

10 June 2010

UNESCO's Earth Science Education Initiative in Africa Synthesis of Regional Scoping Workshops

At the African regional launch of the International Year of Planet Earth, UNESCO announced that it would embark upon a new initiative on earth science education for all of Africa, based on its conviction of the importance of the earth sciences for the equitable and sustainable development of the continent.

In order to understand the existing situation and scope the new initiative, UNESCO and partners together organized a series of regional workshops between late 2009 and early 2010. These workshops engaged with 160 participants in Egypt, Angola, South Africa, Senegal and the Democratic Republic of Congo.

Rather than produce a quantitative status report, these workshops presented a thoughtful description of the current major challenges to earth science education in Africa drawing connections to the situation of African research, employment, and the global appreciation of the earth sciences.

The ideas and recommendations which came out of these workshops were much more sensitive, reflective of all dimensions of the existing situation, than an exhaustive reporting exercise.

Similar issues were highlighted by earth scientists from all regions, however dramatic differences do exist regionally, nationally, and even between institutions within countries.

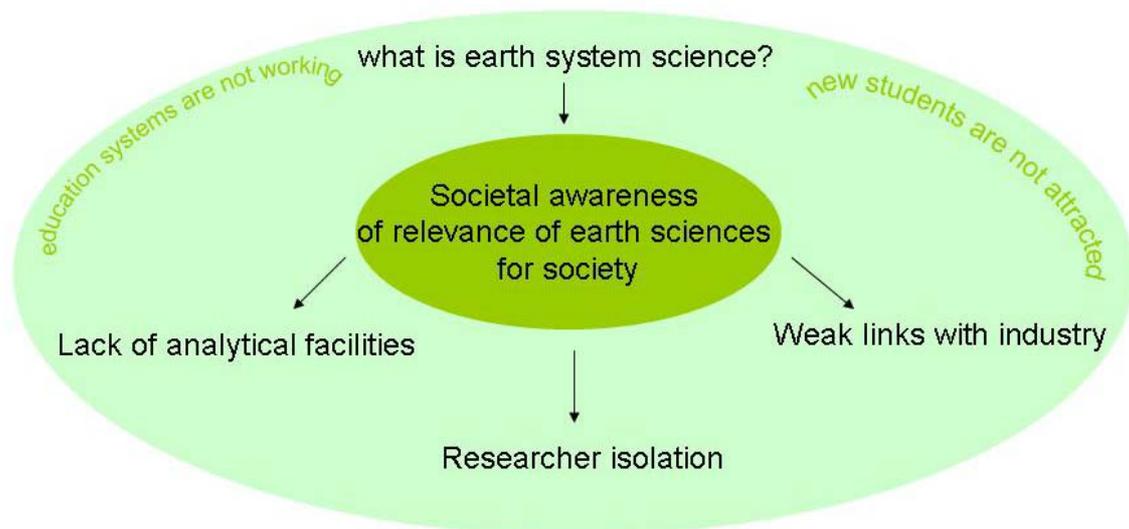
Recommendations for action also varied from the immediate to the long term (10 years +) and actors at various levels are implied. This synthesis presents a summary of the observations and recommendations posed. The action plan for this Initiative will be crystallized during the October 2010 meeting at UNESCO headquarters in Paris.



**Earth science
education initiative
in Africa.**

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1. Background

Based on requests from African National Committees of the International Year of Planet Earth, the Director General of UNESCO announced a new Earth Science Education Initiative at the regional launch of the International Year of Planet Earth in Arusha, Tanzania on 8 May 2008.

The overall intention of this Initiative is to support the development of the next generation of earth scientists in Africa who are equipped with the necessary tools, networks and perspectives to apply sound science to solving and benefiting from the challenges and opportunities of sustainable development. The opportunities in the earth sciences are great, starting with traditional mineral extraction and extending into environmental management such as climate change adaptation, prevention of natural hazards, and ensuring access to drinking water.

In the initial scoping phase of the Initiative, UNESCO is developing a partnering scheme with the many relevant bodies already involved in earth science education in Africa. A component of this partnering scheme is to encourage existing networks of communication and cooperation. Through a series of regional workshops in Africa, an assessment of the existing capacities and actual needs within existing faculties, universities, laboratories and applied schools was conducted and has been synthesized in this document. Based on the recommendations received from these regional workshops and relevant partners, a strategy to proceed will be discussed and developed during a conference to be held in UNESCO's Paris Headquarters on 28 – 29 October 2010. Action plans with innovative approaches will be proposed to interested donors.

Organizational partners for the initial scoping of the Initiative and the organization of the workshops have included:

- Geological Society of Africa (GSAf)
- International Union of Geological Sciences (IUGS)
- International Centre for Training and Exchanges in the Geosciences (CIFEG)
- African Association of Women Geoscientists (AAWG)
- International Year of Planet Earth (IYPE)
- Royal Museum of Central Africa (RMCA)

2. Workshops

Five regional scoping workshops were organized between October 2009 and February 2010. A balance between languages, geographic representation, and practical logistics determined the location of these workshops.

The objective of these workshops was to assess regional capacities and needs in earth science education, research and industry underlining existing centres of excellence through conversation with relevant regional and international experts including representatives of Universities, Applied Schools, Geological Surveys, Industry, and Government and plotting the way ahead for earth science education.

Participants included senior experts as well as younger students and practitioners. There was a balance between practical and theoretical discussions on the type and role of Earth science education needed for the future. In the spirit of a workshop, each followed a common basic structure and addressed the same questions, but the conversations and environment of each meeting varied.



Northern Region (Arabic, English) 28-29 October 2009 at the University of Assiut, Assiut, Egypt.

Workshop organized with the UNESCO office in Cairo and SGAf.

Western Region (French, English) 9-10 December 2009 at Cheikh Anta Diop University, Dakar, Senegal.

Workshop organized with CIFEG and the Senegalese Ministry of Mines, Industry, and Small and Medium Sized Enterprises.

Central Region (French, English) 4-5 February 2010 at the Centre of Geological and Mining Research, Kinshasa, Democratic Republic of the Congo.

Workshop organized with the Royal Museum of Central Africa and with the cooperation of Belgium.

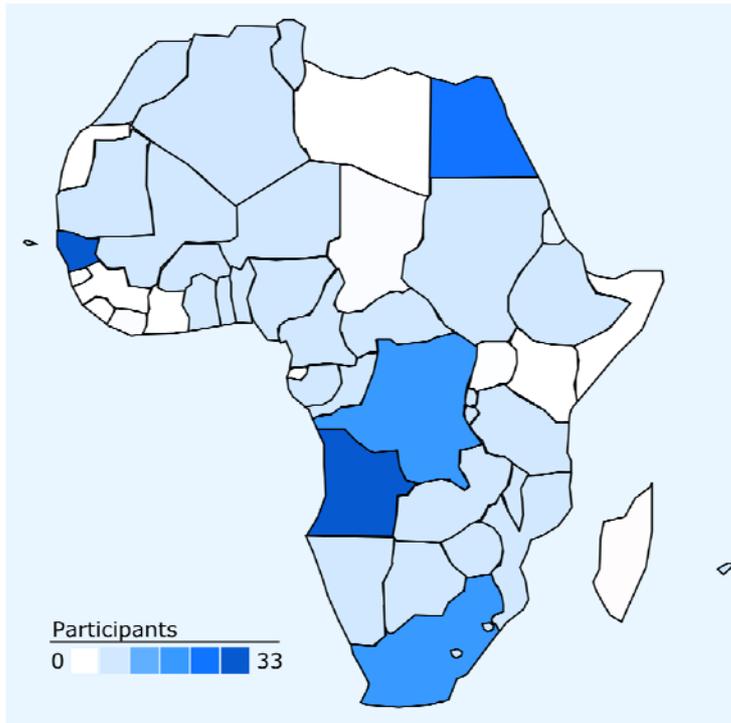
Portuguese-Speaking Countries (Portuguese) 12-13 November 2009 at Agostinho Neto University, Luanda, Angola.

Workshop organized with the International Year of Planet Earth and the Angolan Ministry of Environment.

Southern Region (English) 26-27 November 2009 at the University of Cape Town, Cape Town, South Africa.

Workshop organized by the African Earth Observation Network (AEON) of the University of Cape Town.

Each workshop had approximately 30 participants. In total 175 participants were involved in these workshops coming from 31 different African countries, and 7 non-African countries. A complete list of participants can be found in Annex II.



Map showing the home countries of participants to the workshops. The darker shade indicates higher numbers of participants. Participants from island countries reminded the workshops that the islands are part of Africa and should be included in maps of the continent.

3. Workshop Findings

The workshops took place in various different languages, structural, and geographic environments. Thus, it is not surprising that there were many differences between the discussions and recommendations that took place at each workshop, but likewise there were many similarities that emerged.

Based on the different workshops held in different regions of Africa it became clear that the challenges and opportunities of earth science education have similarities between regions but are not entirely the same. The summaries of commonalities and differences follow in terms of observations made and recommendations proposed. The detailed recommendations from each workshop can be found in Annex III.

3.1 Observations

Earth sciences are necessary for sustainable development but not well understood or recognized outside of the geoscientific community.

The participants of the workshops, as members of the geoscientific community, were already convinced of the important role that earth sciences can and must play for society. The examples of this relevance ranged from the richness of mineral and petroleum resources in the African continent, to opportunities in geothermal energy, to

understanding and enriching the global knowledge of climate change, to proposing adaptation and mitigation measures to that change, to coping with natural hazards, to identifying and assuring reliable sources of drinking water.

However, the participants of all workshops also agreed that this important role for earth sciences is not acknowledged outside of the geoscientific community by policy makers or the general society. Furthermore, this relationship between science and society is not often implicit in the teaching of the scientific material.

21st century Earth System Science Education must transcend the conventional view of geological sciences and the teaching of Earth Sciences needs to be multidisciplinary in its approach.

Participants at all workshops agreed that the future of the field of geology is in a more interdisciplinary 'earth science'. Earth System Science is defined as 'the study of the Earth System - the unified set of physical, chemical, biological and social components, processes and interactions that together determine the state and dynamics of Planet Earth, including its biota and its human occupants- with an emphasis on observing, understanding and predicting global environmental changes involving interactions between land, atmosphere, water, ice, biosphere, societies, technologies and economies.'¹

Teaching earth science includes classic geology coursework such as mineralogy, structural geology and sedimentology as well as other fields of environmental science and the relationships between the different fields. The role of humans within the earth system is an important new dynamic to be included in this approach.²

The importance of fieldwork in this new perspective was discussed extensively in all workshops along with the difficulties of conducting fieldwork in the African context. The extreme expense and logistical difficulty of fieldwork was highlighted – especially in central and western regions where it was indicated that students and faculty must pay an extra fee in order to conduct fieldwork.

In other regions, field work is not safe – for example in Angola, the fieldwork required for detailed geological mapping throughout the country is not possible because of remnant landmines. In parts of northern Africa, the logistics of fieldwork are not socially acceptable for female students, thus limiting the opportunities for women earth scientists.

Geology is only taught from the University level, not before.

All workshops highlighted the need to include the earth sciences in school curricula at primary and secondary level before students enter University. The Kinshasa workshop

¹ Earth System Science Partner website (n.d.) Accessed 29 March 2010, available online at: <http://www.essp.org/>

² The terms *geology*, *geoscience*, *earth science* and *earth system science* are used indiscriminately during the rest of this synthesis. In all cases, a multidisciplinary systems approach including the human role is assumed.

highlighted the three benefits of starting earth sciences earlier: 1) all students - and hence a broader portion of the population - are exposed to earth sciences and the relationships in the earth systems and the environment on which we all depend 2) more students are aware and attracted to studying earth sciences at higher levels 3) parents are educated by their young children reporting on what they have been learning at school.

Strong connections between Industry and Universities do not exist.

All workshops identified a lack of strong connections between Industry and Universities. From the University perspective, this results in a deficiency of those practical students who are seeking a course of study with job opportunities upon graduation. From the Industry perspective, University programmes and even graduate programmes are not producing students who are well trained to work in national or international companies. This situation is severe enough that some companies have resorted to building their own schools in African countries such as Nigeria in order to ensure that they have trained local staff.

More frequent interactions between university and industry would thus be mutually beneficial by fostering awareness of geosciences career opportunities, and thereby increasing enrolment, as well as by providing an educated population of local geologists who are prepared to work.

African researchers are isolated.

The overwhelming observation from all workshops was of the isolation of African researchers. Workshops included participants from countries sharing political boundaries or languages with the host country. However, in all cases, the majority of participants had not previously met or worked together. Participants representing continental or international organizations often presented information about relevant networks, which was new for participants. This isolation may be a result of language, poor communication infrastructure, and political instability, in some cases, but whatever the cause, leads to a status quo of seclusion. Not only are strong connections with the international research community missing, but also interactions across the continent, within regions (such as between Angola and its neighbours), and across countries such as the Democratic Republic of Congo are weak to non-existent.

There is a lack of adequate analytical facilities.

Except for South Africa, participants from every other country indicated a lack of adequate analytical facilities. In different regions, this means limited equipment for laboratory experimentation and research, difficulty accessing scientific literature, and a lack of updated geological mapping techniques. There is a need to improve analytical infrastructure both by dealing with obsolete infrastructure and poor continental wide distribution of facilities.

Existing earth science education in Africa suffers as a result of all of these elements.

Teaching and earth science education as a whole suffers from all of these situations. Northern Africa was the only region, except for the country of South Africa, which indicated an adequate number of well-organized earth science departments. Most other regions indicated unevenly distributed and inadequate number and quality of departments. In particular, Mauritius, Namibia, Botswana, Swaziland and Malawi were highlighted during the Cape Town workshop for the absence of, or very small, departments. The challenges of brain drain of academic staffs and lack of support for well-trained teachers was highlighted as contributing to the insufficient number of good teachers. The unacknowledged, but critically important role, of junior teaching staff many of which are coming from recent graduation pools in the same department was discussed in Kinshasa. It was stressed that these junior teaching staff must be supported.

Strong students also play an important role in the earth science education equation. All workshops highlighted the importance of a strong background in physics, chemistry and math in incoming students, a requisite that was in most cases not adequately fulfilled. Many participants highlighted that the earth sciences have very little status compared to other basic science disciplines, thus making it difficult to attract the best students. In Northern Africa where a large number of well-organized geology departments and geological surveys exist, there is still a decreasing trend in the number of students enrolled in earth science programmes.

Good teachers and students certainly exist in the African earth sciences, but not at the numbers that we all would like to see.

This description of observations has mainly been a summary of commonalities between regions, however the differences are striking and should not be underestimated. In the first place, it is useful to be reminded of the immense scale of the African continent and the different environmental conditions found therein. The first striking difference is the basis of our work: the geological environment. It makes sense that regional expertise would respond to regional geologic opportunities. Likewise, histories and modern realities are very different between countries and have major impacts on the research and study environment. Language seems to have been a divisive factor rather than a uniting element, and must be overcome for pan-African cooperation. In one example of the extreme cultural discrepancies present in the region, while most workshops were predominantly male and academic, the participants in the workshop in Angola were at least half female coming from backgrounds in industry and speaking only Portuguese. The workshop participants in Luanda expressed a great interest in collaborating with colleagues regionally and establishing relevant regional centres with the support of the government and industry: perhaps the differentiating elements can now contribute to unity and cooperation?

3.2 Recommendations

The earth science community must engage in outreach exercises to educate the general public on the importance of earth sciences for society.

It was agreed at all workshops that there is a need for more visibility and advocacy for the earth sciences. Outreach must show the earth sciences at work in communities and orient communication to explain how geosciences can participate in development and the improvement of living conditions.

Media could play an important role for the earth sciences in terms of awareness and promotion. In Assiut and Luanda it was proposed to strengthen the link between earth science centres and media with weekly or monthly pages in newspapers or radio and TV reports. There was a general consensus that the geoscientific community has a responsibility to reach out to the media.

Various workshops discussions took place about developing other creative communication methods through geoparks and geoheritage, supporting academic competitions such as Geosciences Olympiads, encouraging open geology days with university museums and establishing travelling exhibits.

On the other hand, it was acknowledged that earth science education is not adequately oriented toward development issues in the first place. Drawing these connections strongly into the education process would train practical earth scientists.

In Assiut, it was proposed that the curriculum needs updating to meet international standards and at the same time to include specific courses directed at societal development and environmental protection. International standardization to the LMD system (Licence-Master-Doctorate) was also discussed in Dakar, although there was debate about whether standardization is the best way forward for earth science education in Africa.

21st century Earth System Science Education must transcend the conventional view of geological sciences and the teaching of Earth Sciences needs to be multidisciplinary in its approach.

Teaching within the earth sciences should include an orientation towards more applied courses such as water management, geological hazards/natural disasters, mineral resources, climate change, energy resources, Geographic Information Systems (GIS) and modelling, health, urban planning especially for arid areas, oceans, natural heritage, and still include classic geology with the fundamental skills of geological mapping and fieldwork. Discussions in Cape Town revolved around ways in which to teach classic geological skills such as field mapping using the assistance of modern techniques like remote sensing. In this way, students still complete traditional fieldwork, but, before heading into the field, they analyze their study site using satellite imagery so that their fieldwork can be more targeted and efficient. In this way, traditional geological skills are being taught using the assistance of state-of-the art technology and are therefore not as time consuming, so that earth sciences course curricula can accommodate the new applications and connections within the field.

The Cape Town workshop recommendations went further than endorsing the teaching of earth system sciences to promoting 'Responsible Earth System and Science Stewardship', which would focus specifically on equipping the young generation of African geoscientists with the tools to cope with the global challenges of the 21st century and therefore the responsibility to care for the earth system.

Also, the Cape Town and Dakar workshops discussed the need to use existing regional African examples in geosciences courses and that an effort should be made to develop earth-related indigenous knowledge.

Geology should be included in the school curriculum at primary and secondary levels.

There was no consensus as to how the education system of the continent could be moved to include earth sciences in the curriculum, however the Cape Town workshop requested that UNESCO endorse and lobby for compulsory geosciences education at schools, with content adjusted to the local environment.

The Kinshasa workshop findings suggested the following progression: 1) In maternal and primary schools, teaching should focus on observations of nature and understanding natural phenomena. 2) At the secondary level, courses should maintain existing geography studies and introduce geology courses. This teaching would introduce the scientific method in laboratories and in the field. 3) At University and Superior levels, students should be introduced to research and learn to develop independent modes of study. The teaching at higher levels needs to be adapted to modern societal needs and new directions in geosciences. All workshops agree that it would be useful to involve professionals in the University-level training.

It is important to build connections between Industry and Academia.

Workshop participants recommended reinforcing partnerships between universities and enterprises by establishing educational programmes together, involving professionals in teaching, facilitating practical training in the enterprise, finding sponsors for specific courses and financing research programs for the economic sectors concerned. Participants from Universities recommended that Universities and regional centres of expertise could include mining engineering topics in their curriculum and collaborate more closely with mining schools.

The Kinshasa workshop proposed that fixed quotas of local hires, which are required by international industrial enterprises, would motivate both universities and enterprises to find solutions and collaborations to fill the need on both sides.

Reinvigorate old networks and build new ones between African researchers and the global research community.

One strong recommendation which came in response to this issue is to establish a continental network of earth scientists as a legacy of the UNESCO Earth Science Education Initiative scoping workshops in an effort to break the isolation of African

researchers, stimulate collaborative and cross-disciplinary research and promote earth systems science. This network would be the first action of the Initiative and has already been spurred on by the connections made through the workshops.

An important collaboration tool could be continent-wide scientific databases to share knowledge and support scientific researchers, companies, schools and governments. This webpage could include a real-time communication system to discuss geosciences-related issues and a virtual library and database of geosciences information (comprised of students' thesis work, scientific reports, etc.). Sharing these between African universities through a tool such as this one way could be a solid means of reinforcing south-south cooperation and twinning between African institutions.

National committees of international efforts such as the International Geosciences Programme (IGCP), the International Union of Geological Sciences (IUGS), and the International Year of Planet Earth (IYPE) were recognized as an important tool for communication and collaboration. However, it was acknowledged that these committees are far from representative across the continent and a concerted exercise needs to be undertaken to review the relationships between these different kinds of national committees, and start new committees in countries where none exist.³

It was also recognized that many other organizations have an important role to play in building better African earth science networks. These organizations include university-based outreach initiatives, NGOs, local organizations such as national geosciences societies, national committees promoting geosciences at grassroots levels and international projects to share geodata and geoinformation such as AEGOS (African-European Georesources Observation System), GIRAF (Geosciences InfoRmation in AFrica), and OneGeology.

IGCP, as the international geosciences research programme of UNESCO and IUGS, was discussed at all workshops and specific recommendations regarding increased funding for African projects and training of African project leaders have already been incorporated into current IGCP activities.

Mobility and exchange of professors and students between African institutions and globally was also identified as an important way in which to break research isolation and build functioning research networks. It is therefore necessary to reinforce the existing structures of lecturer-researcher-technician exchange in order to support newly established or small earth science departments and to improve their teaching capacities. Joint research projects with PhD and masters students were suggested as one way to encourage cooperation between universities. Postgraduate students likewise would benefit through exchange programmes and international visits. Postdoctoral mobility scholarships for 6-12 month were proposed. This increased exchange would also improve the reintegration for PhD students formed overseas to continue to teach and do research nationally, although the entire situation needs to be improved to effectively fight brain drain.

³ At the time of writing, there were 21 African IGCP committees and 22 African IYPE committees out of 53 African countries.

The Geological Society of Africa has worked extensively to build a continental network of earth scientists. One exercise in support of this goal has been to develop a database of all African institutions with earth science departments. The Dakar workshop, in particular, recommended that an exhaustive status update on the situation with higher education, research and development be implemented in order to build up a strategic vision on the local, national, regional, and continental situation of earth science education.

Counter the lack of adequate analytical facilities through exchange, sharing, and obtaining new equipment through new funding mechanisms.

Some workshops discussed using exchanges or sharing rotations to give adequate access to analytical facilities, but discussions in Cape Town highlighted the continental dearth of adequate facilities. Therefore, it was recommended that UNESCO endorses and lobbies for the creation of an African Geosciences Analytical Fund, possibly managed through an institution like ICSU-ROA (International Council for Sciences Regional Office in Africa), to facilitate access to analytical equipment hosted in Africa-based centres of expertise.

Centres of excellence were also identified as centralized locations where analytical facilities could be made available regionally, so smaller investments could focus on developing state-of-art laboratories that were available to a large number of researchers. The idea of a series of regional centres of excellence was discussed at all workshops. The idea of developing centres with expertise in appropriate fields and locations such as geothermal energy in eastern African, groundwater management in northern Africa, and partnerships with the private sector in Angola with a focus on teaching and research was well-received by most workshop participants. These centres would house analytical facilities, develop teaching materials based on African geological heritage, provide teaching support, foster regional research projects and reinforce existing regional centres and infrastructure.

However, a number of important considerations were raised about the model of centres of excellence. In Dakar, it was indicated that the need for a functioning network around these centres of excellence pre-supposes having the ensemble of national academic actors. In Kinshasa, the non-effectiveness and European-dependence of existing regional training centres was pointed out, and a proposal to focus on regional *networks* of expertise, reinforcing existing institutions, was developed.

Improving earth science education will require addressing many elements of the status of earth science in Africa but must also focus on teaching.

There is a major need to focus on “training the trainers” to ensure that students graduating from African earth science faculties are as well equipped as their international counterparts for work and continued graduate study. The quality of the teachers has a major role to play in this success, and junior teaching staff has been widely overlooked. This circle can be inverted by a) adequate new didactical training facilities and material and b) bringing the junior and senior teaching staff up-to date with modern scientific models. The former is more of institutional problem; the latter might be tackled through refresher seminars and promoting professional continuing education. A dedicated website for outreach and teaching material could be very useful for teachers.

Also, support for teaching missions and encouraging teaching partnerships (i.e. twinning system) with International universities would support teachers and prevent brain drain.

A number of different innovative teaching networks were presented at workshops. The common message for teachers was to use practical and innovative methods. The African landscape is full of important and exciting examples of geological phenomena and field research opportunities; these places can become the basis of earth science courses as well as graduate theses. The promotion of Geoparks and other designations to acknowledge and protect sites of geological significance also protects and develops teaching and study opportunity.

Networks that build community and foster enthusiastic exchanges about the relevance of earth sciences for society are another important tool for engaging with more students. The YES (Young Earth Scientists) network was highlighted at the Cape Town workshop as an important new movement that is providing role models, peer support for early career earth scientists, and opportunities for international research and exchange. YES participation should be encouraged to increase in Africa.

3.3 Creative proposals

There were many creative proposals suggested at these workshops, a few of which are described below:

Theme	Idée / Idea	Description
Analytical facilities	An ICP-MS for a Tank Initiative	One participant from Ethiopia estimated that it would cost the government the same amount to buy a new military tank as it would to buy a new mass spectrometer - why not the mass spectrometer?
Networks	Post-doc exchanges	Two-way post-doctoral exchanges could provide international perspectives and teaching to African departments.
	YES Africa roundtable symposia	A roundtable symposium of 'Young Earth Scientists' will discuss issues related to the application of earth sciences to society and create a network of young African scientists.
	Engage with the African Diaspora	Propose short-term teaching possibilities in African departments for academics who are based outside of Africa.
	IGEO meeting to include a training Geosciences Olympiad	The Geosciences Olympiad will focus on African students with Asian trainers experienced in organizing the Olympiads in Asian countries.

	Raise societal awareness of earth sciences through open museum days at University geology museums	Encourage interaction between academics and the public through existing facilities and resources.
	Africa Alive Corridors	A proposed network of sites around Africa to tell the '4.6 billion year biography of the earth' from geologic, biologic, and cultural perspectives.
Teaching	Geosciences Teaching Train	A proposal was discussed to develop a teaching train that could bring geology classes to rural schools via the railways of southern Africa.
	To close the gap between higher education and economic realities Twinning mechanism	Bridging the associations between professionals from both academic as well as industrial backgrounds through the development of courses capable of meeting the needs of these different sectors. Develop twinning mechanism between universities in order to improve the quality of higher education in geosciences and facilitate mutual recognition and programme validation.

3.4 Added benefits of the workshops

As was highlighted in the observation regarding the isolation of African researchers and academics, all of the workshops provided an important networking opportunity for participants who, in most cases, had not previously met the participants from other parts of their country or region. These individual connections will be reinforced by UNESCO with the establishment of a continental network of earth scientists as a legacy of the UNESCO Earth Science Education Initiative scoping workshops with the mandate of breaking the isolation of African researchers, stimulating collaborative and cross-disciplinary research and promoting earth systems science.

The workshops also provided Initiative partners including the AAWG and GSAf with an opportunity to promote their organizations and build awareness and membership in previously less represented regions of the continent. For example, the Dakar workshop hosted the launch of the AAWG and GSAf National Chapters of Senegal. The AAWG organized a dinner debate during the Dakar workshop on 'Women in the management of natural disasters taking place under changing climate conditions in Africa.'

The Luanda workshop was organized in concert with the official launch of the IYPE in Angola. This combined event provided high political profile and international industry participation for the workshop and content to the IYPE launch and other subsequent activities in Angola. As a result of the strong liaisons between IYPE and the Angolan Government, the African Forum for Sustainable Development is currently in discussion with the Angola Council of Ministers. That Forum, in turn, might fuel additional activities by the National Committee and may also support the developed of a Centre of Excellence, as recommended in the UNESCO Workshop.

Ground for both individual and institutional partnerships was established. The workshops also provided an opportunity to reinvigorate latent partnerships with UNESCO, utilize and justify existing institutional cooperation such as the on-going investment by the Belgian funding agency in the partnership between MRAC and the CRGM, and to introduce personal connections between researchers who will potentially follow-up on research topics. During the Kinshasa workshop, a challenge was issued to the GSAF councillors in central Africa to develop a new proposal under the Young IGCP funding scheme.

4. Actions

It is critical that these workshops serve as the catalyser for the beginning of a series of new networks, actions, and programmes at UNESCO and elsewhere. UNESCO recognizes that the current situation with earth science education in Africa will require some long-term programming and political commitment while, at the same time, there are some concrete recommendations which are underway now or can be responded to in the very near future.

The following table indicates the kinds of time frames envisioned for different workshop recommendations and also underscores the recognition and commitment from UNESCO for a long-term initiative.

	2010	5 years	10 years
Multidisciplinary approach in geosciences			
Continental network of earth scientists			
Reinforcement of lecturer/researcher/technician exchange			
Strong outreach activities in Africa			
Identification and promotion of Geological Heritage			
Regional centres of excellence			
African Geosciences Analytical Fund			
Compulsory Geosciences Education at schools			

Some shorter-term recommendations have already been followed-up with action as described in the following table.

Theme	Recommendation	Action	Dates
Earth System Science	Earth System and Stewardship Science	African Earth Observation Network (AEON) striving to be a pan African collaboration in research, teaching and learning	
Awareness	Outreach activities (museums, press, competitions)	IYPE	2007-2009
	Geoheritage (Geoparks, Africa Alive Corridors)	First Arabic and African Geopark meeting	2011
		African geopark training by Chinese geoparks	
	Encourage competitions such as Geosciences Olympiads	First earth science training Olympiad organized by IGEO (International Geosciences Educators Organization) to take place at GeoSci VI	29 Aug - 3 Sept 2010
Networks	International Networks	AfricaArray, etc	
	International two-way researcher exchanges	Mawari	2005-2010
	Networking amongst early career earth scientists, globally	YES Africa (Young Earth-Scientists) roundtable symposia at CAG23	8-12 Jan 2011
	Coordinate work on Geo-Information	GIRAF, AEGOS, GEOSS	
	Reinforce and increase IGCP national committees		
	Focus on African leadership of IGCP projects	New Swedish development funding obtained from IGCP chair for this purpose	Next IGCP proposal deadline

5. Conclusions

The wide range of actions proposed by these workshops will require work by partners at various levels from individuals to government to international agencies. The importance of African government support for the Initiative in particular, as well as any actions springing from it, has been underlined repeatedly by academic and corporate workshop participants.

In fact, the Luanda, Dakar, and Kinshasa workshops all enjoyed ministerial level participation during some point in the meeting – a strong sign that the Initiative is already compelling enough to governments to catch their attention. The October Launching

Conference at UNESCO will work to assure that support and hold governmental attention.

The recommendations from all five workshops fall into two very distinct categories that require the involvement of different partners. The first type of recommendations require action on the medium to long term, mostly on “how to re-organise” the education of Earth Sciences by considering programmes, curricula, facilities and centres of excellence. These actions will involve political and educational actors and substantial funding.

The second type of recommendations is a set of short-term quick-win initiatives through reinforcing networks and reinvigorating or focusing programmes and activities. These activities will need to focus on facilitating the participation of African geoscientists.

Regarding the short-term initiatives, the first priority is in breaking researcher isolation by reinforcing networks. This can be done first by improving the connection between the newly created network emerging from these workshops and enlarging it with existing networks. A good Initiative website could assist in this integration.

The strategic review and expansion of national committees of IYPE, IGCP, and IUGS to improve the representation across the continent, is an important and relatively simple step. The IGCP board has already acknowledged awareness of Africa-specific challenges and steps are being taken to address these challenges and to increase African participation and leadership in IGCP projects and relevant EU-FP7 call of proposals.

The Initiative network can also connect international training and research exchange opportunities with potential funding, or help to organize training groups of young African scientists on specific new technologies such as space imagery, geochemistry, water and aerosol analyses, and ductile formation. The continued elaboration of an international partnering scheme of interested academics will be an important step.

The IYPE has spent the past two years focusing on earth sciences outreach and has certainly made some headway in raising public awareness globally of the relevance of the earth sciences. Continued efforts to raise societal awareness of the multidisciplinary approach to earth sciences through various kinds of outreach is a mandate for all partners through their daily work. Progress in African Geoparks is being made through various planned conferences and trainings.

The improvement of the connection between industry and universities in Africa can be initiated imminently but will require a long-term commitment on both sides. A focus on providing job-relevant training to students may be one inroad as well as improving access to African analytical facilities. These priorities must be taken up by partners on both sides of the academic/industry divide as mutually beneficial progress.

In terms of longer-term goals, the reorganization of national curricula to meet international standards and teach the society-relevant multidisciplinary earth science described here will take commitment from governments and the networks established on the short term.

The proposal for regional centres of expertise based around regionally relevant themes will require further feasibility research to understand the best way to sustainably develop such networks within existing human and physical infrastructure.

In the short term, networks of expertise should be developed to begin to reinforce strengths, explore regional topics of interest and expertise, identify partners and determine the need and role for a physical centre.

Therefore, the following actions are proposed for discussion and integration into an action plan at the October Launching Conference at UNESCO:

- 1. Build upon the network created by the workshops, employing the necessary tools to create a stronger network between African earth scientists and engaging the international earth sciences community with the African community.*
- 2. Establish teaching and research exchange between institutions internationally. All African research projects should include at least an African researcher.*
- 3. Develop international networks of expertise that centre on regional African hubs.*
- 4. Review, revise, and expand upon the system of national committees to make them more effective and representative.*
- 5. Contribute to an outreach strategy based on the legacy of the IYPE.*
- 6. Schedule and plan for an African presence in the upcoming Geoparks meetings and training.*
- 7. Challenge governments to be involved, perhaps beginning with the role and necessity of geological surveys, which do not exist in many African countries.*
- 8. Engage with Industry, developing at least one proposal for long-term exchange and training.*
- 9. Engage with other UNESCO basic science education programmes to discuss strategies and means to have earth sciences included in primary and secondary curricula. Explore opportunities to develop teaching material with African examples.*
- 10. Endorses and lobby for the creation of an African Geosciences Analytical Fund.*
- 11. Develop a funding mechanism for education based on the royalties from geo-resource exploitation.*
- 12. Convince multi-donor agencies or development bank to finance the earth science education programme through out the African continent.*

6. Annexes

Annex I: Abbreviations

Annex II: Workshop participant list

Annex I: Abbreviations

AAWG: African Association of Women Geoscientists

AEGOS: African-European Georesources Observation System

AEON: African Earth Observation Network

CIFEG: International Centre for Training and Exchanges in the Geosciences

EU-FP7: European Union – Seventh Programme Framework

GEOSS: Global Earth Observation System of Systems

GIRAF: Geoscience Information in Africa

GSAf: Geological Society of Africa

ICP-MS: mass spectroscopy

ICSU-ROA: International Council for Sciences Regional Office in Africa

IGCP: International Geoscience Programme

IGEO: International Geosciences Educators Organization

IUGS: International Union of Geological Sciences

IYPE: International Year of Planet Earth

LMD system: Licence-Master-Doctorate system

RMCA: Royal Museum of Central Africa

UNESCO: United Nations Educational Scientific and Cultural Organization

YES: Young Earth Scientists Network

Annex II: Workshop Participant List

Institution	Number of Participants	Home Country	Dakar	Kinasha	Cape Town	Ass
2IE	1	Burkina Faso	X			
AAWG	1	Egypt				
AEGOS	1	South Africa			X	
AEON	2	South Africa			X	
African Association of Women in Geosciences	1	Morocco		X		
Alexandria University	2	Egypt				
Ambasadde de France	1	France	X			
Ambassade du Canada	1	Canada				
ANGW	1	Senegal	X			
ANSTS	1	Senegal				
Association des Géologues Congolais	2	DRC		X		
Banque Mondial	1	Senegal				
BREDA	1	Senegal				
Cabinet du Ministre de la Recherche Scientifique	2	DRC		X		
Cadastre Minier	1	DRC		X		
CAREEQ	2	Senegal				
Cellule Technique de Coordination et Planification Minière	1	DRC		X		
Centre de Recherches Géologiques et Minières	2	DRC, Cameroon		X	X	
Centre Intenational pour la Formation et les Echanges en Géosciences	1	France		X		
CIFEG	2	France				
CNGSAF	1					
Colégio Graceland	1	Angola				
Council of Geoscences	1	South Africa			X	
DMG	1	Senegal				
Écoles Secondaires	1	DRC		X		
EES division UNESCO- Cairo	1	Egypt				
Egyptian Environmental Affairs Agency	2	Egypt				
EMIG	2	Niger				
ENDIAMA-EP	3	Angola				
ENI-ABT	1	Mali	X			
ESCOM	1	Angola				
Faculdade de Ciências	16	Angola				
Freestate University	1	South Africa			X	
Geological Survey of Tanzania	1	Tanzania			X	
GSAf	2	Austria				

Institution	Number of Participants	Home Country	Dakar	Kinasha	Cape Town	Ass
ICS	1	Senegal	X		X	
Independent Environmental Consultant	1	Lesotho			X	
Institut de Recherche et Development	1	Senegal	X			
Institut de Recherches Géologiques et Minières	1	DRC		X	X	
Institut des Bâtiments et Travaux Publics	1	DRC		X		
Institut fur Angewandte Geowissenschaften	1	Germany				
Institut Supérieur de Techniques Appliquées	1	DRC		X		
International Council for Scientific Unions	1	Tanzania		X		
ISCU ROA	1	South Africa			X	
IST	1	Senegal	X			
IYPE	2	Angola				
Kigali Institute of Education	1	Rwanda		X		
Link Community Development	2	Malawi, South Africa			X	
Midrilco	1	DRC		X		
MIFERSO	1	Sengal				
MINAMB	1	Angola				
Ministère de l'Enseignement Supérieur et Universitaire, R.D.C.	1	DRC		X		
Ministère des Mines, R.D.C.	3	DRC		X		
Ministre des Mines	1	Senegal				
Mintech International	1	Senegal	X			
MMPITPME-DMG-CDCM	1	Senegal				
Musée royal de l'Afrique centrale	3	Belgium		X		
Nitrokemfor Senegal	1	Senegal				
North West University	1	South Africa			X	
Sociedade Mineira do CATOCA	2	Angola				
Sociedade Mineira do Chitolo	1	Angola DRC, Central African Republic, Ethiopia				
Société Géologique de l'Afrique / Geological Society of Africa	3	South Africa		X		
SOMOIL, SA	1	South Africa				
Sudan University of Africa	2	Sudan				
TOTAL	1	Angola				
TOTAL Nigeria	1	Nigeria			X	
Tshwane University of Technology	1	South Africa			X	
UAN-Reitoria	1	Angola				
UCAD	15	Senegal	X			

Institution	Number of Participants	Home Country	Dakar	Kinasha	Cape Town	Ass
UCT-CND	1	South Africa			X	
United Nations Educational, Scientific and Cultural Organisation (UNESCO)	2	France, DRC, Senegal	X	X	X	X
Universidade Cabo Verde	1	Angola				X
Université Abdou Moumouni	1	Niger	X			
Université Assiut	15	Egypt				X
Université Bujumbura	1	Burundi		X		
Université Bukavu	1	DRC		X		
Université Cadi Ayyad	1	Morocco				X
Université Chouaib Doukkali	1	Morocco	X			X
Université d'Abomey-Calavi	1	Benin	X			
Université d'Algerie	1	Algeria				X
Université de Bamako	1	Mali	X			
Université de Nouakchott Mauritanie	1	Mauritania	X			
Université de Ouagadougou	1	Burkina Faso	X			
Université de Rouen	1	France				
Université de Rouen/Dakar	1	Senegal	X			
Université des Sciences et Techniques de Masuku	1	Gabon		X		
Université Kinshasa	2	DRC		X		
Université Laval	1	Canada	X			
Université Lombe	1	Togo	X			
Université Marien Nguabi	2	DRC		X		
Université Tunis El Manar	1	Tunisia				
University of Botswana	1	Botswana			X	
University of Cocody	1	Ivory Coast	X			
University of Dar es Salaam	1	Tanzania			X	
University of Fort Hare	1	South Africa			X	
University of Ghana	1	Ghana	X			
University of Khartoum	1	Sudan				X
University of Mauritius	1	Mauritius			X	
University of Swaziland	2	Swaziland			X	
University of Witwatersrand	2	South Africa			X	
University of Zambia	1	Zambia			X	
Univesity of Namibia	1	Namibia			X	