LAM Network

The African Laser Atomic, Molecular and Optical Sciences Network (LAM Network) was launched in Dakar in 1991, at the occasion of the first International Workshop on the Physics and Modern Applications of Lasers organized at the University Cheikh Anta Diop of Dakar, Senegal. It was with the support of the International Centre For Theoretical Physics (ICTP), the Senegalese Government, the University Cheikh Anta Diop and the French Embassy in Senegal. Presently the LAM Network is mainly supported by ICTP, by the International Science Programme (ISP) at Uppsala University in Sweden, and by local university and governmental authorities during the workshop, schools and other activities of the Network in Africa.

The main purpose of the Network is to promote the physics of lasers, atoms, molecules, optical sciences and their applications as well as to develop scientific cooperation in these fields in Africa

2. Activities of the network

2.1. Workshops

The LAM Network have already organized the following eight international workshops on lasers and applications.

- Dakar, Senegal, in May 1991;
- Harare, Zimbabwe, in September 1993;
- Cape Coast, Ghana, in August 1994;
- Khartoum, Sudan, in January 1996;
- Gaborone, Botswana, in August 1998;

- Tunis, Tunisia, in December 2002;
- Douala, Cameroon, in December 2004.

The 8th workshop was held in November 2007 in Cape Coast, Ghana, together with the Topical meeting of The International Commission of Optics (ICO) and the meeting of Optics Within Life Sciences (OWLS). The LAM 9th International workshop was held in Dakar from 11 to 16 January 2010 together with the EBASI7 Conference and the NSBP meeting with the Launch of African Physical Society.

2.2. Schools and Conferences

The first school in Optics was organized by the Network in Cap Coast, Ghana, in 1993 in collaboration with ICO. In addition, in September 1996 and 1998, the LAM Network has organized schools in Optics respectively at the University of Abobo-Adjame and the University of Cocody in Abidjan, Côte d'Ivoire. In December 1998 in Dakar, in Collaboration with the American Physical Society and European Physical Society, the Network organized an international conference on Spectroscopy and Applications. In April 2000, the Network organized in collaboration with the International commission of Optics (ICO), the optical Society of America (OSA), and the Abdus Salam International Centre for Theoretical Physics (ICTP), an international Conference on Optics for Sustainable Development in Dakar. In April 2001, the LAM network in Collaboration with the Atomic Physic Division at Lund University organized a training course and workshop on *Laser Spectroscopy in Development*, where different groups from countries like Senegal, Ghana, Kenya, Sudan, Zimbabwe, Ecuador were able to build their own blue diode laser spectrometer to be taken back home. In November 2001 in collaboration with the international Centre for Science and High Technology (ICS), schools on Optical Design were organized in Dakar and Cape Coast. In 2002 a school in Optics and laser applications in Namibia was organized. In 2003 a school on Bio Photonics was held at the University of Dakar.

2.3. Collaboration in other African initiatives for the development of laser and optical sciences In Africa

In 2001, LAM participated in the First meeting in Pretoria at the Council for Scientific and Industrial Research (CSIR), aiming at the creation of a continental African laser centre for the benefit of all of Africa. In November 2003, in Johannesburg, the President of LAM delivered the launching speech of the African Laser Centre (ALC), an initiative for the development of laser infrastructure in Africa endorsed by African governments through the New partnership for African Development (NEPAD), and financially supported for the moment only by the South African government. The President of LAM is one of the directors on the ALC Board of Directors and was a vice chair of ALC at this creation. In December 2004 and in April 2006 in Collaboration with the Optical Society of Morocco, the Network organized Schools on lasers and applications in Tangier, Morocco. And recently, in January 2008, LAM has participated in the USA-Africa EBAL meeting in Cairo, and has sponsored the LAPAM meeting in Algiers in June 2008. LAM was also one of the initiators of the USA Africa meeting on Photon Interaction with Atoms held in Durban in South Africa in 2005 during the world year of Physics.

2.4. Training programmes for the development of capacities building in LAM Centres In Africa

In collaboration with the Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy, the International Programme for Physical Sciences (IPPS), Uppsala, Sweden, and the Atomic Physics Division of Lund Institute of Technology, Sweden, operational Laboratories in diode Laser spectroscopy have been implemented in Senegal, Ghana, Sudan, and Kenya in 1996, after intensive training in July 1996 in Lund, Sweden, followed by the visit of Swedish scientists in all four African countries for the effective running of the spectrometer in African laboratories.

Within the same framework, in April 2001, in collaboration with the Lund Institute of Technology Laser Centre, the Network has participated in a one-month workshop *Laser Spectroscopy in Development* in Lund, Sweden, with participants from Senegal, Ghana, Kenya, Sudan, Zimbabwe, Tunisia, and Ecuador. The workshop was an occasion for each participating country to build its own blue diode spectrometer to be taken home after the workshop. These spectrometers are operational in Africa, for example in Senegal, in Photodynamic Therapy and Plant monitoring applications.

2.5. Scientific exchange visit programmes

The LAM Network is also developing programmes of scientific exchange visit between different research institutions in Africa. Within this framework, several research cooperation and training visits of scientists from Mauritania, Mali, Côte d'Ivoire, Ghana, Cameroon, and Sudan in the laboratory *Atomes Laser* at the ICTP-affiliated centre in Dakar, Senegal, have been organized. Similar visit of scientists from Togo, Cameroon and Senegal to Cape Coast, Ghana, at the ICTP-affiliated Laser and Fibre Optic Centre, have also been organized together with training visits of students of Cameroon in Tunisia. In addition, the CEPAMOQ in Duala, Cameroon, one of the LAM network centres in Africa, has established a strong collaborative scientific link with universities of the central African zone in Congo, Gabon, and Chad by training students at MPhil and PhD level. Through its different activities, the Network has been able to contribute in showing the place and interest of the physics and applications of lasers in the reinforcement and development of scientific and technical training and research capabilities in optical sciences in Africa. Many MPhil and PhD have been trained in laser spectroscopy, atomic physics and optical sciences at the different nodes of the network in Senegal, Ghana, Cameroon, Sudan, Kenya, Zimbabwe, Tunisia, Egypt, Morocco, etc.

3. Structures of the Network

The headquarter of the Network is located at the Laboratory *Atomes Lasers*, an ICTP-affiliated centre at the Faculty of Science and Technology, University Cheikh Anta Diop of Dakar, Senegal. Its directorate includes the President of the Network, regional coordinators, and international contacts. The network involves scientists from almost all African countries. Presently the LAM Network is one of the six ICO International Society Members including the Optical Society of America (OSA), the European Optical Society (EOS), the International Society of Optical Engineering (SPIE), the International Engineering Electrical and Electro-Optical Society (IEEE/LEOS), and Optics within Life Sciences (OWLS).

4. Sponsoring and perspectives

The Activities of the LAM Network are mainly sponsored by ICTP, IPPS, and, during workshops and schools, by governmental and universities authorities of African countries in which the activities of the Network are organized. For many years and up to now, we are trying to convince our university and governmental authorities together with our traditional sponsors from ICTP and IPPS about the creation in Senegal of a regional African Centre in Optics and Photonics with all modern research and training facilities and for the benefit of all of Africa. From perspectives between the African Laser Centre and the LAM Network one can expect that new frontiers in the collaborative actions of the network will be opened. Namely, one can expect the support of African governments for the establishment of hard-laser infrastructure in the different nodal points of LAM Network. We are expecting also a new partnership within Laser Lab Europe, a project in collaboration and together with the LUND Laser Centre and ALC.

Acknowledgement

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We would like to thank Dr. Lennart Hasselgren as well as Professor Sune Svanberg and Professor Katarina Svanberg in Sweden for their support and scientific collaboration with the *Laboratoire Atomes Lasers* and with the LAM Network. We hope to continue in this direction. Special thanks and a tribute to Professor G. Denardo for all the efforts done when he was alive for the development of optical sciences in Africa and for his constant support and friendship. It is thanks to his collaboration with Drs. Lennart Hasselgren and Sune Svanberg that IPPS started his programme with the ICTP-affiliated centres and LAM Network.

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Food research within LANFOOD in Latin America

Jenny Ruales and Luis Arturo Bello-Perez

At the Technological Research Institute, now Department of Food Science and Biotechnology (DECAB) of Escuela Politécnica Nacional, Quito, Ecuador, the Latin American Network for Food Research (LANFOOD) was created in 1995 with the support of Professor Rune Liminga, Director of the International Programme in the Chemical Sciences (IPICS), Uppsala University, who extended generous financial assistance, and with the technical advise of Professor Baboo M. Nair, Department of Applied Nutrition, Lund University, who was behind the idea of having a network in Latin America for promoting regional and international cooperation. LANFOOD received the economical support from IPICS until 2007.

The members of the board were:

Dr. Jenny Ruales (Ecuador), Executive President,
Dr. Juscelino Tovar (Venezuela),
MSc Ana Silvia Bermúdez (Colombia),
Dr. Enrique Yañez (Chile),
Dr. Rune Liminga (Sweden),
Dr. Malin Åkerblom (Sweden),
Dr. Baboo Nair (Sweden).

During this time a family-like relation has been established among the members of the LANFOOD network. We would like to thank all the members of the Board of LANFOOD for having confidence in the aims of the network and for using this system as a complement to their own research activities. IPICS, represented by Professor Rune Liminga in the beginning, later by Dr. Malin Åkerblom and then Dr. Peter Sundin, has been the main source of technical and financial support and it was the inspiration for continued cooperation among the food scientists of Latin American Countries.

At the beginning, the members were mainly Latin American scientists who have had some connection with Sweden. After 5 years of the creation, scientists from thirteen countries, including Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, Uruguay, Venezuela, Sweden, and Denmark are members of LANFOOD.

The aim of the network was to promote regional cooperation between research groups working in the field of food science in order to:

- exchange information on ongoing research in the field;
- identify research problems of local and regional importance;
- share local and regional resources; and
- promote exchange of scientists and training of students.

The "effective research through cooperation" was the main motivation for our activities. Effort in establishing regional cooperation leading to collaborative work was being sponsored by IPICS, and we have succeeded in sharing local and regional resources through exchange of scientists and postgraduate students among the research groups of Latin America. It is important to mention that common postgraduate programs in Food Science have also become a reality.

The main objectives of the network were to increase the cooperation between regional and international research groups and to improve the sharing of research facilities among the members. It was also important to identify problems and formulate projects of local importance as well as to develop a policy and a mode of operation for supporting regional cooperation. Exchange of scientists and postgraduate students in the network needed to be strengthened and also the sharing of information on food analysis and on nutritional composition data. It was natural to create a database of resources available for research among the members.

Scientists from 11 countries are taking part in LANFOOD and around 24 scientists have been participating as project leaders: Mexico, Costa Rica, Colombia, Ecuador, Venezuela, Peru, Bolivia, Brazil, Argentina, Uruguay and Chile.

The main area of research was focused on adding value to local raw materials from the region, named as plantain, quinoa, tropical fruits, potatoes, beans, native roots, and tubers, etc. They have been characterized as raw materials, and products have been developed. The new products are mainly functional foods, because the interest is addressed to bioactive components like polyphenols, carotenes, fibers, resistant starch, or carbohydrates with low digestibility.

The uses of facilities of the groups who are more developed in different areas have been the major achievement. Strong links have been established among the partners and due to that, complementary analyses have been performed in Mexico, Venezuela, Ecuador, and Brazil.

Around 90 scientific publications have been prepared based on the results and the publications having as co-authors partners of LANFOOD.

It is important to mention that those groups who have tradition to publish were helping other to do it. Postgraduate students at Master and PhD level from different research groups have performed complementary analysis in laboratories and fulfill the research requirement for their postgraduate programs with the contribution of LANFOOD partners. Around 35 students have been complete the postgraduate studies with the help of LANFOOD at Master and PhD level.

Exchange of staff and students between the different research centres has been an important issue supported by LANFOOD. Scientific regional events have been organized in several Latin American countries, giving to the scientists of the region the opportunity to share the experience and knowledge with others working in the same field of work. LANFOOD has also coordinated some training in Ecuador, Venezuela, Argentina, Chile, Mexico, and Spain, as well as visits by its members to regional laboratories, with funds mainly from IPICS, but also from IPS, CYTED (Ibero-American Technical Cooperation for the Development of Science and Technology), ONCYT's (National organizations for Science and Technology of the Ibero-American countries) and French Technical Cooperation.

LANFOOD has been the seed to promote collaboration with research centres mainly from Spain, France and Belgium, and also with other countries from outside the region. Research projects sponsored by the European Union and through bilateral cooperation have involved scientists from LANFOOD.

The main field of collaboration was related to characterization of starches from non-traditional regional materials like roots, tubers, and tropical pulses, and to their utilization according to their intrinsic characteristics. Physico-chemical, functional, rheological and nutritional characteristics are being evaluated in starches. Dietary fibre is also of interest of the members of the network, as are studies of micronutrients, like lipo- and hydro-soluble vitamins and minerals as Fe, Zn and Ca. The effect of processing on the quantity and bioavailability of pro-vitamin A is also studied.

Minerals, the content and their availability by using in-vitro and in-vivo methods, were also studied. Different processes are being applied for improving the stability, nutritional properties and sensory characteristics of the final products based on cassava, rice, tropical pulses, etc. Research activities on cassava, quinoa, lupine, tropical beans, roots, tubers, and non-traditional fruits, are oriented to adding value to local materials by using their bioactive compounds, or maybe enzymes with special characteristics.

Training programs of students and exchange of scientists have been carried out in collaboration with CYTED. Through joint efforts between LANFOOD and CYTED a large number of exchanges programs have been performed. Through the European Union postgraduate programs in Latin America in Food Science and Technology are being under discussion for their validation.

Since 1995 several workshops, conferences and symposia have been held in the region. Proceedings from these meetings have been produced, which have added to the scientific communication within the network. In 1999, a practical Handbook on methods for the characterization of carbohydrates has been published also in cooperation of CYTED.

Some examples of studies carried out by LANFOOD members are the following.

Quality assurance

Some inter-laboratory analysis has been performed with some accredited laboratories like from Ecuador, Brazil, Chile and Argentina regarding to vitamins (Vitamin C, β-carotenes and minerals like Fe, Ca and Zn).

Arsenic studies

Research studies on arsenic were supported in Argentina and Ecuador, in collaboration with CYTED. Certified samples has been purchased with funds of LANFOOD and distributed to research groups working with contamination of arsenic in Iberoamerica (Bolivia, Chile, Argentina, Spain, Ecuador, Mexico, and Costa Rica).

LANFOOD sponsored some studies carried out in Argentina where hydroarsenism affect all the provinces.

The main goal of this research group was to add value and to improve the uses of local raw materials. The studies were focused on the chemical and nutritional evaluation of the non-traditional products in order to contribute to the improvement of the nutritional status of the population. In this way, soybeans, lupine and quinoa, fruits, roots, and tubers, pulses, has been the matter of research work. Cooperation with CYTED has been established, and support has been given to young Latin-American researchers who wanted to participate in projects and networks of CYTED.

Data base of food composition

Through Costa Rica, LANFOOD is represented in Central America. INCIENSA is coordinating activities in the food composition table in Central America and many seminars and workshops have been organized and also the generation of data has been done with the support of LANFOOD

LANFOOD has also contributed in the organization of national and international scientific events in food science, in Mexico, Venezuela, Costa Rica, Peru and Ecuador. The contribution has been not only funds but also contacts with scientists who participated in the events.

Adding value to local roots, tubers and fruits rich in starch

Starches from local roots, tubers and from Achira (*Canna edulis*), Zanahoria blanca (*Arracacia xanthorriza*), sweet potato (*Ipomoea batatas*), Oca (*Oxalis tuberosa*), Melloco (*Ullucus tuberosus*), taro (*Colocasia esculenta*), Mashua (*Tropaeolum tuberosum*), and cassava (*Manihot esculenta*), and from fruits like plantain (*Musa paradisiaca* L.) were isolated and physico-chemically characterized. Calorimetric analyses, like differential scanning calorimetry (DSC), rheological tests, X-ray diffraction, and infra-red spectroscopy were performed to determine the nutritional and functional properties of native starches as well as of chemically and thermally modified starches. Scanning electron microscopy (SEM) was also performed on starch samples.

Some recommendations of uses of those starches were done based on their properties. Some functional foods were suggested to be developed due to their low starch digestibility, high content of fiber and also some industrial applications like fat replacer and also other as ingredient for products kept at low temperature, those who usually present syneresis. The starches that presented good film properties have been used to produce edible biodegradable films and coatings to be applied in food industry. Starches from *Canna edulis*, cassava and plantain were used for the developing of those packaging materials. Also, bioactive compounds like extracts with antifungal or antibacterial effect were added to films to be used mainly in freshly cut fruits, meat, etc.

The research centres involved in this area of research are CEPROBI-Mexico, EPN (Ecuador), Universidad Central de Venezuela (Venezuela), Universidad la Molina (Peru), Instituto Criogénico de La Plata (Argentina). Lund University, Sweden, and CIRAD, France, were also supporting some research activities with Ecuador.

Cassava and production of glucose, maltose and fructose syrups from cassava starch using immobilized amylolytic enzymes

This project was part of a PhD thesis and it is carried out in collaboration with Department of Biochemistry of the Universidad de la Republica del Uruguay (Professor Francisco Batista), Department of Food Science and Technology of Escuela Politécnica Nacional.

Carotenoides: total amount and availability, antioxidant activity

The research up to now was focused on social and productivity work. The Escuela Politécnica Nacional (EPN) from Quito-Ecuador took contact with Gatazo-Zambrano Community, Chimborazo Province, Ecuador which is one of the major carrots producers. This work dealed with postharvest studies of carrots keeping organoleptic and nutritional quality. The development of a carrot juice after lactic acid fermentation, stable at room temperature with relatively high vitamin A availability, was being studied. The project was performed in collaboration with the Department of Food Science at Chalmers University of Technology and Ecuador. The analytical method developed in the study for β-carotenes quantifications and was implemented in Bolivia and also to Colombia, where it was utilized to quantify the content of β-carotenes in fruit palm, a fruit from the Amazonas region, very rich in carotenoids.

Enzymes inmobilization

A research on the inmobilization of enzymes to increase the extraction rate and to increase the amount of soluble solids in fruit pulps was performed in Universidad del Valle, Colombia, and also at EPN. Different substrates and different inmobilization technologies were applied. The Department of Biotechnology of Universidad de la República del Uruguay, Universidad del Valle-Colombia and also EPN-Ecuador were involved in this research. CIRAD from France also gave the technical support in this study.

Clarified juice from non-traditional fruits

Cross-flow microfiltration is being applied to produce clarified juices with good organoleptic and nutritional characteristics. The novel technology has been applied in passion fruit, Andean blackberry, etc. This project has been performed in collaboration with CIRAD-FLHOR, France, with financial support from the French Technical Cooperation, IFS, and IPICS. Later on an INCO project was financed, and the research was performed in some Latin American research centres in Mexico, Costa Rica, Ecuador and Brazil, in collaboration with some European research centres in the United Kingdom, Belgium, France and Germany.

Laboratory supplies and set-up of methods

LANFOOD was also supporting the purchase of minor equipment, which was basic for running some equipments like lamps for the atomic absorption spectrophotometry. Mineral analysis has been an important issue for the food composition table in Argentina. Scientists from EPN-Ecuador collaborated in the installation and set-up of methods, mainly for vitamin analysis by HPLC in the laboratories of Santa Cruz Bolivia, fully equipped but those instruments were not used.

Other activities

The members of LANFOOD have been invited to take part in scientific events and also to give scientific comments to the different aspects in which we are involved.

LANFOOD has also supported the organization of scientific events alone and also in collaboration of LANBIO, CYTED, and LATINFOOD.

The culture of publication is not high in Latin America; therefore the collaborative work has encouraged and promoted the art of publishing. The number of publications with the participation of two or more groups is still low (35).

A strong effort is being done to obtain funds to keep the network together, and some of the partners are now involved in a European program called the ISEKI_Mundus 2 project. Some efforts are also being done to establish research projects under South-South collaboration financed maybe by OPCW. Contacts have been taken with research groups in Burkina Faso, Benin, and Cameroon.

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Food Science and Nutrition Network for Africa: Achievements, challenges, and a way forward

Francis M. Mathooko

Abstract. The idea of establishing a network for Food Science and Nutrition professionals was mooted during a Workshop on Regional Collaborative Activities in Eastern, Central, and Southern African Regions – Regional Action Plan for Food Security and Action, held in Nairobi, Kenya, in 2000. Later in the year subsequent meetings were held in Addis Ababa, Ethiopia, under the sponsorship of the International Science Programme, Sweden, and Food Science and Nutrition Network for Africa (FOSNNA) was formed.

FOSNNA was officially inaugurated during its first Biennial Conference held in Dar es-Salaam, Tanzania, in 2002. Among its many objectives are: to network individuals and institutions within African countries through exchange of information and experiences in the fields of Food Science and Nutrition; to initiate, develop, promote, and coordinate research and training in the areas of Food Science and Nutrition and their applications for the improvement of the livelihood of people in African countries; to promote collaborative research in Food Science and Nutrition among African countries as well as foster and maintain research links with scientists outside Africa working in areas of Food Science and Nutrition; and to organize Food Science and Nutrition conferences, workshops, seminars and/or symposia.

FOSNNA also seeks to provide information on scholarships and/or fellowships for Food Scientists and Nutritionists for further training and/or research; to design and implement short tailor-made training programs in Food Science and Nutrition; to foster open laboratory systems in each member countries; to facilitate access to laboratory and other facilities in member countries; and to mobilize resources (financial and human) for promotion of training and research.

Over the years FOSNNA has been able to achieve some of its objectives particularly with respect to: hosting biennial conferences, students exchange, staff exchange for sabbatical leave and external examination, provision of research grants to postgraduate students, and sharing of the limited physical facilities in the respective institutions.

This paper gives an overview of FOSNNA, its achievements, challenges, way forward, and possible areas of interregional collaboration with like-minded networks with a view to achieving its objectives.

1. Introduction

Food Science and Nutrition play a pivotal role in society and have potential in enhancing the livelihood of people through improving food accessibility and wholesomeness, poverty alleviation and making food suitable for special groups such as young children, pregnant and nursing mothers, the sick and the elderly. Despite this, nutrition deficiencies remain among the major public health problems in Africa and constitute one of the principal causes of morbidity and mortality, particularly among the vulnerable groups, and yet food is a fundamental human right.

Malnutrition is one of the most important risk factor for disease. Poor absorption, inadequate or inappropriate food and nutrient-deficient diets are among the major challenges of African people leading to disease-prone situations. Eliminating hunger and malnutrition is technically feasible. The challenge lies in generating the requisite political will, developing realistic policies and taking concerted actions nationally and internationally. Food-based interventions focus on food – natural, processed, fortified, or in combination – as the primary tool for improving the quality of the diet and for overcoming and preventing malnutrition and nutritional deficiencies. This approach recognizes the essential role of food science for improved nutrition.

Currently, circulation of information and exchange of knowledge in Food Science and Nutrition research in African countries is minimal. Little is also happening on the transfer of knowledge in solving problems at the ground level. It is against this background that the Food Science and Nutrition Network for Africa (FOSNNA) was established with a view to fostering the role of Food Science and Nutrition in improving the livelihood of people in the region.

The substantial human resources knowledge, skills and facilities in African countries could be harnessed through enhanced communication, collaboration/exchange, and networking. The Food Science and Nutrition Network for Africa (FOSNNA) was formed in 2000 in Addis Ababa, Ethiopia, with support from IPICS through Dr. Malin Åkerblom. The founder members are: Dr. Girma Akalu, Ethiopia; Professor Joyce Kikafunda, Uganda; Dr. Roserita Kingamkono, Tanzania; and Professor Francis M. Mathooko, Kenya. Since 2002, FOSNNA has been working in various regional initiatives, research collaboration, gatherings of professionals.

The Food Science and Nutrition Network for Africa (FOSNNA) is an apolitical, non-sectarian and non-profit-making network for professional and individuals working or interested in food and nutrition-related areas. The network aims at providing an opportunity for the exchange of ideas among food scientists in Africa who know each other through the Internet, workshops and symposia. It addresses challenges related to R & D and how to generate additional information that can improve transfer of technology.

2. Objectives of FOSNNA

The main objectives of FOSNNA are to

(a) Network individuals and institutions within African countries through exchange of information and experiences in the fields of Food Science and Nutrition;

(b) Initiate, develop, promote, and coordinate research and training in the areas of Food Science and Nutrition and their applications for the improvement of the livelihood of people in African countries;

(c) Promote collaborative research in Food Science and Nutrition among African countries as well as foster and maintain research links with scientists outside Africa working in areas of Food Science and Nutrition;

(d) Organize Food Science & Nutrition conferences, workshops, seminars and/or symposia;

(e) Provide information on scholarships and/or fellowships for Food Scientists and Nutritionists for further training and/or research, as well as design and implement short tailor-made training programs in Food Science and Nutrition;

(f) Develop and make periodic updates of a data bank of food scientists and nutritionists, food industries, research institutes, and training institutions in African countries;

(g) Collaborate with food industries in product development and problem solving;

(h) Disseminate Food Science & Nutrition Information, Education and Communication (IEC) materials through electronic and mass media in member countries;

(i) Foster open laboratory system in each member country for quality assurance performing collaborative research;

(j) Facilitate access to laboratory and other facilities in member countries;

(k) Mobilize resources (financial and human) for promotion of training and research.

3. Organization of FOSNNA

FOSNNA has three categories of principal organs for the management of its affairs, namely:

- FOSNNA Advisory Board (FAB);
- FOSNNA Regional Executive Board; and
- FOSNNA National Chapter Coordinating Committees.

3.1. FOSNNA Advisory Board (FAB)

(a) An Advisory Board composed of representatives of African and non-African individuals/organizations interested in supporting the objectives of FOSNNA is established to assist the Coordinating Board in planning, designing and financing the activities of FOSNNA;

(b) Nomination of Advisory Board members may come from any ordinary member. The Regional Executive Board decides on which individual/organizations will be invited to join the Advisory Board;

(c) The advisory Board provides advice only to the Coordinating Board, in consultation and correspondences with the Regional Network Coordinator or another member of the Regional Coordinating Board designated by the Regional Network Coordinator;

(d) Membership to the Advisory Board is reviewed by the Regional Coordinating Board every few years and their membership ends either through a letter to the Regional Coordinator or to them from the Regional Executive Board;

(e) The Members of Advisory Board and their representatives have no voting rights in the Regional Executive Board meetings unless they are attending the meetings as members in their own right.

The current Advisory Board members are: Professor Rune Liminga, Sweden; Professor Pauline Kuzwayo, South Africa; Dr. Malin Åkerblom, Sweden; and Professor Sefa Dedeh, Ghana.

3.2. The FOSNNA Regional Executive Board

This acts as the supreme decision-making organ of FOSNNA and for the purpose of giving the necessary leadership and guidelines for the administration of the affairs of FOSNNA. Specifically, it

(a) Considers and approves proposals for any short- or long-term development plan of activities and strategies for implementation, the budget of FOSNNA, auditors' reports/audited accounts and financial statements relating to the accounts of FOSNNA;

(b) Receives, reviews and evaluates reports on implementation of projects and any other reports submitted by the country chapters and issue appropriate directions for compliance by the competent organs or officers of FOSNNA;

(c) Considers and approves proposals by the Country Chapters/Sub-Regional Offices to appoint a Committee to perform special tasks;

(d) Receives, considers and resolves any issue of question for determination and in respect of which this Constitution makes inadequate or no provision for its resolutions;

(e) In consultation with members of FOSNNA, ratifies or amends the FOSNNA constitution as it deems appropriate for the better fulfillment of the network's aims and objectives;

(f) Lays down and changes from time to time such rules as may be thought necessary for the proper functioning of FOSNNA.

(g) Enters into agreements with other organizations for enhancing the capability of FOSNNA in pursuit of its objectives;

(h) Delegates the exercise of its powers under this constitution to the Regional Coordinator for conducting the affairs of FOSNNA smoothly and efficiently.

The Board used to meet at least once a year and has been the Central Executive Committee (CEC) of FOSNNA, but this is no longer the case due to lack of commitment on the part of coordinators.

The Executive Board is currently comprised of:

Dr. Girma Akalu, Executive Secretary,
Professor Francis M. Mathooko, Kenya,
Professor Joyce K. Kikafunda, Uganda,
Dr. Roserita Kingamkono, Tanzania,
Professor Alfred Traore, Burkina Faso.

FOSSNA has since its formal inauguration in 2002 been coordinated from Ethiopia, by Dr. Girma Akalu (male) at the Ethiopian Health and Nutrition Research Institute (EHNRI).

In 2008 Dr. Girma took another position with Save the Children, USA, and the coordination responsibility was temporarily transferred to Professor

Francis M. Mathooko (male), then based at Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya. Recently, Professor Mathooko was appointed to the position of Deputy Principal (Academic and Student Affairs) at the South Eastern University College, a constituent college of the University of Nairobi, Kenya. However, despite this added responsibility, Professor Mathooko has continued to coordinate FOSNNA activities until the time when a suitable coordinator will be identified.

4. Achievements

Since its inception, FOSNNA has been quite active in a number of activities in line with its objectives:

(a) Held its First Biennial Conference in Dar es-Salaam, Tanzania, in 2002, supported by the Swedish Agency for Research Cooperation (SAREC), IPICS, IFS, ISP, African Institute for Capacity Development, International Union of Nutritional Sciences (IUNS), and IPGRI. During this meeting, FOSNNA was inaugurated and a draft constitution discussed and membership was extended to all countries in Africa and additional coordinators elected;

(b) FOSNNA website was launched in 2003: www.fosnna.org;

(c) The logo and a brochure were developed, and the network was introduced at many regional and international meetings;

(d) Some collaborative research among institutions/researchers has been initiated and continue to remain active;

(e) subregional offices established and focal persons at national level identified;

(f) A Programme Officer based at Regional Office was recruited, but is no longer working for FOSNNA;

(g) The second biennial conference was held in Addis Ababa, Ethiopia, in 2004. This meeting was supported by funds from IPICS, EHNRI, MOST, AICAD, Ambo Mineral Water, Awash Winery, Faffa Food Factory, and AU, among others. Additional FOSNNA coordinators were elected, mainly for Western and Southern Africa regions.

(h) The third biennial conference was held in Ouagadougou, Burkina Faso, on 9th to 11th April 2007.

(i) Sponsored scientific meetings, more recently being the sub-Saharan Africa Regional Workshop on Food Education, Security and Social Perspectives in Addis Ababa, Ethiopia, from 6th to 8th October 2008;

(j) Sponsored participants to conferences, e.g., to the First International Society for Horticultural Science (ISHS) International Conference on Postharvest and Quality Management of Horticultural Products of Interest for Tropical Regions held at Crowne Plaza Hotel, San Jose, Costa Rica from 20th to 24th July 2009;

(k) Sponsored beneficiaries of FOSNNA Postgraduate Research Fellowship to present their research findings at the International Conference on Regional and Interregional Cooperation to Strengthen Basic Sciences in Developing Country, held at the United Nations Conference Centre, Addis Ababa, Ethiopia, from 1st to 4th September 2009.

5. Staff exchange

This was facilitated through networks established during FOSNNA conferences. No funding by through ISP to FOSNNA yet. This has involved:

(a) Sabbatical leaves;
(b) Short term teaching/research;
(c) Curriculum development;
(d) Quality assurance.

6. Student exchange

FOSNNA started three-month postgraduate research grants in 2005 through IPICS support. The first awardees were as listed in Table 1.

In 2006, nine applicants were successful, distributed as: Cameroon 2, Ethiopia 3, Kenya 2, Nigeria 1, Uganda 1.

In 2007, 14 applicants were successful, distributed as: Burkina Faso 1, Cameroon 7 (including group of 5 students), Ethiopia 1, Kenya 5, Nigeria 2, Tanzania 1, Gabon 1.

It is clear that with additional coordinators, FOSNNA is getting well known across the continent and the coordinators are best based at universities.

FOSNNA has also a one-month Undergraduate Student Exchange Programme with support from IPICS/ISP. Awardees started the programme in 2007.

Undergraduate practical training was also undertaken with a group of 70 Food Science and Technology students from the Kigali Institute of Science and

Technology, Rwanda, being trained annually at the Department of Food Science and Technology of Jomo Kenyatta University of Agriculture and Technology.

Table 1. JKUAT: Jomo Kenyatta University of Agriculture and Technology, Kenya (4); Ethiopia (4); and Uganda (1) (only lab-based research).

Name	*Institution*	*Host Institution*
P. N. Muoki (F)	JKUAT, Kenya	Makerere University, Uganda
G. M. Kariuki (M)	JKUAT, Kenya	Makerere University, Uganda
M. A. Ogubi (F)	Kenyatta University, Kenya	JKUAT, Kenya
S. O. Oiye (M)	University of Nairobi, Kenya	JKUAT, Kenya
M. F. Turyashemererwa (F)	Makerere University, Uganda	Mulago Ref. Hospital, Uganda
E. Admasu (M)	Addis Ababa University, Ethiopia	JKUAT, Kenya

Table 2. 2006 Applicants by country.

Country		*# of applicants*
Kenya	KE	8
Cameroon	CM	5
Ethiopia	ET	4
Nigeria	NG	3
Uganda	UG	2
Madagascar	MG	1
DRC	CD	1
Ghana	GH	1
Morocco	MA	1

7. Challenges

Despite its achievements, FOSNNA has also met various challenges. Among them are:

(a) Financial and time constraints on the part of the coordinators;

(b) subregional and national offices not funded to undertake activities aimed at publicizing the network;

(c) Poor communication among coordinators – linked to poor access to internet – lack of funds to blame;

(d) Lack of commitment on the part of some coordinators. Voluntary – no financial gain;

(e) Infrequent communication and timely guidance from the regional office;

(f) Lack of professional organizations/societies in Food Science and Nutrition to bring professionals together;

(g) Individualization vs. Institutionalization of FOSNNA activities.

8. Future plans

(a) Identification of committed coordinators;

(b) Establishment of collaboration with partner organizations to fund some of our activities – has worked for the biennial conferences;

(c) Writing proposals for sponsorship of some of our activities by other donors;

(d) Enhanced funding of subregional and national offices – especially the new ones;

(e) Development and posting of databank for professionals, industries, research institutes and institutions of higher learning – been proposed – lack of funds.

(f) Look for funds to support staff fellowships and sabbatical leave;

(g) Development of short courses;

(h) Enhancement of collaborative research;

(i) Solicit for funds to initiate staff exchange;

(j) Look for other possible donors rather than relying on IPICS/ISP;

(k) FOSNNA website has not been updated for some time due to change in coordination from Ethiopia to Kenya without corresponding change of website host;

(l) Production of printed materials, e.g. brochures and newsletter;

(m) Financial empowerment of local chapters;

(n) Solicit for funds to offer full postgraduate students scholarships.

Acknowledgements

On my own behalf and that of the other coordinators, I thank the International Programme in Chemical Sciences (IPICS) and the International Science Programme (ISP) for the continued support of FOSNNA activities since its inception; the coordinators for publicizing FOSNNA in various scientific meetings and all sponsors who co-sponsored with FOSNNA various scientific meeting. I thank the ISP for sponsoring me to attend the International Conference on Regional and Interregional Cooperation to Strengthen Basic Sciences in Developing Countries.

Francis M. Mathooko, PhD, is Professor and Deputy Principal (Academic and Student Affairs) at South Eastern University College (a constituent College of the University of Nairobi), Kitui, Kenya. He is also affiliated to the Department of Food Science and Technology, Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya. In 2008−2009 Professor Mathooko temporarily took responsibility for coordinating FOSNNA activities.

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Networking in basic science enhances human capital development and better application of science in development: Experiences from IPICS-funded and SABINA projects in Southern Africa

John Saka and Jane Morris

Introduction

Partnership which entails all parties agreeing to work together in implementing a programme is a key in fostering quality and multidisciplinary research which advances knowledge and application in a society. Two projects housed in the Department of Chemistry, Chancellor College, University of Malawi, Zomba, Malawi, offer attractive examples of the value of networking to create a platform that has the ability to attract additional and high-level funding for basic and applied science research. The MAW 01 project on chemistry and biology of tropical root crops in Malawi has received supported from ISP/IPICS since 2002, while SABINA obtained funding from Carnegie-IAS RISE as a Regional Initiative in Science and Education (RISE) in September 2008. These two projects generate basic scientific knowledge including applications in agriculture, medicine, and value addition to natural resources. They focus on enhancing the links between biology and chemistry through the scientific disciplines of molecular biology/functional genomics, natural product chemistry, biochemistry, and food science.

Both projects train both PhD- and MSc-level scientists through research in the biochemistry and chemistry of natural products. SABINA network partners are the University of Malawi, the University of Namibia, the University of Dar es-Salaam, the University of Pretoria, the University of the Witwatersrand, the Council for Scientific and Industrial Research, and the Tea Research Foundation of Central Africa. The IPICS MAW01 partners are the University of Malawi, the University of Free State, and the National Root and Tuber Crops, Department of Agriculture Research Services, Malawi.

Objectives of the network projects

The IPICS MAW 01 project concerns the genetics and chemistry of tropical roots and tuber crops such as cassava, sweet potato and cocoyam in Malawi. The main objective is to generate knowledge and build the local and regional institutional capacity (human and infrastructure) for effective research into the chemistry, molecular biology, and biotechnology of tropical root crops, and thus enhance productivity, utilization, and commercialization of these crops in Malawi.

The main objective of the SABINA project is to implement proactive postgraduate programmes in chemistry/biochemistry of natural products and thus develop functional networks integrating chemical and biological sciences, and implement both PhD and MSc programmes which benefit scientists in key SADC universities.

Common characteristics of the two projects

The two projects have common features and these include:

(i) Development and training of staff and students;
(ii) Co-supervision of students between faculty in different partner institutions;
(iii) Students exchanges between partner institutions;
(iv) Commitment to at least 30 % female participation;
(v) Proactive publications of knowledge and experiences in refereed journals;
(vi) Complementarities of research focus.

Both SABINA and IPICS MAW 01 projects emphasize regional and international networking. The IPICS MAW 01 involves partners from the University of Free State, South Africa, and with contacts at Lund University, Sweden, and Escuela Politecnica Nacional, Ecuador. The key partners in the SABINA project include Chancellor College, University of Malawi; the Tea Research Foundation of Central Africa (TRFCA), Malawi; the Department of Chemistry and Biochemistry, University of Namibia, Namibia; the African Centre for Gene Technologies (ACGT), South Africa; the Centre for Scientific and Industrial Research (CSIR); South Africa University of Pretoria; the University of the Witwatersrand, South Africa; and the University of Dar es-Salaam.

Resource mobilization for sustainability of R & D activities

The two funding bodies encourage research groups to identify alternative and complementary funding to ensure more research beyond the lifetime of present funding. Based on the work funded by ISP/IPICS, partners at the African Centre for Gene Technologies and University of Pretoria easily established functional linkages with our team at Chancellor College, Malawi. It is evident that networking and networks are very important vehicles for resource mobilization for research. The Malawi team has therefore been able to forge multidisciplinary research/approach and hence benefited from large research funding including the SABINA RISE projects. Furthermore, participation in the SABINA RISE project has relieved the academic project leader from administrative work through the appointment of a research project manager.

The multidisciplinary skills and complementarity have enabled Professor Jane Morris of a key node, ACGT, to mobilize additional funding of 945,350 EUR for Policy and Support actions for Southern African Natural Product partnership (POL-SABINA) from the EU Africa-Carribean-Pacific Programme. It is expected that other nodes and partners from elsewhere will come forward to work with us. Plans are advanced to organize in 2010 a training workshop in project management for SABINA key staff and some of the student beneficiaries. The network has also received supplementary funding from Carnegie-RISE amounting to 24,000 USD in 2010 for networking activities.

The future

IPICS MAW 01 has formed a platform for international networking with other institutions and partners, and SABINA is one of these important outcomes. The SABINA programme offers opportunities and benefits to institutions in Malawi, Tanzania, and Namibia to strengthen their capacities and capabilities in research work through the utilization of advanced equipments available in South African Universities. Further exploitation of this niche is being vigorously pursued by the projects teams to diversify funding and continue participation in high-level and relevant research in science.

Acknowledgements

The authors thank ISP/IPICS and Carnegie/RISE for funding the group and/or network projects in Southern Africa as well as funding the participation of Professor Saka at the ISP/AU/AAU International Conference on Regional and Interregional Cooperation to Strengthen Basic Sciences in Developing Countries, held 1–4 September, 2009, Addis Ababa, Ethiopia.

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Saka, J. D. K., and Gaynor, N. (2008). Irish-African partnership for research capacity building: Core partnership principles. Entebbe, November 2008.

John D. Saka is a chemist with research interests in utilization and commercialization of natural resources for household incomes, improved health, and nutrition. He has twenty-one years of active research and published over twenty papers in international, regional and national refereed scientific journals. Presently, he is the principal investigator of projects related to genetics and chemistry of tropical root and tuber crops in Malawi funded by ISP/IPICS (to the tune of 60,000 USD annually for the period 2004−2010); and Biochemistry and Informatics of natural products funded by SIG/RISE to the tune of 800,000 USD. These projects include a component of postgraduate training contributing to human capital development in basic and applied chemistry.

The ISP-funded outfit involves partners from the University of Free State, while the SIG/RISE initiative, being a network project, entails participation of the Universities of Malawi, Pretoria, Dar es-Salaam, Namibia, and the Witwatersrand, and research institutes: the Tea Research Foundation of Central Africa, African Centre of Gene Technologies, and the Council of Scientific and Industrial Research.

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E. Jane Morris has a PhD in biochemistry from the University of Aberdeen. She has worked in the South African biotechnology sector, in both academia and industry for many years.

She is currently Director of the African Centre for Gene Technologies (ACGT), a collaborative initiative between the CSIR, the University of Pretoria, and the University of the Witwatersrand. The University of Johannesburg and the University of Limpopo are also associated with the organization. The ACGT aims to promote the development of advanced bioscience and biotechnology amongst the partner institutions.

Jane Morris is a member of a wide variety of national and international committees, and has been instrumental in raising funds to support a variety of collaborative research programmes. She holds an appointment as Extraordinary Professor of Biochemistry at the University of Pretoria.

Professor Morris is the key contact for the South African group.

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Group Discussion, Theme 1: Research training and the role of networks

Paul Vaderlind and Mary Teuw Niane

Chairperson: Mary Teuw Niane.
Rapporteur: Paul Vaderlind.
In the group discussion participated twenty-eight delegates. Most of the time was used to identify the problems shared by the researchers in developing countries. The session concluded by some recommendations in order to improve the situation.

1. Indicated problems

1. No adequate support from local governments for training, research and scientific networks. Not enough engagement of the governments for basic sciences;
2. No satisfactory strategic plans for universities and networks;
3. Lack of training inside the existing networks and regional and inter-regional cooperation. Africa has a substantial potential to develop MSc and PhD programs, but there are not enough programs to meet this potential;
4. Lack of appropriate scientific infrastructures like universities buildings, libraries, computers, and fast internet access;
5. Poor social conditions, like low salaries, lack of local fellowships for MSc and PhD students, and bad working environment;
6. Overload of teaching hours both for postgraduate students and for university staff. This substantially delays the progress in study and gives no time for research activities;
7. The steady brain drain continues to have its negative effect on the increase of the scientific level of the departments;
8. Some of the networks are far from efficient in using founds and human resources in training and research projects;

9. Low level of knowledge of secondary school teachers in basic sciences and particularly in mathematics;

10. Big differences within regions in scientific curricula, which has a negative effect on cooperation;

11. Lack of experimentations in physics and chemistry;

12. Not enough university positions to meet the demand from the increasing number of students;

13. The lack of scientific and pedagogical competence of academic staff. It happens that a teacher lectures on a subject that he/she is not a specialist in;

14. The curricula in physics often do not cover the necessary mathematics and some fundamental parts of physics;

15. At some universities students' and teachers' strikes during the academic year have a negative effect on the achievements and fulfilling the curricula;

16. There is not enough cooperation between mathematicians and other sciences;

17. Graduate students do not take all the possibilities of grant-offers from various institutions inside the country and abroad;

18. At some universities the cost of registration is much too high.

2. Proposed solutions to some of the problems mentioned

1. Finding the ways of strengthening the local support from the governments and enterprises. Make them aware of the importance of basic sciences. Increase salaries, improve the infrastructure and the scientific environment;
2. Make the Pan-African and international organizations constantly aware of the basic science situation in Africa and the importance of improving it;
3. Create more networks and strengthen their scientific significance;
4. Use the experience of the networks the MSc and PhD students;
5. Use the potential of the networks and regional groups to improve the local training of MSc and PhD students. Use the specialist coming from the North and local specialist from the networks. Good example for this

may be found in the network EAUMP, the Eastern African Universities Mathematics Programme;

6. If possible use the guest lecturers to start the research groups and use their knowledge for supervising MSc theses;
7. Discuss with the International Mathematical Union and similar organizations in other sciences about the possibility to create a periodical award for scientists strongly involved in work for developing countries (once a year or every second year);
8. In case of co-direction strengthen the cooperation between the local and the foreign supervisors;
9. We need better qualified staff members to match the demand of local supervisors of theses;
10. Open possibilities for mobility of staff members between universities within the country and abroad;
11. Encourage the African scientists to publish their results in internationally high-ranking journals. Even when working for some time in the North, mention the home university in references;
12. There is sometime a positive effect of the brain drain. This happens when a scientist, while working abroad, keeps a scientific contact with his/her home university. The scientific diaspora could and should be used to reinforce the capacity of networks;
13. Encourage the universities to create equivalent curricula within a country and region;
14. Work on governments and enterprises to increase the number of MSc and PhD grants;
15. Create a program for increasing the knowledge of subjects for the secondary school teachers;
16. Start the use of internet in teaching and cooperation between the universities.

Paul Vaderlind is a senior lecturer at the Department of Mathematics, Stockholm University. In the last ten years he was strongly engaged in the work of ISP in Africa and South East Asia, teaching mainly combinatorics and set theory for MSc and PhD students. During those years Paul has visited a large number of African universities and gained a lot of experience of teaching there.

Paul sees his work as a unique possibility to spread his enthusiasm and appreciation for mathematics and, at the same time, meeting plenty of wonderful and gifted students in a large variety of countries.

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Mary Teuw Niane holds a PhD in mathematics from Université Cheikh Anta Diop (1984) and is now President of Université Gaston Berger, Saint-Louis, Senegal.

Group Discussion, Theme 2: Networks as a vehicle for increased funding of science

Patrick Weke and Wandera Ogana

Chairman: Wandera Ogana, University of Nairobi, Kenya.
Rapporteur: Patrick Weke, University of Nairobi, Kenya.
Focus: To come up with ideas on how to improve funding mechanisms and increase allocation of competitive funds to researchers and networks in developing countries.

1. Preamble

The theme members shared their experiences in the funding of their proposals and the following points were noted.

(i) The networks represented obtained their funding through various organizations;
(ii) Most of the networks represented received support from ISP, at one time or another;
(iii) Some grants were awarded as a result of networks contacting the funding organizations while others were awarded as a result of competitive response to announcements;
(iv) Most of the networks did not have direct financial support from governments and industry in Africa.

2. Questions

1. Can networks be used as a vehicle for increased funding of the Basic Sciences?

2. How can networks work together to increase chances of obtaining funds from international, regional, and internal funding sources?

3. What interventions do networks need in order to mobilize funding and manage network projects?

3. Recommendations

(a) Networks are very important

- Due to limited resources available in developing countries;
- Address local and regional problems;
- Lead to multidisciplinary research/approach;
- Tend to spread risks and gains;
- Electronic innovations (e.g., internet) make networks feasible.

(b) High demand for network funding in the region

- Demonstrated by the large number of proposals submitted in response to announcements, e.g., in the RISE project.

(c) Need to apply results-based management in order to be able to write good research proposals (AAS to be approached for training).

(d) Need to know the requirements of funding regimes/agencies.

(e) Need to establish database for researchers and areas of research in the networks/regions.

- Setting up of web page is necessary.

(f) Establishment of research and development offices within our respective universities.

- For facilitation, liaise with industry, call for proposals, etc.

(g) Need for each network to collaborate with researchers in other countries and continents.

(h) Need for networks to contact governments at the highest possible levels.

- Networks should directly contact governments and regional bodies within which they operate.
- In Africa, for instance, the networks could request the African Academy of Sciences to write to the African Union and ECA on the need to support networks.

(i) Sida/ISP be asked to continue supporting networks.

(j) Networks should strive to acquire expertise in the writing of proposals.

Professor Patrick Guge Oloo Weke was appointed Associate Professor at the School of Mathematics, University of Nairobi, in 2009 after working in the same department as a Tutorial Fellow (1988), Assistant Lecturer (1993), Lecturer (2001) and Senior Lecturer (2003). He has been teaching Actuarial Science and Mathematical Statistics at both undergraduate and postgraduate levels. He is also involved in postgraduate supervision in Actuarial Science, Financial Mathematics, and Statistics. He graduated with a B.Sc. (honours) in Mathematics, Statistics and Computer Science in 1986 from the University of Nairobi, an M.Sc. (Mathematical Statistics) in 1988 from the University of Nairobi, an M.Sc. (Actuarial Science) in 1992 from City University, London, and a PhD (Mathematical Statistics) in 2001 from Harbin Institute of Technology, China. He has published over ten papers in peer-refereed journals.

He is Coordinator, Eastern African Universities Mathematics Programme (EAUMP), which is sponsored by ISP, Sweden; Member, Life Insurance Council Standing Committee on Kenyan Mortality Investigation; Member, The Institute of Actuaries (UK); Member, International Biometric Society; and Member, Actuarial Education Network (AEN)

Professor Weke's research interests are:
Statistical Inference with emphasis on Order Statistics and Outliers;
Applied Actuarial Statistics (Ruin Theory, Credibility Theory, and Risk Modelling);
Technical Claims Reserves (IBNR Claims Reserving and Negative Claims); and
Life and other Contingencies (Life Table and Mortality Investigations).

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For a presentation of Wandera Ogana see page 125.

Group Discussion, Theme 3: Networks and Centres of Excellence

Mohamed E. A. El Tom and W. Lohawijarn

Chairperson: W. Lohawijarn.
Rapporteur: Mohamed E. A. El Tom.
Participants: 14 (Africa, Asia, and Europe)

1. Following a lengthy discussion on interpretation of terms and concepts, the group decided to focus its deliberation on the following.

   (a) How to make the best use of existing institutions and networks to create an enabling environment for science; and
   (b) Possible ways of linking networks and centres in different disciplines.

2. Observing that developing countries share in common important characteristics regarding the status of science and the objective of strengthening it, the group decided to extend the discussion to all developing countries rather than restricting it to Africa.
3. The group agreed that networks constitute an essential element in the establishment of enabling environments for science.
4. In response to the question: *What are the factors that help create a disabling environment for science?*, the group identified four factors:

   (i) Lack of awareness on the part of the political elite and society at large of the nature of science and its contribution to sustainable development and progress, more generally;

   (ii) Lack of 'cross talk' between politicians on the one hand, and scientists, on the other;

   (iii) Lack of information about networks: objectives, mode of work, membership, achievements, locations, etc.;

   (iv) Low levels of funding.

5. Noting that organization is a critical tool for the achievement of common objectives;

   Cognizant that while the promotion of science is the responsibility of all stakeholders, the onus of responsibility, in this regard, falls primarily on the shoulders of the scientists themselves;

   Aware that the establishment of an enabling environment is a process that unfolds in a specific context;

   The group recommends to participants in the International Conference on Regional and Interregional Cooperation to Strengthen Basic Sciences in Developing Countries:

   (A) Scientists should consider as a matter of urgency the establishment of national and regional disciplinary associations/societies, and where these exist, they should seek means of strengthening them;

   (B) National disciplinary bodies should coordinate efforts and play a proactive role to enhance the effectiveness of corresponding regional bodies;

   (C) Scientists should devise, via their national associations or disciplinary institutions, effective strategies for popularizing and 'marketing' science;

   (C) Scientists should mobilize all stakeholders (for example, engineers and teachers of science) to achieve their objectives;

   (E) Each network should establish a web site and, where it exists, should ensure that it is regularly updated;

   (F) Each network should seriously explore ways of diversifying their sources of funding;

   (G) Networks in Africa, Asia, and Latin America which share in common themes and objectives, should take steps to create intercontinental networks;

   (H) The good offices of regional bodies, such as the African Union Commission and the UN Economic Commission for Africa, should be approached to help facilitate dialogue between scientists and politicians, and in support of science, more generally;

   (I) This conference should constitute a committee to set up appropriate mechanisms for operationalizing some of these recommendations.

Mohamed E. A. El Tom has also written an article a new collaborative model for strengthening capacity in matheamtical research; see page 173; for a presentation of him, see 182.

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Warawutti Lohawijarn is a former professor of geophysics at the Prince of Songkla University in Hat Yai in Thailand. Now retired, he is a member of the scientific reference group for the physics program of ISP.

Group Discussion, Theme 4: The role of science in development and poverty alleviation

Peter Sundin and Bernard Aduda

Chairperson: Bernard Aduda.
Rapporteur: Peter Sundin.
Theme 4. The role of science in development and for poverty alleviation. There is a need to provide convincing arguments for and examples on how science could and have contributed to development and poverty alleviation. This group should gather concrete examples of success stories, but also try to analyse the factors behind such success.

Participants (10)

- Bernard Aduda, Kenya (chair),
- Casimiri Vizzino, UNESCO,
- Enserum Kelbessa, Ethiopia,
- Altaf Hussain, Bangladesh,
- Ould Ahmed Izid Bih Isselkou, Mauritania,
- Krishna Garg, India,
- Leonida Kerubo, Kenya,
- Mohammed Mosihuzzaman, Bangladesh,
- Nelson Torto, Botswana/South Africa,
- Yvonne Bonzi, Burkina Faso,
- Peter Sundin, Sweden (rapporteur).

It was noted by the discussion group that science and technology are of different character, and need to be distinguished. Pure science will not solve immediate problems but may contribute to this on longer term because science is the base for technological applications. The base for science is curiosity; technology emerges out of necessity, but there is no technology without science. In policy development science and technology are usually considered together, while their distinctive differences should motivate that they are treated as separate entities.

In general, science has the potential to contribute to development and poverty alleviation because it provides a common mindset, surpassing cultural, ideological and other constraints by introducing critical and analytical thinking, opening minds, fighting prejudice and reducing ignorance. A scientific approach to problems and needs is among the prerequisites for peace, democracy and development.

Among examples on how science has contributed to development and poverty alleviation the group identified the following:

- High yielding crops and crop varieties suitable for marginal and dry areas;
- Crop management, food products, and clothing;
- Water purification, food security and medicine – including family planning;
- Light-emitting diodes (LED) have brought a revolution in rural lightning due to low cost and high efficiency.

The group also identified examples where the contribution of science to development and poverty alleviation could be improved:

- Standardization of herbal medicines (in line with the anti-malaria drug artemisin) and other natural products. This would increase the export potential of such products creating revenue for the producing country;
- Dissemination of scientific results for awareness, to enable people to make better choices, considering, e.g., risk posed by incorrect use of technology (such as pesticides);
- Increased use of science to address local problems.

Still, constraints were identified by the group with regard to the possibilities to increase the role of science in development and poverty alleviation:

- The quality of primary and secondary education may be insufficient, and the potential to introduce a scientific approach from these early levels needs to be explored;
- Scientists usually aim for funding and academic promotion, not commonly for commercialization of useful results.
- Governments in developing countries tend to have little understanding of the notion that pure science leads to development. If there is little government interest in funding scientific research, the country's problems cannot be addressed by internally developed technological solutions and applications, but there is a dependence on external sources of knowledge not always adapted to the local situation.

- Brain drain is still a major problem where resources and means for scientific research are not provided locally.

Peter Sundin is also the author of *A Word of Welcome*, page 13, and the *Concluding Remarks*, page 409. For a presentation of him, see page 14.

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Concluding remarks

Peter Sundin

In the concluding panel discussion a number of statements were made that are suitable as a starting point for summing up the proceedings of the conference and for pointing to the future. These statements are supplemented by personal reflections and comments.

University base of regional collaboration

From the university perspective, global collaboration is important, because knowledge is global. It can be observed that most scientific network nodes or members of regional collaboration activities presented at this conference are at universities. In accounting for network achievements the role of universities should be acknowledged. Credit needs to be given to strengthen the position of universities, not the least in a national perspective. The research groups participating in network activities should also not be forgotten. It is their capacity and abilities that is the basis for the scientific achievements of the network they are part of.

The benefits of regional scientist-to-scientist cooperation in developing countries, within specific scientific fields, may be enhanced when paralleled by the concerned universities also collaborating among themselves at a more general level. It may strengthen the position of the network nodes in the respective country.

The basic sciences, Biology, Chemistry, Mathematics, and Physics, play a fundamental role both in applied and fundamental research, and likewise in technology development – which applies fundamental knowledge. Fundamental and applied research is interconnected, and for applied research to be successful, there need to be a strong base of knowledge in the basic scientific fields. The latter extends, of course, to undergraduate education, where the scientists of the future are being prepared.

The different position of teachers at most African universities compared to teachers at European and North American universities should also be recognized. In Europe, universities have been built over centuries, including governance and developing the political infrastructure for nurturing science and technology. In Africa and other developing regions this usually needs to be accomplished in a considerably shorter period of time, and undergraduate education is often prioritized over research and higher education. This hampers scientific development, and the quality of undergraduate education suffers from being disconnected from active scientific research.

Significance of the ISP mode of operation

With regard to ISP's direct support to scientific networks, several speakers pointed out the uniqueness of ISP modalities, which have effects going beyond those of many other financing organizations.

A basic ISP modality that was brought forward as self evident, but rarely practiced by other financing organizations than ISP and Sida, is to have as a starting point the needs and requirements of the local researchers in the local situation, rather than using the competence that is at hand in the South to help solving research questions formulated in a Northern perspective, or from the side of what the supporting organization is believed to be the local need. An important objective of ISP is to build local and regional capacity for research and higher education to be used to address developmental problems as seen from the local and regional perspective, as well as in the context of global challenges. The capacity development process needs to take its starting point in the local situation in order for a solid scientific base to be formed there and allowing for a scientific approach to these challenges. Northern scientists may be important partners, but imposing scientific questions and technical solutions not suitable in the local perspective may be counter-productive and the long-term stability of the capacity built may be compromised.

An important ISP modality is application by invitation only. This allows for support also to academic environments that are not strong enough to be able to produce successful grant applications in global competition. In order to make this modality productive, there is the additional ISP modality of long-term support to an activity (research group or scientific network), meaning decades when necessary.

Long-term support allows efforts to truly take roots, unlike short term grants of maybe three to five years, which may have no long term effects at all. Short term support may even lead to brain drain in frustration over the lack of capacity building and a foreign research agenda, leaving the involved scientists with nothing but the option to continue their research at high-standard research environments abroad. The consequence of this is that developing countries will supply industrialized countries with intellectual capacity at the expense of their own future.

With stable long-term support, also at a quite modest level, intellectual and instrumental resources can be developed to a degree where the supported network or research group becomes competitive. The long term support catalyzes a development that allows benefactors to draw additional, complementary funding, and in the end be independent of the continuation of ISP support.

What is starting as stray complementary funding to long-term ISP support thus finally may become the main financial resource. However, it is when governments realize the potential of developing basic sciences that the ball really starts rolling. An illustrious example of this is given by the Thai university network presented in this volume, page 195.

Furthermore, ISP invitation to apply for support is scientist-to-scientist, which is a very important complement to e.g. bilateral programs on the government level. In both cases it is desirable that the activities developed be governed by strategic priorities and policies in the target country. The scientist-to-scientist approach, however, will lead to activities governed also by the possibilities at hand, taking off from there, while the bilateral support agreed on a government level may have less flexibility at the individual scientist level and may sometimes take a starting point in what is desirable to achieve rather than what is possible to do in the first place.

Finally, unlike most bilateral support, ISP supports South-South cooperation between scientists in different countries, strengthening the intellectual capacity and resources in a given scientific field, and facilitating the sharing of technical resources. Numerous examples of this have been presented at this conference.

Significance of governmental support

In the panel discussion, several speakers came back to the example brought from Thailand, showing what can be achieved once a government decides to put basic sciences and scientific research on the development agenda, in order to increase international competitiveness. However, for this to take place there may first be constraints in infrastructure and in human and environmental resources to overcome, constraints which may demand a very clear vision to be removed.

To attain fruitful interaction with government, scientists need to be active and take responsibility for this to happen. One approach is to build in outreach into the objectives, and to explain science to the public, to members of parliament, to government authorities and to government members. This may be through public seminars and lectures, school visits, and demonstration projects in the field, as well as in direct communication and as expertise in government committees. To be able to influence governments, scientists also need to know how the governing processes work, e.g., with regard to policy making and possibilities for lobbying for support.

For scientific networks to be recognized and useful as lobbying organizations, some kind of legal status may have to be attained. Strictly scientifically speaking, peer-to-peer networks can be very productive in terms of research and higher education without much formal structure. However, in interactions with government and also when it comes to attracting funding, networks may benefit from being formalized in some way.

It was noted that in developing countries there is a lack of science journalists who can help explain science to the public. Information was given that the African Union Commission plans to address this shortcoming by setting up education programs.

Future of regional cooperation by scientific networking

Several speakers were impressed by the number of scientific networks presented at the conference as well as by the quality of their achievements. But it was also noted that the corresponding self-esteem and confidence was not as prominent as could be expected from this. Where there is confidence there is also a larger possibility to make governments and donors to see the importance and potential of the results being produced. Making themselves visible and pointing out the achievements made in interactions between network participants, scientific networks will increase the possibilities for governmental and other funding of scientific research. Scientists need to be bold and have visions going beyond the initial achievements.

Long-term funding according to ISP and Sida modalities, it should be remembered, should to a large extent be seen as catalytic, and networks need to find strategies to adjust to regular sources of funding, offering support for more limited periods of time. This is the reality researchers in the North live with. To handle this, however, it is helpful to have a government that supports not only undergraduate education at universities but also the development of higher education and research, and provides the necessary infrastructure.

Peter Sundin is also the author of *A Word of Welcome*, page 13, and the rapporteur from Theme 4, page 405. For a presentation of him, see page 14.

Programme

⋆⋆ **Opening Ceremony, 1 September 2009**

Peter Sundin: *A word of welcome*

Tsige Gebre-Mariam: *Welcoming speech*

Jean-Pierre Ezin: *Keynote address*

Berth Abrahamsson: *A word of welcome from the Embassy of Sweden*

Tomas Kjellqvist: *Regional research cooperation in the basic sciences in Africa*

Zerihun Kebede: *Opening Speech*

⋆⋆ **Plenary Session, 1 September 2009**

Ana María Cetto: *Regional and international cooperation: Putting science to the service of development*

Julia Hasler: *The contribution of UNESCO to regional and interregional cooperation to strengthen basic sciences in developing countries*

Mohamed Hassan: *Regional and international cooperation for promoting research and education for sustainable development in Africa*

John Ball: *Support for mathematics in developing countries*

⋆⋆ **Plenary Session, 2 September 2009**

Mohammed Mosihuzzaman: *Importance of collaboration and networking in capacity building in basic sciences in developing countries*

Aderemi Kuku: *Regional and international cooperation to strengthen basic sciences in Africa*

Ameenah Gurib-Fakim: *Natural product networks in Africa and their contribution to regional and interregional cooperation*

⋆⋆ **Parallel Sessions, 2 September 2009**

⋆ **Biotechnology and Molecular Biology**

Alejandra J. Troncoso: *Latin American Network for Research in Bioactive Natural Compounds. Past, present, and future*

Laura Franco Fraguas: *The contributions of LATSOBIO to protein biotechnology: A short-time experience generating long-term potentials*

Yogeshkumar Naik: *The Southern African Biochemistry, Molecular Biology and Biotechnology (SARBIO) Network: Challenges and the way forward*

Alfred Traore: *A regional network of training and research to the service of the development in Africa: R.A.BIOTECH*

⋆ **Mathematics and Physics**

John Mango: *Presentation of Eastern Africa Universities Mathematics Programme, EAUMP*

Lesley Cornish: *Genesis of a new network: African Materials Science and Engineering Network (AMSEN)*

Hamidou Touré: *Lessons learned from ten years' network activities*

Margaret Samiji: *Five years of MSSEESA*

⋆ **Natural Products Chemistry**

Jacob Midiwo: *Natural products network for East and Central Africa*

Ermias Dagne: *ALNAP: Exemplary model for regional cooperation in the area of natural products research and development*

Mohammed Mosihuzzaman: *Asian Network of Research on Anti-Diabetic Plants (ANRAP)*

Vijaya Kumar: *Challenges and constraints in South-South collaboration*

⋆⋆ **Poster Session, 2 September 2009**

⋆⋆ **Plenary Session, 2 September 2009**

Wandera Ogana: *Promoting mathematics in Africa through the African Mathematics Millennium Science Initiative (AMMSI)*

Alfred Traore: *Difficulties of the regional cooperation in Africa: the case of university cooperation and research*

Harry De Backer: *EU-Africa partnership on Science and Technology*

Pascal Kossivi Adjamagbo: *Three proposals to strengthen regional, continental and intercontinental cooperation in favour of basic sciences in Africa*

Lennart Hasselgren: *Regional cooperation: Some reflections with respect to Eastern and Southern Africa*. (Read by Bernard Aduda.)

Charles H. McGruder III: *Africa and the Square Kilometer Array (SKA)*

⋆⋆ **Plenary Session, 3 September 2009**

Mohamed E. A. El Tom: *Towards a new collaborative model for strengthening capacity in mathematical research in Africa*

Yogeshkumar Naik: *Proposal for a new network on chemicals managment in sub-Saharan Africa*

⋆⋆ **Parallel Sessions, 3 September 2009**

⋆ **Analytical, Environmental and Instrumental Chemistry**

Berhanu Abegaz: *Networking to build regional capacity in Africa: The efforts of NABSA*

Altaf Hussain: *The genesis and activities of the Network of Instrument Technical Personnel and User Scientists of Bangaldesh (NITUB)*

Nelson Torto: *SEANAC: The home of analytical chemists in Africa*

Michael A. Kishimba: *Eight years of ANCAP: Achievements, challenges, and the future*. (Read by Negussie Megersa.)

⋆ **Physics and Geoscience**

Dumisani John Hlatywayo: *Challenges and accomplishments of the Eastern and Southern Africa Regional Seismological Working Group*

Ahmadou Wagué: *The African laser Atomic molecular and optical science network activities for the development of optical sciences and their application in Africa*

⋆ **Food Chemistry**

Luis Bello: *LANFOOD (Latin American network for food research)*

Francis Mathooko: *Food science and nutrition network for Africa (FOSNNA): Achievements and way forward*

John Saka: *Partnership in basic science enhances human capital development and better application of science in development: Experiences from IPICS-funded and SABINA projects in Southern Africa*

⋆⋆ **Poster Session, 3 September 2009**

⋆⋆ **Plenary Session, 3 September 2009**

Ghirma Moges: *Presention of a coming workshop in chemistry, December 2009*

Manat Pohmakotr: *Centres of Excellence: Thailand's experience*

George Thompson: *Regional networking: An integral part of a broader strategy*

John Mathiason: *Results-based management of basic research*

⋆⋆ **Parallel Sessions, 3 September 2009**

Group discussions: Themes 1–4.

⋆⋆ **Plenary Session, 4 September 2009**

⋆ **Summary of group discussions**

Paul Vaderlind, Rapporteur: *Group discussion, Theme 1: Research training and the role of networks*

Patrick Weke, Rapporteur: *Group discussion, Theme 2: Networks as a vehicle for increased funding of science*

Mohamed E. A. El Tom, Rapporteur: *Group discussion, Theme 3: Networks and Centres of Excellence*

Peter Sundin, Rapporteur: *Group discussion, Theme 4: The role of science in development and poverty alleviation*

⋆⋆ **Closing Session, 4 September 2009**

Concluding remarks were made by Jean-Pierre Ezin, Tsige Gebre-Mariam, Mathias Krüger, and Peter Sundin.

Table of acronyms

Acronym	*Full name*	*Page*
AAMPS	African Association of Medicinal Plants Standards (Mauritius)	110
AAPAC	African Association of Pure and Applied Chemistry	354
AAS	African Academy of Sciences	60, 70, 72, 102
AAU	Addis Ababa University	16
ACGC	Asian Coordinating Group for Chemistry	299
ADB	Asian Development Bank	196
AFASSA	Africa Asia South America	309
AfDB	African Development Bank	60
AFNNET	African Natural Products Network	97
AFRA	African Regional Co-operative Agreement for Research, Development & Training Related to Nuclear Science & Technology	38
AFRA-NEST	The AFRA Network for Education in Nuclear Science and Technology	39
AIMS	African Institute of Mathematical Sciences (Capetown, South Africa)	95
ALC	African Laser Centre	366
ALNAP	African Laboratory for Natural Products (Addis Ababa University, Ethiopia)	291
AMCOST	African Ministers of Science and Technology	26
AMI-Net	African Mathematical Institutes Network	
AMMSI	African Mathematics Millennium Science Initiative	94
AMRS	African Materials Research Society	258
AMSEN	African Materials Science and Engineering Network	257
AMU	African Mathematical Union	95
ANCAP	African Network for the Chemical Analysis of Pesticides	348
ANRAP	Asian Network of Research on Anti-Diabetic Plants	299
ANSTI	Association of the Network of Scientific and Technological Institutions (Kenya)	
ARAPKE	African Regional Action Plan on Knowledge Economy	150
ARASIA	Co-operative Agreement for Arab States in Asia for Research, Development and Training Related to Nuclear Science and Technology	38
ARCAL	Acuerdo Regional de Cooperación para la Promoción de la Ciencia y Tecnología Nucleares en América Latina y el Caribe; Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean	38
AU	African Union; Union africaine (UA)	17
AUC	African Union Commission	17
AUU	Acta Universitatis Upsaliensis	1
BDT	Bangladeshi taka (currency unit)	
BECA	Biosciences East and Central Africa	97
BIHS	Bangladesh Institute of Health Science (Dhaka, Bangladesh)	301
BIRDEM	Bangladesh Institute of Research and Rehabilitation for Diabetes, Endocrine and Metabolic Disorders (Dhaka, Bangladesh)	299
BSc	Bachelor of Science	
CAS	Chinese Academy of Sciences, China	71
CBD	Convention on Biological Diversity	111

CBG	Centro de Biodiversidad y Genética (Cochabamba, Bolivia)	229
CE	Commision européenne; European Commission (EC)	
CEMB	National Centre of Excellence in Molecular Biology	71
CEPROBI	Centro de Desarrollo de Productos Bióticos	375
CERN	Organisation européenne pour la recherche nucléaire; European Organization for Nuclear Research (Geneva, Switzerland)	44
CHE	Commission on Higher Education (Thailand)	196
CIMPA	Centre international de mathématiques pures et appliquées (Nice, France; *also* ICPAM)	265
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement	376
CIRDES	Centre international de recherche-développement sur l'élevage en zone subhumide (Burkina Faso)	245
CNPq	Conselho Nacional de Desenvolvimento Científico e Tecnológico (Brasil); National Council for Scientific and Technological Development (*before 1971* Conselho Nacional de Pesquisa)	71
CONACYT	The National Council on Science and Technology (Mexico)	71
CPA	Africa's Science and Technology Consolidated Plan of Action	17
CPF	Country Programme Framework	36
CRSBAN	Centre de recherche en sciences biologiques, alimentaires et nutritionnelles; Research Centre in Biological, Food and Nutritional Sciences (University of Ouagadougou, Burkina Faso)	244
CSIR	The Council for Scientific and Industrial Research	71, 366
CSUCA	Confederacion Universitaria Centroamericana; Confederation of Central American Universities	219
CTA	Centro de Tecnologico Agroquímico	229
CYTED	El Programa Iberoamericano de Ciencia y Tecnología para el Desarrollo; O Programa Ibero-americano de Ciência e Tecnologia para o Desenvolvimento; The Ibero-American Development Programme for Science and Technology	373
DAAD	Deutscher Akademischer Austausch Dienst; German Academic Exchange Service	288
DBT	Department of Biotechnology of the Government of India	71
DECAB	Department of Food Science and Biotechnology (Quito, Ecuador)	371
DST	Department of Science and Technology (Pretoria, South Africa)	256
EANAOP	East African Network for the Analysis of Organic Pollutants	348
EAR	East African Rift	357
EASSy	Eastern Africa Submarine Cable System	142
EAUMP	Eastern African Universities Mathematics Programme	251
EC	European Commission; Commision européenne (CE)	
ECA	United Nations Economic Commission for Africa (*also* UNECA)	60
EGNOS	European Geostationary Navigation Overlay Service	142
EHNRI	Ethiopian Health and Nutrition Research Institute	383
EISMV	École inter-états des sciences et médecine vétérinaire (Dakar, Senegal)	245
EMEA	European Agency for the Evaluation of Medicinal Products	108
EOS	European Optical Society	368

ESARSWG	Eastern and Southern Africa Regional Seismological Working Group	355
ESCOP	European Scientific Cooperative on Phytotherapy	108
EU	European Union; Union européenne (UE)	139
FACS	Federation of Asian Chemical Societies	322
FASBMB	Federation of African Societies of Biochemistry and Molecular Biology	238
FDA	Food and Drug Administration (USA)	109
FOSNNA	Food Science and Nutrition Network for Africa	379
GC	Gas chromatography	347
GDP	Gross Domestic Product	
GIBEX	Global Institution for Bioexploration (Rutgers, New Jersey, USA)	314
GIRAGA	Groupe inter-africain de recherche en analyse, géométrie et applications	94
GM	Genetically modified	57
GMS	Greater Mekong Subregional Countries	199
GRAS	Generally recognized as safe	109
GRED	Groupe de recherche sur les équations différentielles; Group of Research on Differential Equations	265
GSHAP	Global Seismic Hazard Analysis Program	360
GUSD	10^9 USD, one billion US dollars	
HDI	Human Development Index	175
HEJ	The Hussain Ebrahim Jamal Research Institute of Chemistry (Department of Chemistry, Karachi University, Pakistan)	300
HMPWP	Herbal Medicinal Products Working Party	109
HPLC	High Performance Liquid Chromatography	347
IACS	The Indian Association for the Cultivation of Science	71
IAEA	The International Atomic Energy Agency (Vienna, Austria)	35
IAS	Institute for Advanced Study (Princeton, New Jersey, USA)	146
IBNs	International Biosciences Networks	44
IBRO	International Brain Research Organization	44
IBSP	International Basic Sciences Programme	44
ICCBS	The International Centre for Chemical and Biological Sciences (Pakistan)	71
ICCM	International Conference on Chemicals Management	192
ICGEB	International Centre for Genetic Engineering and Biotechnology (Trieste, Italy)	45
ICIPE	International Centre of Insect Physiology and Ecology (Duduville Campus, Kasarani, Nairobi, Kenya)	61
ICMI	International Commission on Mathematical Instruction (IMU)	74
ICNPR	International Centre of Natural Product Research	302
ICO	The International Commission of Optics	366
ICPAM	International Center for Pure and Applied Mathematics (Nice, France; *also* CIMPA)	265
ICSU	International Council for Science (*formerly* International Council of Scientific Unions)	41
ICT	Information and Communication Technology	40
ICTP	The Abdus Salam International Centre for Theoretical Physics (Trieste, Italy)	53
IDF	International Diabetic Federation	303
IFS	International Foundation for Science (Stockholm, Sweden)	37

IHES	Institut des hautes études scientifiques (Bures-sur-Yvette, France)	147
IHP	International Hydrological Programme	45
ILC	International Laboratories, Corp.	199
IMSP	Institut de mathématiques et de sciences physiques (Université d'Abomey-Calavi, Porto-Novo, Benin)	95
IMU	International Mathematical Union (Berlin)	
INCIENSA	Instituto Costarricense de Investigación y Enseñanza en Nutrición y Salud (Costa Rica)	374
INIS	International Nuclear Information System	39
IPCP	International Panel on Chemical Pollution	192
IPICS	International Programme in the Chemical Sciences (Uppsala University, Sweden; *a part of* ISP)	227
IPMS	International Programme in the Mathematical Sciences (Uppsala University, Sweden; *a part of* ISP)	252
IPPS	International Programme in the Physical Sciences (Uppsala University, Sweden; *a part of* ISP)	363
IRMA	Institut de recherches en mathématiques (Université de Cocody, Abidjan, Côte d'Ivoire)	95
ISEKI-Food	Integrating Safety and Environmental Knowledge into Food Studies Towards European Sustainable Development	377
ISHS	International Society for Horticultural Science	385
ISP	International Science Programme (Uppsala University, Sweden)	14
ISRA	Institut sénégalais de recherches agricoles	97
IUBMB	International Union of Biochemistry and Molecular Biology	45
JAES	Joint African-European Strategy	22
KNUST	Kwame Nkrumah University of Science and Technology (Kumasi, Ghana)	75
LAM	African Laser Atomic Molecular and Optical Science Network	365
LAME	Laboratoire d'analyse mathématique et d'équations; Mathematical Analysis Laboratory of Equations	265
LANBIO	Latin American Network for Research in Bioactive Natural Compounds	227
LANFOOD	Latin American Network for Food Research	371
LANI	Laboratoire d'analyse numérique et d'informatique; Computer Science and Numerical Analysis Laboratory	265
LATSOBIO	The Latin American Network for Solid Phase Protein Biotechnology	231
LDCs	Least Developed Countries	79
LMS	London Mathematical Society	74
MAB	Man and Biosphere Programme	45
MARM	Mentoring African Research in Mathematics	120
MDG	Millennium Development Goal	48, 62
MEd	Master of Education	
MeerKAT	Karoo Array Telescope (South Africa)	164
MINEDAF	Ministers of Education of African Member States	128
MIRCENs	Microbial Resources Centres Networks	44
MPA	Major Priority Action	48
MPhil	Master of Philosophy	
MRC	Medical Research Council (South Africa)	317
MSc	Master of Science	

MSEK	10^6 SEK, one million Swedish crowns	
MSI	Millennium Science Initiative	94
MSSA	The Microscopy Society of Southern Africa	258
MSSEESA	Materials Science and Solar Energy Network for Eastern and Southern Africa	160
MTHB	10^6 THB, one million Thai baht	
MUARIK	Makerere University's Agricultural Research Institute Kabanyolo (Uganda)	350
MUSA	Mathematics and its Uses in Southern Africa	94
MUSD	10^6 USD, one million US dollars	
NABNet	North Africa Biosciences Network	98
NABSA	Network for Analytical and Bioassay Services in Africa (University of Botswana, Gaborone)	313
NASAC	Network of African Science Academies (Nairobi, Kenya)	59
NEPAD	New Partnership for Africa's Development	25
NAPRECA	Natural Products Research Network for Eastern and Central Africa	287
NIA	National Innovation Agency	199
NIMS	National Institute for Mathematical Sciences (Kumasi, Ghana)	75
NITUB	Network of Instrument Technical Personnel and User Scientists of Bangladesh	322
NMC	National Mathematical Centre (Abuja, Nigeria)	95
NSBP	National Society of Black Physicists (USA)	164
NUFU	Nasjonalt program for utvikling, forskning og utdanning; The Norwegian University Committee for Development, Research and Cooperation	94
NUSESA	Network of Users of Scientific Equipment in Eastern and Southern Africa	110
ONCYT	Organismos Nacionales de Ciencia y Tecnología	373
OPCW	Organization for the Prohibition of Chemical Weapons (The Hague, Netherlands)	289
OSA	Optical Society of America	368
OWLS	Optics Within Life Sciences	366
PAEMS	Pan-African Environmental Mutagen Society	194
P-ANPL	Pan-African Natural Products Library	320
PAU	Pan-African University	18
PDEMC	Partial Differential Equations, Modelling and Control (a network in Western Africa)	265
PERCH	Consortium of Postgraduate Education and Research Program in Chemistry (Thailand)	196
PERCH-CIC	PERCH Center for Innovation in Chemistry	196
PERDO	Postgraduate Education and Research Development Office (Thailand)	196
PERENESA	Pesticide Research Network for Eastern and Southern Africa	348
PhD	Philosophiae Doctor; Doctor of Philosophy	
POPs	Persistent Organic Pollutants	350
PPP	Purchasing Power Parity	
PROTA	Plant Resources of Tropical Africa	105
PTT	Petroleum Authority of Thailand	199
R.A.BIOTECH	Réseau ouest-africain des biotechnologies; West-African Network of Biotechnologies	129

RAGAAD	Réseau africain de géométrie et d'algèbre appliquées au développement	94
R & D	Research and Development	
RBM	Results-based management	218
RCA	Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (for Asia and the Pacific)	38
RIMS	Research Institute for Mathematical Sciences (Kyoto, Japan)	147
RISE	Regional Initiative in Science and Education (administered by SIG)	98
RSC	Royal Society of Chemistry (London and Cambridge, UK)	97
SABINA	Southern African Biochemistry and Informatics for Natural Products	97
SAICM	Strategic Approach to International Chemicals Management	192
SAIP	South African Institute of Physics	258
SAMSA	Southern Africa Mathematical Sciences Association	95
SANBio	South African Network for Biosciences	97
S & T	Science and Technology	
SAPAM	Society of African Physicists and Mathematicians	167
SARBIO	Southern African Regional Cooperation in Biochemistry, Molecular Biology and Biotechnology	236
SAREC	Swedish Agency for Research Cooperation with Developing Countries (up to 2008-09-30)	21
SARIMA	Soutien aux activités de recherche informatique et mathématique en Afrique; Support for Research Activities in Data Processing and Mathematics in Africa	265
SEANAC	Southern and Eastern Africa Network for Analytical Chemists	337
SEK	Swedish crown (currency unit)	
SEM	Scanning electron microscope	157
SESAME	Synchrotron-Light for Experimental Science and Applications in the Middle East (Allan, Jordan)	44
SETAC	Society of Environmental Toxicology and Chemistry (Brussels, Belgium; Pensacola, Florida, USA)	192
SCG	Siam Cement Group	199
Sida	Swedish International Development Cooperation Agency	31
SIG	Science Initiative Group (at IAS, Princeton, New Jersey, USA)	98
SKA	Square Kilometer Array	163
SLU	Swedish University of Agricultural Sciences	348
SMART	Specific, Measurable, Achievable, Relevant and Timely	223
SOACHIM	Société ouest-africaine de chimie; West-African Society of Chemistry	129
SPIE	International Society of Optical Engineering	368
STI	Science, Technology and Innovation	54
TC	Technical Cooperation	35
TCDC	Technical Cooperation among Developing Countries	38
TEM	Transmission electron microscope	157
THB	Thai baht (currency unit)	
TM/CAM	Traditional Medicine / Complementary and Alternative Medicine	109
TUSD	10^{12} USD, one trillion US dollars	
TWAS	The Academy of Sciences for the Developing World (Trieste, Italy; *formerly* The Third World Academy of Sciences)	53

TWOWS	Third World Organization of Women in Science	41
UA	Union africaine; African Union (AU)	17
UB	University of Botswana	320
UCAD	Université Cheikh Anta Diop (Dakar, Senegal)	122
UE	Union européenne; European Union (EU)	139
UEMOA	Union économique et monétaire ouest-africaine; West African Economic and Monetary Union	129
UNCC	United Nations Conference Centre (Addis Ababa, Ethiopia)	21
UNDP	United Nations Development Programme	70
UNECA	United Nations Economic Commission for Africa (*also* ECA)	145
UNEP	United Nations Environmental Programme	192
UNESCO	United Nations Educational, Scientific and Cultural Organization	43
USD	US dollar (currency unit)	
USIU	United States International University (Nairobi, Kenya)	125
USM	Universiti Sains Malaysia (Malaysia)	71
UU	Uppsala University (Uppsala, Sweden)	10
WABNet	West African Biosciences Network	97
WANPRESS	West African Network of Natural Products Research Scientists	110
WATS	West African Training School	167
WHO	World Health Organization	109
WIOMSA	Western Indian Ocean Marine Science Association	219
WIPO	World Intellectual Property Organization	110
WTO	World Trade Organization	110
XRD	X-ray diffraction	157
ZAR	South African rand (currency unit)	