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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.
E-mail: bitjongndombol@yahoo.fr

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.
E-mail: ailori1@yahoo.com

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.
E-mail: toureh98@yahoo.fr

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 Univer-

sity, 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.

Acknowledgements

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