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Cooperation in earth observation missions in Africa: a role for afrigeoss

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Abstract This paper is aimed at examining the role of African Global Earth Observation System of Systems (AfriGEOSS) in Earth Observation (EO) mission cooperation on the continent of Africa. It discusses the importance of earth observation programs for developing countries as well as the benefits of international cooperative efforts. The paper further examined some collaborative projects on Earth Observation in Africa and their associated problems. It specifically looked at the EO data coordination initiatives such as the Spatial Data Infrastructure (SDI), GEOSS, Africa Discovery Broker, etc. It then situates AfriGEOSS in the context of African Space Agenda (ASA) with recommendations especially to the Africa Union Commission for the realization of ASA set goals. The paper reiterated that regardless of whether developed or developing, Earth observation information provides substantial benefit supporting economic development, decision making and policy implementation of all countries of the world. This is as a result of its multifarious benefits to humans in areas like agriculture, forestry, risk management, disaster monitoring, maritime, defence and security and natural resources management. Consequently, the paper argued that the numerous benefits from space assets have driven countries within the continent of Africa to either acquire or develop capabilities in space systems which is devoted to improving quality of life in general. The paper concluded that while space systems are expensive, there is need for continuity and sustainability as a result of its numerous advantages to the human's society.

Keywords Sustainable development · Spatial data infrastructure (SDI) · GEO · GEOSS · AfriGEOSS · Earth observation · Capacity building · Satellite

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Introduction

Located mostly within the tropical region of the world, Africa stands out to be one of the most richly endowed continents in the world in terms of abundant natural resources and population size. Unlike in America, Europe and part of Asia, despite all the abundant resources (or wealth) present in Africa, the continent has not been able to translate it to providing efficient essential services in the areas of effective and efficient electric power supply, provision of clean and affordable portable drinking water, good road and railway network connectivity, effective ports management and communications. Consequently, African countries continue to rely on exporting primary commodities

without added value and as such cannot generate enough investment capital from within thereby failing to attract the desired foreign investments (Uzonwanne 2015). It is a known fact that any economy that specializes in exporting primary products and importing manufactured goods would end up having terms of trade shifting against its economy (Sanusi 2016). It is, therefore, imperative to stress that the benefits of space services (Earth observation, satellite communication, navigation and positioning, space science and astronomy) have accrued to Africa indirectly, as a consumer of services and space-derived products provided by multi-national companies and inter-governmental agencies mostly from abroad. Regrettably, Africa currently lacks the technical know-how to participate independently in space-related activities as a service provider (AU 2015). This has become even more unappealing because the inability of a society to gain control over her environment will lead to decreased societal value system, stagnant or slow socio-economic advancement, insecurity, and poor wellbeing of the people.

To promote an integrated growth and ensure sustainable development, it will be recalled that the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa recognized the urgent need for coordinated observations of the state of the Earth in its effort to haul the World's 2 billion poorest people out of misery and restore/nurture the damaged environmental web that sustains all of its life. Following the 2002 WSSD, there is, therefore, the need 'to create a world where decisions and actions are informed by coordinated, comprehensive and sustained Earth observations' (GEO 2005a).

This paper is, therefore, aimed at examining the role of AfriGEOSS in Earth Observation (EO) mission cooperation on the continent of Africa. Its objectives include discussing the importance of earth observation programs for developing countries as well as the benefits of international cooperation efforts. The paper further discussed the challenges in the effective use of Earth Observation (EO) data to handle sustainable development challenges of African continent. In specific, the paper presents the developmental challenges of Africa in "Developmental challenges of Africa within the context of EO data availability" section. EO Data availability and the national/regional coordination initiatives in Africa aimed at strengthening and further developing infrastructure for a more coherent exploitation of Earth observation data (space and in situ), technologies and services for sustainable development in Africa is presented in "EO data availability/coordination initiatives in Africa" section. Likewise, in "Global initiative" section, the initiative of Global Earth Observation System of Systems (GEOSS) and the consequence of the overlapping, non-ownership and non-domestication nature on EO data access and effective utilization are presented. Also examined are the possible roles for AfriGEOSS in the Africa EO missions which are aimed at enhancing Africa's capacity for producing, managing and using Earth observations data and information by developing a continental coordination framework. Furthermore, the risks associated with international cooperation efforts aimed at providing EO data for Africa developments are presented. Recommendations on the way forward in the realization of the EO data coordination within the African Space Agenda (ASA) are then presented.

Developmental challenges of Africa within the context of EO data availability

No doubt, Africa is the 2nd largest continent, and also the 2nd driest (drought) continent of the world. With 1.1 billion population which is expected to reach 2 billion in 2050, the continent accounts for 15% of the total world population (Worldometeres 2016; Adducation 2016). On the average, the life expectancy is 60 years (2015) (Statista 2015; Agbaje 2014). Africa's key developmental challenges include: poverty (including high debts), food insecurity, water scarcity, disasters, environmental degradation, climate change, peace and security, and energy resources. Recognizing the critical role EO data plays in supporting Africa's development efforts in priority areas of challenge, it is clear that there is an urgent need to build awareness in exploiting African resources for sustainable development and economic transformation using space science and technology (Elwaer 2013).

Despite Africa's size and population, Africa remains the least mapped continent in the world, hence the lack of suitable EO data and difficulty of access to available ones for developmental planning. Clearly if it can't map, surely it can't be managed. Resources are squandered, all economic figures are estimates, and the unprecedented poor level of human

resources management resulted in brain drain—loss of the continent's highly educated and skilled manpower.

Development Plan solution for Africa situation will require technology and skill acquisition, natural resources management, infrastructure development, and monitoring of the environment in both time and space (Agbaje 2014). Some national, regional and international initiatives to tackle headlong the EO data availability and coordination problems in Africa are yet to yield the desired results. We must also bear in mind that true development can neither be started nor sustained by outsiders. Real development is achieved through internal activities rather than from external influences (Agbaje 2014)

The 2015 MDG's report on Africa put the overall poverty rate at 48%, and that much more work lies ahead to ensure living standards of the African people. In addition, poor implementation mechanisms and excessive reliance on development aid, undermined the economic sustainability of several MDG interventions in the continent (ECA 2015). The Report finally showed that tackling sustainability development will require rigorous development planning approaches underpinned by strengthened capacities, integrated approaches to the continent's development challenges, and access to reliable and quality data. Therefore, to achieve the SDGs by 2030, Africa must take EO data issue very serious.

EO data availability/coordination initiatives in Africa

Joint European Commission (EU) and African Union Commission (AUC) projects

The European Commission (EU) and the African Union Commission (AUC) collaborated in a succession of projects to help African countries get better access to Earth Observation data. Preparation for the Use of MSG (Meteosat Second Generation satellite) in Africa (PUMA) project (2001–2006) was the first of such initiative and was meant to provide access to satellite data for weather forecasting. It resulted in the deployment of 53 EUMET Cast stations to all African National Meteorological Services and Regional Centers to ensure operational and real-time access to relevant data and products. The project was funded by EC to the tune of €11.4 million (EUMETSAT 2016). However, very few of the stations are currently operational.

The African Monitoring of the Environment for Sustainable Development (AMESD) project (2006 to mid-2013) is the successor to PUMA with the objective to provide all African nations with the resources they need to manage their environment more effectively and ensure long-term sustainable development in the region. It received funding of €21 million from the European Commission through the European Development Fund (EUMETSAT 2016). The project suffered issues of ownership and domestication by the beneficiaries.

The next project currently being implemented is the Monitoring of Environment and Security in Africa programme (MESA) launched in 2012 and to run till 2018. It has as its main objective "to increase the information management, decision-making and planning capacity of African continental, regional and national institutions mandated for environment, climate, food security and related responsibilities by enhancing access to and exploitation of relevant Earth Observation applications in Africa''. It is also expected to be funded to the tune of €37 million by the European Union.

The Global Monitoring for Environment and Security in Africa (GMES and Africa) initiative was launched following the Maputo Declaration signed on 15 October 2006. The aim of this initiative is to strengthen and further develop infrastructure for a more coherent exploitation of Earth observation data (space and in situ), technologies and services in support of the environmental policies for sustainable development in Africa. GMES and Africa is now expected to succeed MESA as part of the series of project initiatives on EO data being funded by the EU. Full implementation under the direct supervision of the African Union Commission (AUC) is expected to commence in early 2018.

SERVIR Africa

SERVIR is the Regional Visualization and Monitoring System for environmental management and disaster response. It was initially set up to serve Latin America, it has however, extended to Eastern, Southern, and Western Africa. It started in Africa in 2008, when NASA and CATHALAC partnered with Regional Centre for Mapping of Resources for Development

(RCMRD). SERVIR integrates satellite observations and predictive models with other geographic information (sensor and field-based) to monitor and forecast ecological changes and respond to natural disasters (SERVIR 2010). It is expected to extend its operation to other regions of Africa.

Following the efforts examined above in "Joint European Commission (EU) and African Union Commission (AUC) Projects" section and "SERVIR Africa" section, the questions that would always be asked are—(1) Are the projects meeting the set targets? and (2) After 17 years of implementation what are the measurable impacts on the EO data utilization for development planning in Africa?

National space agencies

Some African countries have National Space Agencies while some are in the process of developing their own space-related capabilities and programs, and have proceeded to build institutions to manage these programs. Nigeria, South Africa, Algeria and Egypt operate satellites with Earth Observation sensors in space, launched through their respective national space agency. Many of the nations of Africa are involved in Earth observation, both as collectors and users of data. Ghana, Kenya, and Gabon have also sets up their space agencies.

African resource and environmental management satellites constellation (ARMC)

The African Resource and Environmental Management Satellite Constellation (ARMC) is a joint satellite programme between Nigeria, South Africa, Algeria, Kenya and any other interested country in Africa, laying the foundation of sustainable technology development in Africa. The project is one of the key flagship projects in the NEPAD Science and Technology Ministerial Program areas. The ARMC constellation has been described as fulfilling the need for regular high resolution data over Africa for resource management applications (Dowman and Kufoniyi 2010).

The countries involved in ARMC would collaborate in building capacity to support space programmes in Africa. Indigenous resources, most notably the existing knowledge base, could be developed to benefit the entire continent by meeting the growing resource management needs. After the signing of the Agreement of Intent, the countries involved have not been able to contribute the constellation satellites within the agreed period. Indeed only one of satellites has been launched so far. The ARMC initiative came in under the auspices of the African Leadership Conference (ALC) on Space Science and Technology for Sustainable Development. The ALC focus is to sensitize African leaders on the importance of science and space technology for the sustainable socio-economic development of Africa. It provides a regular forum for the information exchange and promotes inter-African co-operation in the development and the application of space technology (Dowman and Kufoniyi 2010).

African Union Commission (AUC): the African space agenda

Having participated in various space programmes designed and implemented by the African Union Commission (AUC) with commitment from the Member States in collaboration with EUC, and seeing the gaps, the AUC felt it is time to take the bull by the horn. As a first step forward, AUC set up of a Pan-African University (PAU) for education, training, human capacity building, and research in the areas of space science and technology (Elwaer 2013). The Commission had seen the need to harness space science and technology for socio-economic development; harmonize space programs in Africa; and establishment of a mechanism for coordination of pan-African space initiatives. In this respect, the Commission had setup a Space Secretariat to support the technical activities for all space initiatives. To cap it up the Commission has just developed an African Space Policy and Implementation Strategy, which was recently approved in February 2015.

The African Space Policy and Strategies outlines ambitious high-level goals to mobilize the continent to develop the necessary institutions and capacities to harness space technologies for socio-economic benefits that will improve the quality of lives and create wealth for Africans (AU 2015). This initiative recognizes existence of national space infrastructures and as such it will not reinvent the wheel in the process of developing a continental space programme for Africa. It is these national efforts that will collectively represent the seed that could be nurtured towards a

continental programme, without devolving the focus of the national space programmes (AU 2015).

China–Brazil earth resources satellite program (CBERS)

CBERS is a technological cooperation program between Brazil and China to develop and operates Earth Observation satellites. In all, 4 satellites have been launched starting with CBERS-1 launched in 1990; CBERS-2, CBERS-3, and CBERS-4 were launched in 2003, 2013, and 2014 respectively. CBERS data are free for download over Africa. Remarkably, this free and open dataset is quite easy to manipulate with standard image processing software packages (SANSA 2016).

Global initiative

Spatial data infrastructure (SDI)

Spatial Data Infrastructures (SDI) have been widely adopted for geospatial data discovery, accessibility, production, management, integration, and dissemination, satisfying the requirement of a multi-disciplinary geospatial framework to enable users working in different domains search through and access heterogeneous geospatial resources (Giuliani et al. 2015). SDI is an integrated data management structure in which human, legal and institutional aspects plays key role. However as observed by Giuliani et al. 2015 two common obstacles are currently preventing the implementation of such integrated approaches: (1) difficulties to find data, and (2) difficulties to integrate data.

Unlike most developed countries where manual cataloguing exists prior to the SDI trend, most African countries geospatial data (where available) are poorly documented or even worst are simply lacking metadata and difficult to access for any meaningful development planning (Agbaje et al. 2008; Giuliani et al. 2015).

The SDI effort in the Africa is led by the UN Economic Commission for Africa (UNECA) through its Committee on Development Information, Science and Technology (CODIST), which published an *'SDI Implementation Guide'* (UNECA et al. 2003). The focus is to assist stakeholders in African countries to understand the institutional and technical issues involved in SDI implementation similar to the *SDI Cookbook* published by the Global Spatial Data Infrastructure (GSDI).

Despite all the efforts put in by UNECA, only four (4) African countries have adopted officially metadata standard and made effort to develop SDI Policy: Botswana, Ethiopia, Nigeria, Senegal, and South Africa. In spite of this official adoption, access to their data and metadata through their national geo portals are almost impossible because of dead links, as the related infrastructure is not supported and/or maintained anymore (Giuliani et al. 2015). Major hindrance to the establishment of the SDI remains lack of political will/support, inadequate funding, inadequate critical mass of people with relevant skills, and poor internet connectivity.

As rightly identified by Giuliani et al. (2015) a major issue with multi-disciplinary frameworks such as the SDI is the integration of different technologies, arrangements, protocols and formats to publish its resources. The Group on Earth Observation (GEO) is implementing a multi- disciplinary interoperability within the Global Earth Observation System of Systems (GEOSS) as "Users and Data Providers are not asked to implement any specific interoperability technology but to continue using their tools and publishing their resources according to their standards -as much as possible" (Craglia et al. 2013 in Giuliani et al. 2015).

Global earth observation system of systems (GEOSS)

In response to the 2002 Johannesburg WSSD call for urgent need to a coordinated observations of the state of the Earth; the G8 Evian, France meeting of June 2003 that re-emphasizes the importance of Earth Observations; the 1st and the 2nd Earth Observation Summits (EOS) that took place in Washington (July 2003) and Tokyo (April 2004) respectively which adopts the 'Framework Document', that defines nine (9) Societal Benefit Areas (SBAs) for Earth observations (see Fig. 1), the 3rd EOS in Brussels (February 2005) adopts a 10-Year Implementation Plan for a Global Earth Observation System of Systems (GEOSS). The Group on Earth Observation (GEO) was also established by the Summit with the task to implement GEOSS (GEO 2005b). The vision of GEOSS is to realize a future wherein decisions and

Fig. 1 GEOSS—showing the 9 Societal benefit areas. *Source* (GEO 2016a)

actions for the benefit of humankind are informed by coordinated, comprehensive, and sustained Earth observations and information. Earth Observation resources world-wide across the multiple SBAs would be available for better informed decision-making. GEO objectives are mainly to improve and coordinate observation systems (thereby avoid duplications); advance broad open data policies/practices; foster increase use of EO data (Science, Applications); and building capacity.

GEOSS is expected to advance full and open exchange of data and data products (Fig. 2) at minimum time delay, free of charge or at minimal cost. GEO is a voluntary partnership of governments and organizations (currently 102 countries and the European Commission, and 103 Participating Organizations).

GEOSS is a System of Systems composed of contributed Earth Observation systems. Using a third-party layer -GEOSS Common Infrastructure (GCI), GEOSS provides access to GEOSS contributing systems—that operate independently within their own mandates. The GCI transparently interconnect GEOSS systems with GEOSS Societal Benefit Areas (SBAs) users (Giuliani et al. 2017).

Africa discovery broker (ADB)

To facilitate the discovery of heterogeneous resources across Africa, Giuliani et al. (2017) developed the Africa Discovery Broker (ADB) using the catalog service developed by ESSI-Lab in the frame of the EU/FP7 EuroGEOSS project. ADB currently have 17 repositories registered giving access to more than 32,442 resources. The Africa Discovery Broker (ADB) exposes several interfaces e.g. the OGC CSW/ISO, OpenSearch, ESRI-Geoportal, etc.) and allow various clients (e.g., QGIS) to query directly the the system without the need to use customized web applications. A key enabler to succeed in leveraging geospatial resources in Africa is to build an efficient network of stakeholders across the continent and develop an effective coordination mechanism and a robust governance structure (Giuliani et al. 2015). The ADB provides a discovery and access to the GEOSS Data Core and is brokered by GEOSS.

AfriGEOSS

AfriGEOSS is an initiative of the African community in GEO, to strengthen the link between the current GEO activities with existing EO capabilities and initiatives in Africa in order to provide the necessary framework for countries and organizations to access and leverage on-going bilateral and multilateral EO-based initiatives across Africa, thereby creating synergies and minimizing duplication for the benefit of the entire continent (GEO 2016a). This coordination initiative will facilitate the Region's participation in

Fig. 2 GEOSS open data access illustration. *Source* (GEO 2016a)

the implementation of the Global Earth Observation System of Systems (GEOSS).

AfriGEOSS is aimed at providing a coordination framework for Earth Observation (EO) data take-up (for sustainable development), and for strengthening partnerships within Africa. It is also expected to serve as the gateway into Africa for International partners and as a platform for Africa's participation in GEO (GEO 2016b).

As discussed in "EO data availability/coordination initiatives in Africa" section, over the last few decades, Africa have witnessed major initiatives, programmes, and projects, especially for environmental monitoring and security e.g. PUMA, AMESD, MESA, etc., resulting in the availability of Earth observation (EO) data, tools and products. These are however inaccessible to users where and when needed due to non-existence of a coordinated framework to make this happen thereby slowing down the expected sustainable growth. The AfriGEOSS initiative concept was endorsed by the GEO-IX Plenary in Foz do Iguacu, Brazii, (November 2012). The official launch of AfriGEOSS took place in November 2013 during the joint Africa-GIS 2013 and GSDI 2014 Global Geospatial Conference in Addis Ababa, Ethiopia. AfriGEOSS is currently made up of 27 GEO Member nations and 9 participating organizations across Africa (see Fig. 3 and Table 1).

AfriGEOSS objectives

As stated in GEO (2016b), the AfriGEOSS objectives are to:

- Coordinate and bring together relevant stakeholders, institutions and agencies across Africa working in Earth observations;
- Foster the participation of African community in GEO by linking GEO activities with existing capabilities and initiatives in Africa;
- Provide the necessary framework for African countries to initiate mutual activities within the scope of GEO;

Fig. 3 Map of AfriGEOSS member countries

- Enhance Africa's capability to access, use and manage EO for informed decision making;
- Foster creation of synergies to reduce duplication of efforts;
- Contribute to the implementation of the African Space Policy and Strategy;
- Advocate for the uptake of EO in decision making and raise awareness on benefits of Earth observations for the continent; and
- Develop a strategy of access and dissemination of Earth observation data throughout Africa;

The implementation strategies to achieve these objectives include Continental, Regional and National Coordination; User Needs assessment and Applications development; Data and Infrastructure development; Capacity Building/Development; Resource Mobilization; and Communication and Outreach programme. Overall AfriGEOSS is expected to deliver an African network of providers and users of Earth observations thereby strengthening the implementation of GEOSS.

AfriGEOSS governance structure

AfriGEOSS initiative coordination is undertaken by the GEO Secretariat, with guidance and leadership support provided by the Chair, Africa Caucus in GEO, and the AfriGEOSS Steering Committee (SC). The Steering Committee members are made up of six (6) members, with each Member State per geographical region (Northern, Western, Central, Eastern, Southern and Indian Ocean Countries (IOC) representation at GEO Principal or Alternate level.

Table 1 List of AfriGEOSS member countries and participating organizations

Member states	Participating organs
Algeria	AARSE
Burkina Faso	ARCSSTEE
Cameroon	ACMAD
Central African Republic	CRTEAN
Congo, Republic of the	EIS-Africa
Cote d'Ivoire	RCMRD
Egypt	RECTAS
Ethiopia	UNECA
Gabon	
Ghana	
Guinea	
Guinea-Bissau	
Kenya	
Madagascar	
Mali	
Mauritius	
Morocco	
Niger	
Nigeria	
Senegal	
Seychelles, Republic of	
Somalia	
South Africa	
Sudan	
Tunisia	
Uganda	
Zimbabwe	

A role for AfriGEOSS in the Africa EO missions

As discussed earlier, some leading African countries now have space infrastructures. Table 2 shows the EO satellites owned by some African countries. Coordinating these data together along with others from other regional EO data initiatives in Africa is fundamental to the realization of sustainable socio-economic turnaround of Africa.

Table 2 Africa EO satellites

Country	EO satellite	Launch year	Spatial res.
Nigeria	NigeriaSat-1	2003*	32 m
	NigeriaSat-2	2011	2.5 m, 5 m
	NigeriaSat-X	2011	22 m
Algeria	AlSat-1	2002*	32 m
	Alsat-2	2010	10 m, 2.5 m
	Alsat-2B	2016	10 m, 2.5 m
South Africa	SumbadilaSat	2009*	6.5 m

*Inactive

AfriGEOSS EO data coordination

Unlike other initiatives, AfriGEOSS is voluntary, relying on Member States commitment to develop the necessary infrastructure for the realization and enhanced capacity to access, use and manage EO data for informed decision making. The bottom–top and top–bottom approach will encourage Member States to establish national GEOSS that will link up with AfriGEOSS while benefiting from developed infrastructure at the global level.

The non-domestication of the various regional level EO projects in Africa has led to ownership gap and non-take up of such data for other applications beyond the projects' life span. Domesticating these initiatives/projects means ensuring that appropriate stakeholders especially space agencies, educational institutions, relevant agencies of government, and the private sector are involved from the conception stage to implementation. This will resolve the ownership problem; ensure knowledge incubation; and encourage partnership among African countries.

The AfriGEOSS Initiative, as a coordination initiative, is not yet expected to generate datasets. It will, however, advocate for adoption of GEO data management and data sharing principles by its Members (GEO 2016b). AfriGEOSS will build historical archive of satellite data over Africa e.g. SPOT Heritage, Landsat, CBERS, etc. and other satellites archives data from various Space Agencies in Africa (SANSA, NASRDA, ASAL, etc.). The objective is to progressively develop regional historical archives of such data together with a number of simple but robust "test cases" on their use in informing decisions in different societal benefit areas.

Several ground receiving stations already exist in Africa, but because they are not interoperable their full potential for supporting research, applications and human capital development has not been realized. To remedy this situation, AfriGEOSS can provide a coordination mechanism to promote interoperability involving interfaces, common file formats, common dissemination standards, etc. (GEO 2016b). In this respect, AfriGEOSS will engage with African Space Agencies/Institutions to contribute their datasets to the GEOSS Data Core; have their data portals brokered by the GEOSS Common Infrastructure (GCI); and to develop portal interoperable to the GCI. This will allow common access globally to Africa and would-be international partners/donors to such data for sustainable development planning.

In line with the African Space Agenda of not reinventing the wheel, the existence of GCI in GEOSS and the establishment of AfriGEOSS have provided an opportunity for the AUC through its Space Secretariat to integrate AfriGEOSS into its Space Agenda and own it. As GMES for Africa project which is expected to succeed MESA has the same Africa EO data coordination agenda, it is important that AUC integrate it into AfriGEOSS for the realization of benefits EO data for the continent. GMES for Africa can be refocused to provide coordination infrastructures and comprehensive capacity programme for Member States. This will help reduce the funding burden associated with AfriGEOSS because of its voluntary contributory nature.

Fundamental ingredients for the realization of AfriGEOSS coordination role

The realization of the coordination role of AfriGEOSS will depend on the following essential ingredients:

- Involvement of key stakeholders.
- Sensitization and awareness.
- Robust and enduring capacity building program.
- ICT infrastructure.
- Partnership.

The above fundamental ingredients are further discussed below.

Involvement of key stakeholders

There is an African proverb that says "If you want to go quickly, go alone, but If you want to go far, go together". Part of the reasons for the failure of most regional projects can be adduced to inadequate involvement of relevant stakeholders (the right expert with the necessary experience and political clout). This has led to projects not being owned by the people and invariably utilization of products from such projects is always at very low ebb. Condition for the assignment of stakeholders (experts) to regional projects by nations should be strictly with clear requirements fulfilled in terms of knowledge, status, availability, and the expected country's contribution. The stakeholders are expected to be involved from planning, design, to implementation of the project.

Sensitization and awareness

It is common knowledge that most Member countries are unaware of various EO initiatives/projects in the continent. This is mainly due to lack of enough sensitization and awareness built into the projects. Also of note is the attendance of Foreign Affairs personnel and calls for participation awareness meetings to the exclusion of key technical personnel due to gap in communication or travel fund constraint. It is, however, observed that communications amongst African governments are generally poor. These issues need to be addressed in projects implementation in Africa.

Robust and enduring capacity building programme

Projects can be owned (identified with) if understood and domesticated. To meet the 2030 SDGs, Africa need to build and strengthen their capacity to assimilate and generate knowledge for sustainable development. For optimal utilization of EO data, education and training programmes focusing on the development of open-source software and open systems, and the development of acquisition and dissemination mechanisms, are of utmost importance (GEO 2016b).

As recognized and stated by Dowman and Kufoniyi (2010) 'considering the number of persons to be trained before achieving capacity utilization, it is necessary to provide alternative solutions through educational networking of institutions in developed and African countries, i.e., through cross-border education and web based education/e-learning'. Overall, the goal should be to design a robust and enduring capacity building program that will build on the existing capacity to enable each country enhance its scientific and technical knowledge and experience in space science and technology in addressing Africa's needs.

ICT infrastructure

Poor infrastructure, particularly low internet bandwidth and lack of basic training in the use of technology equipment, are major drawbacks in the uptake of EO data utilization for development planning. Member countries must make deliberate decision to provide necessary ICT infrastructure fund for any meaningful development in Africa.

Partnership

The 8th Goal of the MDGs target is about development of global partnership for development. Similarly the 17th Goal of the succeeding SDGs is to strengthen the means of implementation and revitalize the global partnership for sustainable development. It is, therefore, important that the current partnership between AUC and EUC on EO data utilization for sustainable development should be encouraged. What we however need to see more is intra-Africa partnership in Space Science and Technology. This will allow for the development of space industries in the continent arising from space spin-offs. The ALC is working towards ensuring African countries collaborate, but need more bites. The ARMC initiative must not be allowed to die. It must be revived to rekindle hope for our up-coming scientists and engineers.

UNECA has established the African caucus of the United Nations Global Geospatial Information Management (UN-GGIM:Africa-URL18) initiative, and with ADB, AfriGEOSS will provide an overarching mechanism to coordinate geoinformation activities involving Member States and putting in place a continental framework for common regional standards, standardization and compliance in line with international policy.

Recommendations in the implementation of the Africa space agenda

1. AUC should adopt AfriGEOSS as the EO data coordination mechanism.
2. AUC should integrate the MESA successor project—GMES for Africa into AfriGEOSS.
3. Towards achieving the 17th Goal of SDGs, AUC should encourage intra-Africa (Member States) and other international collaboration in Space Science and Technology using the ALC platform with support from UNECA.
4. In line with recommendation (3) above, AUC should facilitate the realization of ARMC initiative.
5. AUC should popularize and pursue vigorously a Road Map for EO data utilization within the African Space Agenda in tandem with the needs of the society.
6. AUC should design a robust and enduring capacity building (at human, institutional, and infrastructure levels) program that will build on the existing capacity to develop skills about interoperability, standardization, metadata and data publication, data management, governance, fostering collaboration and cooperation.

Conclusion

AfriGEOSS using the already built GEOSS GCI developed through the collective effort of experts from over 102 member countries using best practice will allow for the coordination amongst various programs, projects and activities across the continent to reduce duplication of effort and address gaps in EO data, tools and capabilities.

The main risk which has always been identified with GEOSS initiative development is related to its voluntary nature. Most often there is paucity of voluntary commitments and where they are made, their realization are always at risk. However, integrating GMES and Africa project and AfriGEOSS will help resolve two vital ingredients for the realization of EO data uptake/utilization for informed decision making at it relates to development planning. These are to support provision of infrastructural equipment for data dissemination, and capacity building programme funding. A society that fails to invest in the future may have no future at all. The need for resource information and mapping using EO data and products in the developing world, particularly in Africa is enormous.

There is need to raise awareness on the central role of space science and technology in Africa's socio-economic development. The draft African Space Policy (AU 2015) is aimed at mobilizing the continent in developing necessary institutions and capacities to harness space technologies for socio-economic benefits that will improve the quality of lives and create wealth for Africans.

Proliferation of databases not tied to national and regional GEOSS efforts will result in limited access to EO data for sustainable development planning. For future development, it is pertinent to commit to the development and growth of information economy, which is presently being driven by space technology. Government need to give greater priority to the development and transfer of knowledge and skills through capacity building, joint participation, knowledge sharing, and bilateral and international cooperation.

AfriGEOSS with the sustaining African Space Policy (ASP), if properly implemented in the continent, will facilitate a rapid improvement of the economy of Africa, including an efficient management of her natural resources, environment, and security. Using indigenous experts, building on existing human capacity, collaborating with relevant experts abroad to develop the infrastructure, and adequate funding will ensure the sustainability of the ASP.

Compliance with ethical standards

Ethical approval This research involves human participants.

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