United Nations
Educational, Scientific and
Cultural Organization

BRAIN GAIN INITIATIVE

Linking African and Arab Region universities to global knowledge

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Published by the United Nations Educational,
Scientific and Cultural Organization
7, place de Fontenoy,
75352 Paris 07 SP, France

Designed & printed by UNESCO

Printed in France

ED-2013/WS/18

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1 INTRODUCTION

The UNESCO-HP Brain Gain Initiative links
19 higher education and research institutions
from Africa and the Arab States

Introduction

The Brain Gain Initiative (BGI) is the fruit of a partnership between UNESCO, HP and higher education institutions in Africa and the Arab States. The vision is to empower university faculty, researchers and students to engage in real-time scientific collaboration with colleagues from around the world and in particular from their native countries. The initiative seeks to reinforce existing North-South and South-South cooperation and to leverage the benefits of innovative information and communication technologies to address social and economic problems.

The UNESCO-HP initiative has come at a time when the existence of a community of skilled expatriates is being regarded less as a loss and more as an opportunity. Remittances from abroad, of course, have long been an important supplement to export earnings for many developing countries. A Diaspora is now seen, increasingly, as a potential engine of development. The Network of African Science Academies (NASAC) notes that "past experience calls for a new, more sophisticated approach to the brain drain challenge [that] would recognize not just the obstacles but also the opportunities for S&T capacity building in Africa afforded by the migration to developed countries of well-educated, productive scientists with great drive and ambition"[1] while the Assembly of the African Union considers the African Diaspora "a substantive entity contributing to the economic and social development of the continent."[2]

> Tens of thousands of Africa's scientists now live and work in developed countries. Most will never return. It is important to recognize this reality and to devise policies that will allow Africa to take advantage of the knowledge and expertise of their emigrant citizens.
>
> Network of African Science Academies, July 2009

Accordingly, "brain gain" is no longer defined as simply the opposite of brain drain. It goes beyond a zero-sum vision where the gain in one country or one region matches and offsets the loss of the others. The "brain gain" that UNESCO and HP

1 Joint Statement by the Network of African Science Academies, NASAC, to the heads of States and governments attending the G8+5 Summit, Italy, July 2009, available at http://www.nationalacademies.org/includes/NASACbraindrain09.pdf / http://bit.ly/1bVVx6k

2 Assembly/AU/Res.1(XVIII), p. 43 in "Decisions, Resolution and Declarations of the Assembly of the Union, eighteenth ordinary session, Addis Ababa, Ethiopia, 29-30 January 2012" http://www.au.int/en/sites/default/files/ASSEMBLY AU DEC 391 - 415 (XVIII) _E.pdf http://bit.ly/13A7FIm

are seeking to create is irrespective of the temporary, circular or permanent character of migration. It refers to an improvement of human capital based on the transfer of skills and experience and the creation of a wider network of expertise and entrepreneurship.

The Brain Gain Initiative builds on the remarkable global connectivity in higher education that is made possible by information technology. Grid computing is a hardware and software infrastructure that clusters and integrates high-end computer resources, databases and scientific instruments from multiple locations to form a virtual environment in which users can work collaboratively. Together with cloud computing (which provides virtualized services over the Internet), these are key tools for the development of emerging centres of excellence on the African continent and in Arab States.

Science, a team sport

Some of the world's most advanced science has become an international "team sport", with scientists collaborating across continents and time zones. But it takes technology to play. Scientists can access resources all over the planet as long as they have the right tools. Behind the scenes there is e-infrastructure: the high performance communication networks and computing resources allowing scientists to engage in research in fields like bioinformatics, physics, molecular science and meteorology. With pooling and remote access to high-performance computers and scientific instruments, technology can enable South-South and North-South-South cooperation on joint projects, helping to bridge the divide in higher education and research.

Scientific research is driven, more and more, by massive amounts of data that can be processed at multiple places and used in research conducted from almost anywhere. The Large Hadron Collider (LHC), the world's largest scientific instrument (and the tool that confirmed the existence of the Higgs Boson), could not work without a network of more than 100 computing centres in dozens of countries. Similarly, the world's biggest telescope – the Square Kilometre Array (SKA) – will actually span several sites including Australia and South Africa, as well as eight sub-Saharan countries. Surveying the sky ten thousand times faster than ever before, the SKA will generate a mind-boggling amount of data. Once the SKA starts operating in 2020, it will leverage high performance computing to process data at speeds equivalent to millions of PCs and will make it available to researchers at several locations worldwide.

BGI projects are, of course, much smaller; they represent the beginning. The Initiative seeks to make a meaningful contribution to the creation of an e-infrastructure that will bring together higher education institutions and research centres. The emphasis is on awareness-raising, training, launching pilot applications and establishing networks. Ultimately, each participating university is to become a "digital hub", developing its research capacity to address local priorities while linking young scientists and other talented local individuals to university resources abroad, funding opportunities and international partnerships. Through the e-infrastructure, they will access and contribute to the abundance of scientific and technical knowledge that is, arguably, the most important opportunity for developing countries today.

GRID AND CLOUD COMPUTING

A grid is a collection of computers and storage linked by the Internet, together with software ("middleware"), that coordinates access to and use of the grid. The computers are usually owned by universities or research laboratories, and are often distributed over several cities, countries or even continents. A grid represents a shared computing facility, typically used by groups of researchers pursuing a common goal. Since such researchers may be broadly geographically distributed, this group is referred to as a "virtual organization", and grid middleware contains tools to support the work of virtual organizations. Qualified researchers are not charged to use a grid. An important example is high energy physicists working with data from the Large Hadron Collider at CERN.

A cloud is also a collection of computers and storage, very often in a centralized, large data center, and typically owned by a commercial entity. The company offers storage or computing services for a fee to any user willing to contract for the services. Access to these services is over the Internet. The user alone is responsible for the software and data that run on the computers and storage contracted. A good example would be the EC2 cloud operated by Amazon.

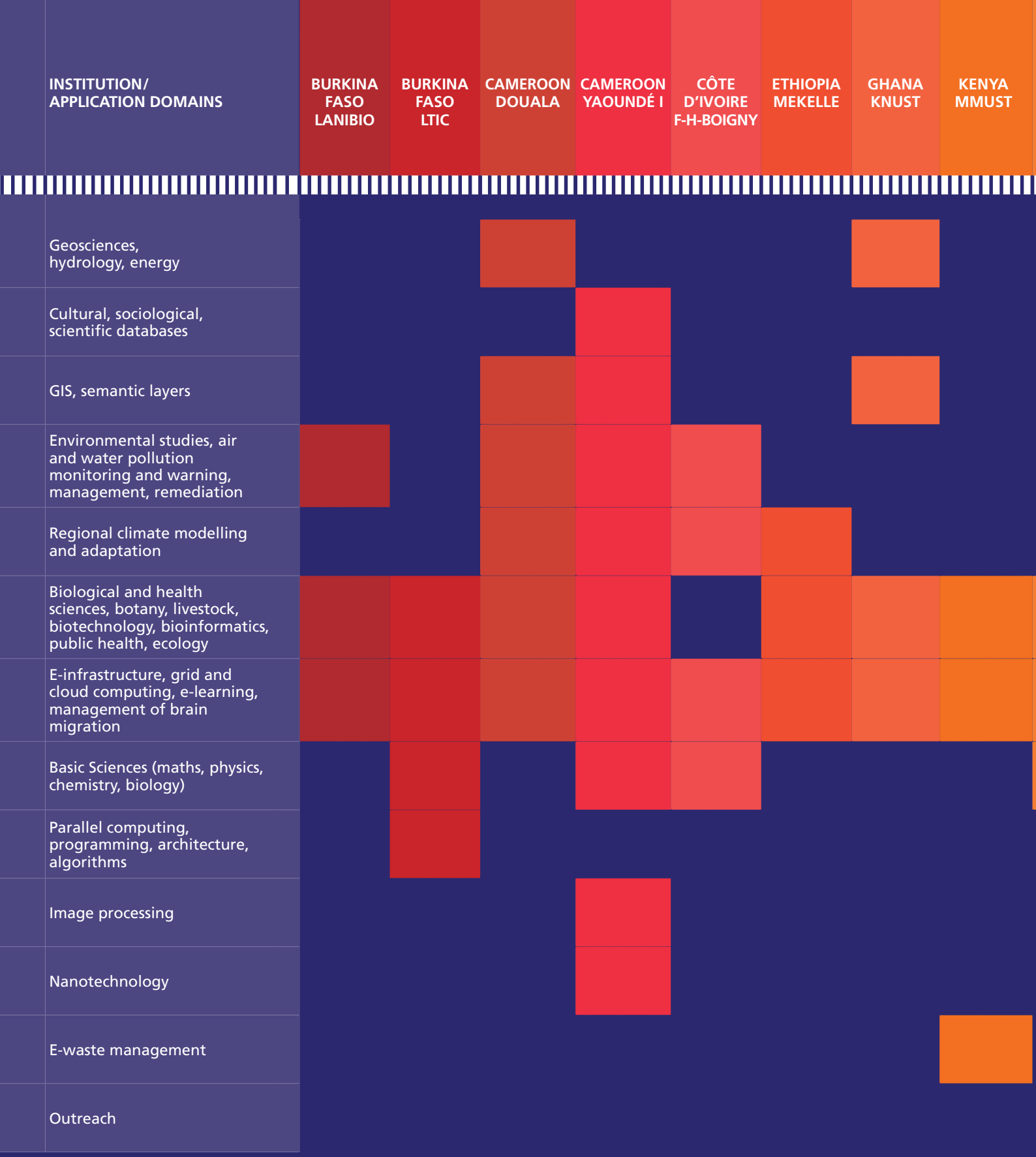
LOOKING FORWARD

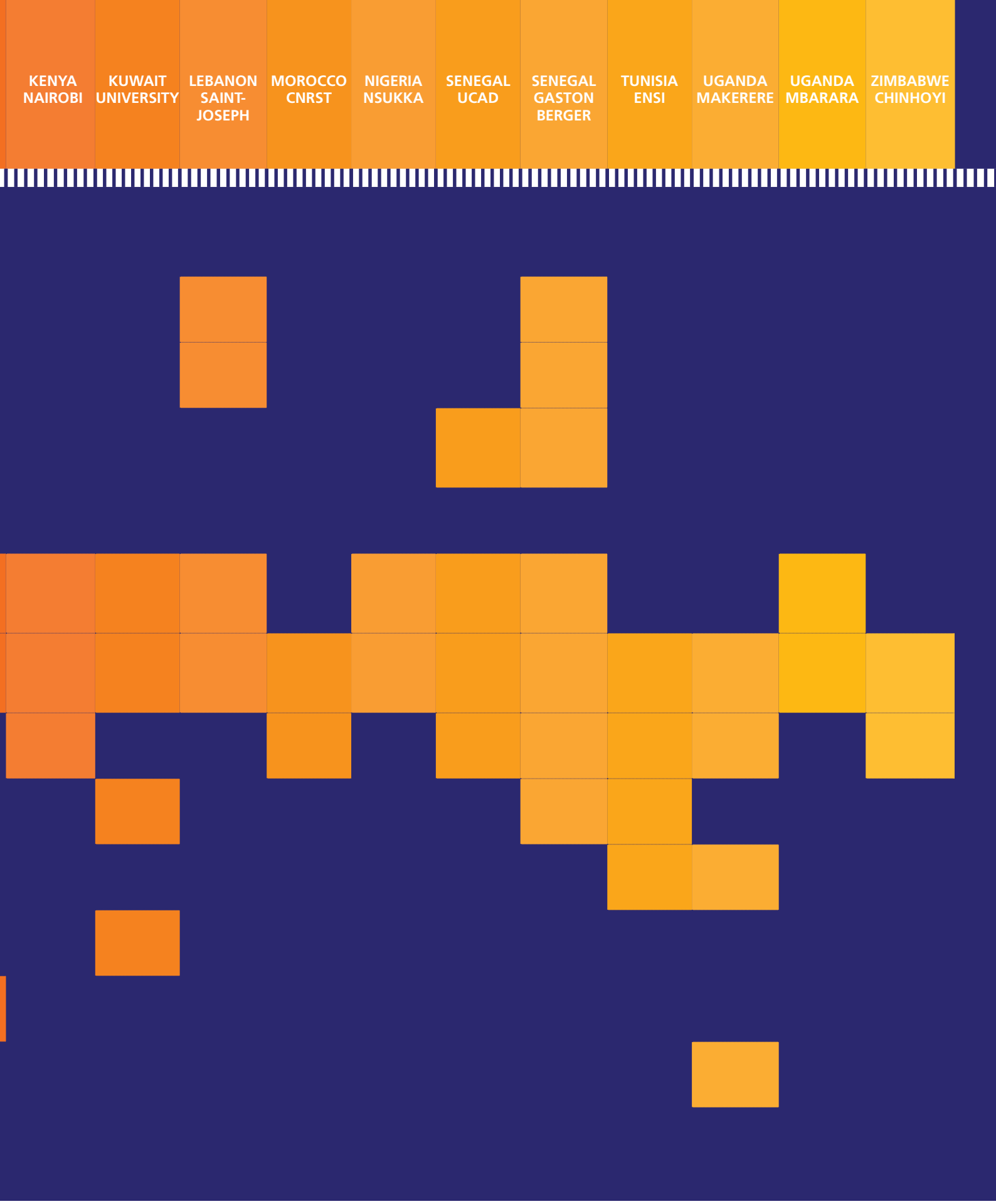
Education and research rely increasingly on electronic infrastructures (e-infrastructures) in order to enable the acquisition and transfer of knowledge necessary for a productive economy. The existence of multifaceted communities of teachers and researchers with diverse needs requires a diverse set of infrastructures, services and tools rather than a single integrated e-infrastructure.

Experience in Europe over the past decade has led to proposals for hybrid e-infrastructure models incorporating publicly-funded infrastructures (e.g. high-performance networks and grids) that interoperate with commercial services (e.g. clouds).

Details and references for further reading can be found in the European e-Infrastructure Reflection Group White Paper 2013,[1] in "Implementation of a European e-Infrastructure for the 21st Century",[2] and in the SIENA Roadmap on Distributed Computing Infrastructure for e-Science and Beyond in Europe.[3]

1 http://www.e-irg.eu/publications/white-papers.html / http://bit.ly/o02uLc
2 https://cds.cern.ch/record/1562865 / http://bit.ly/19zV7Ss
3 http://www.sienainitiative.eu/StaticPage/Roadmap.aspx / http://bit.ly/176d6he


INSTITUTION/
APPLICATION DOMAINS
BURKINA FASO LANIBIO
BURKINA FASO LTIC
CAMEROON DOUALA
CAMEROON YAOUNDÉ I
CÔTE D'IVOIRE F-H-BOIGNY
ETHIOPIA MEKELLE
GHANA KNUST
KENYA MMUST
Geosciences, hydrology, energy
Cultural, sociological, scientific databases
GIS, semantic layers
Environmental studies, air and water pollution monitoring and warning, management, remediation
Regional climate modelling and adaptation
Biological and health sciences, botany, livestock, biotechnology, bioinformatics, public health, ecology
E-infrastructure, grid and cloud computing, e-learning, management of brain migration
Basic Sciences (maths, physics, chemistry, biology)
Parallel computing, programming, architecture, algorithms
Image processing
Nanotechnology
E-waste management
Outreach


KENYA NAIROBI
KUWAIT UNIVERSITY
LEBANON SAINT-JOSEPH
MOROCCO CNRST
NIGERIA NSUKKA
SENEGAL UCAD
SENEGAL GASTON BERGER
TUNISIA ENSI
UGANDA MAKERERE
UGANDA MBARARA
ZIMBABWE CHINHOYI

2 MOBILIZING THE DIASPORA

Mobilizing the Diaspora

HP and UNESCO introduced the Brain Gain Initiative more than seven years ago.[1] The stated goals are to strengthen university teaching and research capacities on the African continent and among Arab States; to advance regional and global scientific collaboration and research for development; and to facilitate links with the Diaspora and enhance brain gain. Five African universities tested the application of grid technology in the 2007-2008 pilot phase. In 2009, UNESCO and HP scaled up the size and scope of the BGI, extending it across Africa and to certain Arab States. Today the BGI partnership comprises 19 universities – in Côte d'Ivoire, Ethiopia, Ghana, Kuwait, Lebanon, Morocco, Nigeria, Tunisia and Zimbabwe – and two each in Burkina Faso, Cameroon, Kenya, Senegal and Uganda.

Participants in the BGI design a scientific project addressing their research interests that can be implemented jointly with experts in the Diaspora by leveraging distributed computing. Candidates are proposed by their country's Ministry of Higher Education. Participants are selected among candidates on a competitive basis. The IT equipment grant (servers, workstations), training and operational funds allow participants to modernize their infrastructure, familiarize themselves with distributed computing and conduct a research project where this knowledge is immediately applied. This creates an enabling environment for collaborative work. Beyond the provision of technology and training, the BGI fosters and supports networking opportunities, such as participation in international conferences.

Representatives from participating universities were trained together in Johannesburg at the end of 2009 and in Pretoria in 2011. While one representative from each institution was typically an IT expert, the second was a senior researcher or, in some cases, head of an IT department or director of a computer centre. The first part of the training focused on how to install and operate grid servers and software; it was followed by an introduction to grid computing, with support from GILDA (INFN, Italy) and South Africa's Meraka Institute. These training sessions have led to ongoing discussions within the BGI network about how to make the most of potential scientific collaboration across a wide range of projects: biotechnology, chemistry, scientific databases, grid development, e-learning, physics, e-waste management, pollution monitoring and alert systems, and modelling the consequences of climate change.

1 The initiative was preceded by an earlier joint HP-UNESCO project – "Piloting Solutions for Alleviating Brain Drain in South East Europe" (launched in 2003) – that succeeded in making universities self-sustainable in the use of grid technology and helping researchers bid for public and private sector funded projects.

E-science in Senegal

The installation of a grid node at Cheikh Anta Diop University (UCAD) in Dakar – in partnership with the Grid Computing Institute of the French CNRS – was a notable milestone for the BGI. This was the first sub-Saharan African component of the grid infrastructure created in 2004 by the European Union – Enabling Grids for E-sciencE (EGEE) – a project that aims to develop cooperation on a global scale for many scientific applications. It gave grid users in Senegal access to EGEE computing power and storage capacity.

The new link was seen as an important step towards bridging the North-South digital divide. "We have suffered in the past from our best talents leaving Senegal to further their careers elsewhere", said Ibrahima Niang, head of UCAD's computer centre. "This project helps us to plug into the world of research. We can build connections with colleagues in other countries, which benefit our own work, and this link also provides an opportunity for our own academics and researchers to further their careers from Senegal."

The expertise acquired with the UCAD grid has been applied to another BGI-support project: the installation of a grid at Gaston Berger University (UGB). At UGB, the team is building a sociocultural encyclopaedia of Senegalese communities. The idea is based on the observation that some communities in Senegal are more familiar with the history and culture of foreign countries than those of their own neighbours in Senegal. The online encyclopaedia, accessible through a wide range of devices, including mobile phones, will serve as an open information repository and a communication channel between communities.

In an example of BGI-supported South-South collaboration, Morocco's CNRST research centre sent a grid expert to facilitate grid computing workshops attended by UGB faculty and students at the end of 2012.

> "Our students and faculty can now do their research inside Senegal and collaborate with scientists all over the world. And members of the Diaspora can mentor our PhD students."
>
> Ibrahima Niang,
> head of the university computer centre
> at UCAD in Senegal

NSUKKA – the Lion Grid

The University of Nigeria, Nsukka (UNN), has installed the first grid node in Nigeria under the sponsorship of UNESCO and HP. The BGI-supported e-infrastructure has helped researchers conduct improved experiments on the micropropagation of cocoyam plant tissue (cocoyam is one of the country's staple crops, and Nigeria is the world's leading producer, accounting for up to 3.3 million metric tonnes annually). The project team developed prototype simulation software, Plantiss, which models the quantity of growth regulators needed for the growth of explants such as roots and leaves. Plantiss helps reduce the number of trials that need to be done in the laboratory. No less than 21 researchers and 200 students from the Department of Plant Science and Biotechnology are directly involved in the primary research area of the project. Based on their research findings, botanist Florence Akaneme and her project team have developed an instructional module that is now available to researchers from other universities in Nigeria working in the field. Animal tissue culture experiments were also conducted using various cell lines that could be used in the treatment of diabetes and other illnesses.

In this as in other projects, the BGI has promoted the development of international cooperation, and

notably with expatriates. Two Nigerian scientists have supported the project from abroad: Stephen Oluwaseun Amoo, an expert in plant tissue culture at the University of KwaZulu-Natal, South Africa; and Augustine Asogwa, a Master's degree student in Information Security at the Robert Morris University in the USA.

Raising awareness of Lion Grid's potential is one of the most important tasks the UNN-BGI project team faces. They have organized hands-on workshops to demonstrate Lion Grid's power as a research tool for many potential users at Nsukka and other Nigerian universities. UNN estimates that over 20,000 researchers and students could benefit from the project, a figure based on the number of higher institutions and students population in South-Eastern Nigeria alone. Since the staff have been given access to distributed resources for research, many have expressed interest in learning how to grid-enable their projects. A workshop in late 2012 led to participants from several universities making project proposals and identifying fields in which to deploy the new e-infrastructure: astronomy, computational fluid dynamics, lysis/crystal structure modelling, genetics and genomics, geomagnetic data analysis, mathematics, nanotechnology, plant tissue culture, seismology, and statistics for social sciences.

Tackling e-waste in Kenya

Tackling the electronic waste problem in Africa could help the environment and create jobs at the same time. A BGI project in Kenya seeks to make e-waste recycling safer and less polluting by supporting the development of a sustainable e-waste management system. Masinde Muliro University of Science and Technology (MMUST) has developed a training programme in e-waste management and is opening a recycling centre for e-waste for western Kenya. With help from the BGI, MMUST introduced a diploma in computer technology and e-waste management – the first of its kind in Africa according to project leader,

MEASURING AIR POLLUTION IN AN AFRICAN CITY

In Cameroon, a BGI project is using remote electronic sensors to measure urban air pollution in the capital city of Yaoundé – in real-time. Project coordinator Emmanuel Tonye, a professor at the University of Yaoundé, designed a semantic website that maps air pollution (through GSM, SMS, and GPRS) while Christophe Bobda, a Cameroonian scientist working at the time in Potsdam, Germany, designed the devices to measure air quality. The new data might convince local authorities to do more to fight urban air pollution. The two engineers hope to pioneer a system that will help in the fight against pollution in other African cities, too.

> "Our ultimate goal is to create a transfer of technology to Africa. I feel it is a duty."
>
> Christophe Bobda

Simon Maina Karume. The project is necessary, he says "to counter an otherwise looming environmental disaster," because of "the alarming rate at which e-waste is increasing in our country."

The project has facilitated new research on the topic of e-waste and figured in papers at several national and international conferences. Notably, a mapping exercise was conducted to collect data and systematically categorize e-waste taken from 10 landfill sites throughout the country. Through a grid service infrastructure for computational chemistry (via a BGI server) and a virtual laboratory coordination centre, MMUST researchers in collaboration with Kenyatta University, Syracuse University, California State University-Fullerton and California State University-San Marcos have implemented a virtual chemistry program which will be accessible to all students in selected high schools in Kenya.

> "I am happy that as a country we are now moving forward after a long struggle thanks to UNESCO-HP and other e-infrastructure initiatives. Our first major task is to raise awareness among scientists."
>
> Simon Maina Karume,
> BGI project coordinator at Masinde Muliro University of Science and Technology, Kenya

At the University of Nairobi, the School of Computing used a BGI grant to focus on establishing a Regional Centre of Excellence for Distributed Systems and Modelling with first applications in medicine and biology. The university has reported running workshops and preparing presentations to potential users at the university and at six other Kenyan universities. "The project supports the research agenda of the nation," explains BGI project coordinator William Okelo-Odongo. "The grid will eventually be opened up and accessed by other researchers and students in the country and region."

Morocco – strengthening regional ties, building a sustainable e-infrastructure

In North Africa, the BGI has led to an expansion of the performance and capacity of Morocco's MaGrid – the computing grid hosted at CNRST (Centre National pour la Recherche Scientifique et Technique). It has also helped CNRST train potential users, which has already translated into greater use of the platform. This is in keeping with the mission of CNRST to support higher education and scientific research.

Over the duration of the project, over 100 participants (researchers and administrators) from various higher education and research institutions attended training sessions. Project coordinator Redouane Merrouch credits the BGI project with enhanced cooperation with Moroccan expatriates. For example, Ms Farida Fassi, a Moroccan expert based at the University of Valencia (Spain) came to CNRST to give grid computing seminars to Master's students and to support doctoral students in Medical Physics and High Energy Physics. Likewise, Mr Othmane Bouhali, a researcher at Texas A&M University at Qatar, delivered a three-day grid computing seminar for 35 students working on a Master's in IT at Tangier's Faculty of Science and Technology.

Furthermore, the project made it possible to introduce a grid computing module for Master's students at Mohammed V Agdal University (Rabat).

The project has been notably successful in the promotion of South-South cooperation. CNRST has hosted researchers from BGI institutions where a grid was not yet operational, such as Burkina Faso, and given them access to its own e-infrastructure. In November 2012, an expert from CNRST facilitated a training session in Senegal and the project also provided support for the organization of a BGI workshop at Mekelle University, Ethiopia. In June 2013, CNRST and UNESCO jointly organized two training sessions welcoming representatives from BGI projects at CNRST headquarters (four Moroccan universities sent delegates to this activity, which was also attended by representatives from two Senegalese institutions, two Cameroonian ones, and one each from Burkina Faso, Côte d'Ivoire and Tunisia).

Finally, the wiki for technical documentation, which is hosted on the national research network (Marwan), proved useful to other BGI projects. "The BGI opened up avenues for a fruitful cooperation between our countries. We aim to pursue further opportunities for South-South cooperation, both formal and informal", says project coordinator Redouane Merrouch, who sees strengthening regional ties as "the foundation on which to build a sustainable e-infrastructure."

Grid computing for Cheminformatics in Kuwait and a South-South proposal from Tunisia

In the framework of the Brain Gain initiative, the College for Women in Kuwait University established the country's first grid node with support from ASREN (Arab States Research and Education Network). The grid infrastructure allows computer science researchers to carry out grid/cloud related projects and research. Project coordinator Paul Manuel says BGI "helped open new domains such as Cheminformatics" and notes that it has enabled collaboration between the Kuwaiti researchers and colleagues from as far away as India and Australia. The university invited researchers from the BGI network (from Côte d'Ivoire, Burkina Faso, Ethiopia, Kenya and Nigeria) to the annual Kuwait conference on e-services and e-systems (KCESS). To ensure sustainability of the achievements of the BGI project, Kuwait University intends to take over the laboratory and to expand it into a research laboratory.

Meanwhile, the project at Tunisia's National School of Computer Science (ENSI) has supported research into hybrid grid and cloud computing platforms for scientists, and security issues in video streaming over P2P networks: a Master's dissertation was prepared and a PhD thesis is ongoing, both under international co-supervision. In March 2011, together with BGI partners from Burkina Faso and Cameroon, ENSI joined a consortium answering a call for proposals issued by the EACEA (Executive agency of the European Commission with responsibility in Education) in the framework of the "Intra-ACP academic mobility scheme". Although the proposal was not retained, the consortium demonstrates the South-South cooperation dynamics established between participants in BGI. The team introduced a notable number of researchers and students to the concepts of e-infrastructure by organizing a workshop and training session, in late April 2011 that gathered 100 participants from several Tunisian higher education institutions as well as international experts from South Africa, Italy, and Switzerland.

> The positive cooperation between several institutions in Lebanon and expatriates abroad was a landmark achievement that will foster further initiatives.

Magda Kharrat,
BGI project coordinator at Saint-Joseph University, Lebanon

E-Flora in Lebanon

Lebanon is a global biological "hotspot" of plant species, many of them endangered. What if each plant could have its own Web page with geo-tagged photos? What if high-quality data – reviewed by experts – were instantly available to teachers, researchers and policy-makers? Wouldn't that move science forward and, ultimately, help the conservation effort?

The idea has become a reality thanks to Saint-Joseph University and BGI. Lebanon-flora.org was officially launched in late 2012. An e-infrastructure now allows scientists in Lebanon and around the world to create and update a collaborative, free-to-access database of species found in Lebanon. By the end of 2012, the database comprised descriptions, pictures and location information of 764 species with pictures of 500 more (with data entry pending). The project team has conducted multiple field studies to gather the data. A set of maps locates endemic species in relation to various parameters, such as soils, average precipitation, etc. The mapping tool is an indispensable resource for identifying where plants are endemic and which areas need protection. Prior to its creation, information on Lebanese flora was dispersed and generally inaccessible. Teachers, from primary to university level, often had to refer to examples from foreign countries when preparing courses and case studies. Now, the e-flora database provides a local approach that highlights the richness of Lebanon's natural resources.

As of March 2013, this innovative project has been included in the Observatoire libano-français de l'environnement (O-LiFE), jointly created by CNRS-L. CNRS, IRD and OSU-OREME (Montpellier 2 University), in partnership with Lebanese and French institutions.

Saint-Joseph University took significant steps to start the deployment of the national grid infrastructure over the duration of the project, organizing a symposium in June 2011 and a BGI-supported training workshop in July 2013. Pending full deployment of the grid infrastructure, numerical simulation jobs are being run in France at the IPHC, a CNRS laboratory in Strasbourg.

> E-Flora is a successful stepping stone that will lead the way towards the construction of national databases on biodiversity, water and environmental management in Lebanon, in an ambition trend to gather and compile lasting information on the environment around the Mediterranean.

Carla Khater,
Researcher CNRS-L;
coordinator of O-LiFE

Uganda – IT at the service of communities

Uganda's Makerere College of Computing and Information Sciences, which is part of the BGI network, focused on using ICT to address community needs in four local projects: using mobile phones to improve follow-up of HIV/AIDS patients undergoing antiretroviral therapy; localizing the VLC open source software in the Rukiga language; adapting open source terminal/server software for use on the Ubuntu operating system, so as to maximize the use of available equipment; and creating an SMS-based application to identify nearby emergency services.

Mbarara University of Science and Technology (MUST) deployed e-learning resources at the Institute of Computer Science and will be using a blended approach (combining traditional classroom and e-learning methods) to introduce distance learning degree programmes. The university's Software Incubation and Innovations Unit is now developing an online tool for quality assessment and quality assurance in the upcoming e-learning offering. The two Ugandan universities joined forces and shared resources at key moments: Makerere contributed expertise in e-learning to help colleagues at Mbarara while the technical expert at Mbarara University became a resource person for Makerere University when it held grid computing seminars.

Coping with climate change, pollution and power failure

Africa has a particular need for climate change models. BGI projects in Burkina Faso, Cameroon, Côte d'Ivoire, Ethiopia and Senegal seek to put grid computing at the service of climatologists and other environmental science specialists so they can create more accurate models of regional weather patterns and contribute to future climate change predictions. The benefits will include a better use of existing (global as well as regional) climate simulation models as well as the creation of new ones. These projects have a very good potential to showcase the usefulness of grid applications to decision-makers. They can help policy-makers in their efforts to reduce malaria, protect biodiversity, increase agricultural productivity and manage the flow of water to hydroelectric dams.

> "In terms of science, we've achieved a great deal. The software has been successfully tested using data from the plains of Gondo: you can see the progressive concentration of certain forms of pollution. We believe that this computer program will enable us to act on potential cases of pollution and that was the purpose of our project."
>
> BGI team coordinator Blaise Somé,
> University of Ouagadougou,
> Burkina Faso

A grid node is expected to benefit at least two such projects at UGB in Senegal: MOMIES, which models fluid dynamics applicable to shallow waters like the Senegal River; and CLUVA (Climate Change and Urban Vulnerability in Africa), which will help African cities identify and cope with climate-change risks. Likewise, Félix-Houphouët-Boigny University in Côte d'Ivoire is using BGI technology to develop a regional climate modelling centre. Another project hosted in Douala University will leverage remote sensors to trigger

flood alerts on the coast of Cameroon. Uninterrupted energy supply is one of the key factors that would enable economic growth in Africa. A BGI project in Ghana is addressing the issue of energy supply and management. In Burkina Faso, a team from the University of Ouagadougou is collecting and analysing data on pollutants in the Sourou River basin. Computer scientists will then create mathematical models to assess the risks of water pollution.

3 BUILDING A LIFELINE FOR TALENT

Building a lifeline for talent

The Brain Gain Initiative has encouraged universities to design projects drawing on their potential to become "digital hubs" of global knowledge. These BGI projects have led to the creation of new educational content and courses; the extension of information services to local communities; and the mobilisation of researchers at home and abroad to undertake promising e-science initiatives.

They have also contributed to a wider appreciation of the digital infrastructure that BGI partners are working to create. A major finding of the external BGI evaluation (July 2013) is the extent to which the Initiative has created awareness of advanced grid and cloud computing among researchers and academics (and not just technical people). This growing awareness is an important factor in the development of national and regional grids. Furthermore, networking opportunities provided by the BGI resulted in positive collaboration between universities and international partners, including with the Diaspora. Participants welcomed and emphasized this potential, particularly for providing training in grid use and in building research capacity. For example, Gaston Berger University expressed its commitment to contribute to the building of a national grid for all the universities in Senegal, and Mekelle University, being the first university in Ethiopia to develop a grid node, now wishes to expand the facility to include other universities.

Participants that have successfully installed a grid node noted the positive impact of having access to high-performance computing capacity: more data can be processed in less time, fostering research development; postgraduate students benefit from training and resources that would otherwise be out of reach; and institutions can develop new courses and curricula. As the grid nodes are in their infancy, usage is still low, but project leaders report that there is growing demand for grid resources. For example, the University of Nairobi notes that its grid node is already in use by at least 20 staff members and 100 students from the university.

Lessons learned

Looking ahead to the next cycle of BGI projects, there are some lessons to be learned. From the beginning, the BGI strategy has been to build a community of African and Arab States experts who can act as champions of the project and raise awareness of the benefits of an e-infrastructure among national policy and decision-makers. These project leaders experienced various challenges: A BGI participant is often the only institution in the country conducting a grid computing project – and the technology is new to many of the researchers themselves. The setup of the infrastructure calls for the cooperation of many stakeholders (administration, donors, ICT experts, researchers, etc.). Regular and steady power supply is needed 24 hours a day (at least a third of participating institutions face power supply challenges), as well as adequate network infrastructure and good bandwidth.

By contacting directly the international partners identified by participants and organizing on-site visits during implementation, UNESCO and HP would raise the project's profile; visits would also improve understanding of successes and difficulties and ensure that a large group of stakeholders is aware of the Initiative and the rationale behind it. Streamlining the process for the delivery of the equipment grant would afford more time for implementation.

Training opportunities were greatly appreciated. BGI partners could consider putting even more emphasis on this item and devising a stronger, more diversified training programme (projects have different needs and expectations). A systematic follow-up activity at the institution would ensure that newly acquired skills and know-how are applied and widely disseminated. The BGI can also work in a more systematic way with organizations possessing technical expertise, including in the context of project-project cooperation, a most valuable trait.

The general framework was developed and refined over the successive iterations of the project and works well. Strong points include asking Ministries of Higher Education to propose institutions, conducting a competitive selection process, and granting BGI teams the freedom to develop projects that correspond to their own research agenda.

The secretariat is also playing a strong role in providing prompt and detailed feedback on narrative reports, responding to needs and requests of project members, and conveying additional opportunities for BGI project teams – for further training, networking, applying for research grants, etc. Officializing the experimental discussion group would provide project teams with a well-identified virtual place for "many-to-many" conversations where they can present their progress, discuss challenges, and develop closer ties.

Gaining momentum

While one could argue that the BGI is too "early" because it demands resources that African and some Arab universities are sometimes in short supply of, that would be to overlook the urgent and timely role of the BGI in bringing content to their emerging e-infrastructure. The geographic and scientific scale of the BGI has laid the foundation for several subsequent and complementary projects.

According to Bruce Becker, Coordinator of the South African National Grid,

> "The Brain Gain Initiative has played a part in addressing not only the creation, but also the sustainability of e-science initiatives. One of the biggest steps was the creation of the Africa-Arabia Regional Operations Centre, supported also by the EC through three FP7 projects (CHAIN, CHAIN-REDS and el4Africa) […]. It's no exaggeration to claim that without the strong base and stimulation to collaborate generated by the BGI, this would likely not have been achieved."

There is clearly scope to involve other institutions by potentially replicating the Brain Gain Initiative model. Future initiatives could launch research projects that can be implemented using the grid across countries.

One of the most encouraging recent developments in Africa and the Arab States Region has been the creation of national and regional research and education networks (NREN), and federations of NRENs that are seeking to connect to the global research and education networking community; the UbuntuNet Alliance,[1] the West and Central African Research and Education Network (WACREN),[2] and the Arab States Research and Education Network (ASREN).[3]

Participants in the BGI are beneficiaries, stakeholders and advocates of the NRENs. There is a mutually beneficial relationship in that successful BGI projects not only depend on these academic networks but also demonstrate their potential. In its roadmap of future activities, the EU-funded CHAIN project (www.chain-project.eu) notes, and recommends that,

> "The UNESCO-HP Brain Gain Initiative left visible traces in the region, being a huge contribution to the recent achievements of the infrastructure development.
>
> UbuntuNet, together with NGIs as well as support of the local governments should look for participation in similar programmes, as well as lobby for setting up further ones."[4]

1 http://www.ubuntunet.net
2 http:// www.wacren.net
3 http:// www.asrenorg.net
4 http://documents.ct.infn.it/record/537/files/CHAIN_D4_4_V12-Final.pdf / http://bit.ly/19nn5Eq

The Brain Gain Initiative therefore calls on its current partners – UNESCO, HP and the higher education institutions themselves – to build on this progress and work in close partnership with the emerging federations of national research and education networks, to mutually reinforce capacity in advocacy, capacity-building, and technical assistance. The time is ripe for such a partnership to deliver an e-infrastructure and a community of users who can tap into global knowledge and apply their learning on home soil.

Linking African and Arab Region universities to global knowledge

Founded upon concurrent trends – the mobility of the highly-skilled and the increased internationalization of higher education and research – the UNESCO-HP Brain Gain Initiative builds on emerging tools to help create the regional e-infrastructure for education and research.

Nineteen higher education and research institutions from Africa and the Arab Region partnered with UNESCO and HP to document the potential of grid and cloud computing as drivers for advancing knowledge necessary for a productive economy.

Some had to overcome considerable challenges in this ambitious enterprise. Their work – individually and as a group – has left visible traces in the region and represents a strong incentive to seize the momentum and drive the Initiative forward.

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