Review of Remote Sensing Needs and Applications in Africa: Executive Summary

16 July 07

Prepared by:
James Rowland[1], Eric Wood[1], Larry L. Tieszen[2]

Contributors:
Kate Lance[3], Erick Khamala[4], Blessing Siwela[5], Alkhalil Adoum[6], Molly Brown[7]

[1] SAIC, contractor to USGS Center for Earth Resources Observation and Science (EROS), Sioux Falls, SD
Work performed under USGS contract 03CRCN0001.
[2] USGS EROS, Sioux Falls, SD
[3] Editor, Spatial Data Infrastructure (SDI)-Africa Newsletter
[4] Regional Centre for Mapping of Resources for Development (RCMRD), Nairobi, Kenya
[5] SADC Regional Remote Sensing Unit (RRSU), Gaborone, Botswana
[6] USGS FEWS NET, AGRHYMET Regional Center, Niamey, Niger
[7] SSAI, contractor to NASA Goddard Space Flight Center, Greenbelt, MD

Executive Summary

Background and Objective

The U.S. Agency for International Development (USAID) requested the U.S. Geological Survey (USGS) Center for Earth Resources Observation and Science (EROS) to conduct a review of current and potential capabilities at regional remote sensing centers in Africa to use remote sensing (RS) applications for societal benefit. In addition, USAID requested an evaluation of the utility and appropriateness of a Web-based data, information, and decision support system (DSS) portal, such as the SERVIR model, for Africa. The SERVIR model is currently implemented for Mesoamerica.

The primary objective of this activity is:

> **to recommend to USAID a feasible and most appropriate approach to support sustainable RS applications at African Regional Remote Sensing Centers.**

We use "RS applications" to refer to the acquisition, maintenance and archiving, dissemination and distribution, and analysis and interpretation of remote sensing data, as well as the integration of interpreted data with other spatial data and models, to address various needs. Our objective, oriented toward sustainability, includes training in all aspects of RS applications. In addition, we limit most of our discussion to sub-Saharan Africa, i.e., "Africa" refers specifically to sub-Saharan Africa. There are many continental, regional, and national institutions, organizations, initiatives, and networks in Africa involved in geospatial data and information analysis and distribution; an evaluation of all such geospatial data activities was beyond the scope of this study. However, because of our historical and current collaboration with three regional RS centers in Africa (the AGRHYMET Regional Center [ARC] in Niamey, Niger; the Regional Centre for Mapping of Resources for Development [RCMRD] in Nairobi, Kenya; and the Southern African Development Community [SADC] Regional Remote Sensing Unit [RRSU] in Gaborone, Botswana), we concentrated on reviewing the current remote sensing needs and applications at those centers. Visiting scientists from RCMRD and RRSU worked with the evaluation team onsite at EROS. ARC staff provided valuable input to this report as well. This report addresses the needs of the Regional Centers (RCs) and their constituent partners for hardware, software, Internet connections and information technology (IT), database management, RS data, and training in RS applications. Note that variable levels of RS applications at each of the RCs results from different mandates, varied funding mechanisms, and significantly different sizes of the three centers. For example, a large part of AGRHYMET's activity supports training in the domain of hydro-meteorology, water management, and vegetation protection, whereas RCMRD promotes all aspects of development and use of geo-information in sustainable development, and RRSU primarily supports food security issues.

Regional Centers

The AGRHYMET Regional Center, created in 1974, is a specialized institute of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS), with particular specialization in science and techniques applied to agricultural development, rural development, and natural resource management. It is an interstate public institute, and has legal status, financial autonomy, and an international status. The ARC has two primary objectives:

- To contribute to achieving food security and increased agricultural production in the CILSS member States
- To improve natural resource management in the Sahelian region by providing *training* and *information* to development stakeholders and partners in agroecology taken as a whole (including agroclimatology, hydrology, and crop protection)

The Regional Centre for Mapping of Resources for Development, established in 1975 under the auspices of the United Nations Economic Commission for Africa and the Organization of African Unity (now the African Union), is an intergovernmental organization with 15 member States from eastern and southern Africa. The operations of the Centre are funded in part by contributions from contracting member States and revenue generated from sales of its products and services. The mission of the Centre is *"To Promote the Development and Use of Geo-information in Sustainable Development of Africa."* The Centre has two primary objectives:

- To develop and constantly update harmonized and standardized digital databases and information on land resources for the region, based on demand
- To develop a regional early warning system for food security, environmental monitoring, and disaster management using mainly satellite technology

The Regional Remote Sensing Unit operates under the Agriculture Information Management System (AIMS) as part of the Food, Agriculture and Natural Resources (FANR) Directorate, based at the SADC Secretariat. RRSU started its operations as a project in June 1988 (funded by the Government of Japan) with technical assistance from the UN Food and Agriculture Organization (FAO). After 1992, operational activities continued with support from the FAO Technical Cooperation Programme. The main development agenda for AIMS is to provide planners and policy-makers easy access to information necessary for revitalizing agricultural and natural resources growth, enhancing food security, and promoting rural development. RRSU facilitates training programs and technical support to member States in RS, geographic information systems (GIS), and agrometeorology in support of food security early warning, natural resources management, disaster management, and environmental change monitoring.

This report also reviews several activities for each of the regional centers.

- Collaboration with the Famine Early Warning Systems Network (FEWS NET), USGS EROS, and other national, regional, and international institutions
- Existing remote sensing projects and data
- Existing capacity of RS applications, including hardware, software, Internet connection, and data dissemination
- Current and historical funding and donor support
- Requirements for RS data/products, information and communication technology (ICT)/infrastructure, hardware and software (for reception, processing, and management of RS databases), and training in RS applications

Questionnaire

Although we limited our in-depth analysis to three RCs, we also solicited and received input from various African institutions through field visits, email contacts, and questionnaire responses. A one-page questionnaire was distributed via the RCs; an online version of the same was disseminated via the Environmental Information Systems (EIS)-Africa website and the Global Spatial Data Infrastructure (GSDI)-Africa newsletter. This report also benefited from input from USGS FEWS NET regional scientists hosted at the RCs (in particular, Tamuka Magadzire at RRSU) and from staff at many institutions in Africa (Consultative Group on International Agricultural Research [CGIAR] centers throughout Africa, the Satellite Applications Center [SAC] in Pretoria, South Africa, and others), which allowed us to capture the most appropriate and up-to-date information on the status of RS activities and needs in African institutions.

The objective of the questionnaire was to assess existing remote sensing capacity, capability, potential, and challenges in Africa. General feedback via the online questionnaire elucidated the following points regarding usage of, and need for, RS data:

- Nearly all of the respondents use RS data in their work (93%) or feel that access to it would assist in their work (98%).
- Most respondents had access to Landsat (88%), but fewer than half had access to Moderate Resolution Imaging Spectroradiometer (MODIS), Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), or high-resolution commercial satellite data such as IKONOS or QuickBird (46%, 41%, and 46%, respectively).
- Of those without access, the majority felt the need to access those data (Landsat, 66%; MODIS, 47%; ASTER, 60%; high-resolution imagery, 79%).

Most RS data were accessed via 1) free download from the Internet, 2) participation in specific projects, or 3) direct purchase. Free Internet downloads came from a handful of well-known sources: USGS EROS, NASA, and Global Land Cover Facility (GLCF, University of Maryland). Offline distribution of free data from the RCs was also common, including distribution of the GeoCover Landsat dataset, a very successful program made feasible through collaboration with USGS and USAID (the RCs have distributed, and continue to distribute, the GeoCover Landsat dataset to many interested institutions in each of the regions concerned). Purchase of data was from both original source providers and a variety of redistributors, and was more prominent in the acquisition of high-resolution data, because free sources of these data do not yet exist.

Over two-thirds of the respondents had problems accessing RS data (70%), with 73% agreeing that high-speed Internet would improve that access. Significant constraints to accessing RS data include cost (85%) and available software (48%). From a wide range of suggestions for improving data access in Africa, several stood out, namely, high-speed Internet access, improved ICT infrastructure, reduced cost (imagery, software, hardware, and training), and better delivery systems (e.g., national or regional portals or clearinghouses). Primary uses of RS data include land use/land cover change (81%), environmental monitoring (58%), quantifying deforestation (44%), and biodiversity (42%).

Assessments of African Capacity and Needs

The application of RS technology in Africa is a complicated, and complex, issue. The area of Africa is large (24.2 M km^2 in sub-Saharan Africa alone, more than three times the size of the conterminous United States), with sparse and/or degraded ground-based earth science data available. Access to data (especially RS data) is limited by cost and file size. Although some regional organizations (e.g., New Partnership for Africa's Development [NEPAD], African Association of Remote Sensing of the Environment [AARSE]) realize, accept, and embrace, the utility of (and need for) RS applications, national governments in Africa have generally not supported RS applications. Nevertheless, the AARSE conference declaration (November 2006) states that the geo-information community in Africa should

- "engage actively at all levels of GEO activities and…initiate programmes within their national and regional development plans in support of integrated and coordinated Earth Observations (EO)."
- "encourage national and regional centres for geo-informatics…to actively engage in EO monitoring for human security and stability…."
- "strengthen and harmonize human resource development…in the fields of EO and GI [Geographic Information] Sciences…."
- "strengthen coordination between different initiatives in Earth Observations and geospatial information to strengthen the impact of each initiative and the overall impact." (http://agirn.org/?id=19, accessed July 10, 2007).

However, bandwidth limitations restrict data available via the Internet (even when available for free download), the costs of common RS and image processing software are prohibitively expensive for many African institutions, and RS programs at universities are few (and often not strong). There is a lack of appropriate skill sets to analyze and interpret RS data, in general, and a lack of a certain threshold of RS skills to maintain local and regional collegial interactions, in particular. Until recently (before the proliferation of wireless communication and cell phones in Africa), communication was very limited, and subsequently regional coordination of RS activities was limited. Nevertheless, specifically because of the historical lack of communication, and the paucity and degradation of ground-based observations and data, there is increased need for developing, maintaining, and supporting RS applications in Africa.

The use of satellite-based data and information in Africa to support development has been recognized as a key aspect to ensure both that funds used to invest in development in Africa are used wisely and that development is sustainable over the long term. Three major (external-to-Africa) programs that are working to increase the use of satellite RS data and information in Africa, and to improve the transition of research to application, include: NOAA's Office of Global Programs, NASA's Applied Sciences program, and the Global Monitoring for Environment and Security program (GMES, funded by the European Space Agency [ESA] and the European Commission [EC]). These programs may, in the long term, greatly increase the demand for climate and/or RS data in African countries, making centers that provide satellite RS and other kinds of climate data and analysis much more viable than they currently may be. However, an enormous investment in capabilities, focused products, and operational delivery in a format usable by the decision maker must occur before such data products can be used. Additional details are provided on each of these programs.

Remote sensing is a relatively young and evolving technology sector in Africa. However, information about African usage of geospatial technologies is lacking. A global analysis forecasted that the total GIS/geospatial core-business revenue for 2006 would grow by 10% in one year for North America as well as for the rest of the world (Daratech, 2006). Presumably, this estimate holds for Africa. Anecdotal information does support this trend. A NOAA-sponsored global remote sensing survey conducted in 2005 reported that 8% of the 1,547 responses were from Africa (Global Marketing Insights, Inc., 2005), signifying an active and enthusiastic community. The responses from African representatives, grouped as government, academic, or commercial, confirmed that the African market is growing rapidly, and each group anticipated a marked increase in investment in remote sensing technologies. Despite this growth, the African market remains poorly analyzed. The continent is usually "lumped" into the "other" or "rest of the world" category when figures, such as market share for commercial satellite image sales, are reported. South Africa, for instance, just makes the grade with 0.2% of global sales (Fortescue and Ntisana, 2005). Although South Africa is not representative of the continent, it is noteworthy that the country currently is experiencing unprecedented growth in image sales, with a total growth of over 150% for the period 2004–2005; medium and (particularly) high-resolution imagery is the main contributor to the satellite image growth (Fortescue and Ntisana, 2005).

The report provides additional information on African capacity and needs with an overview of organizations/principal users, initiatives/programs, investments, services, and capacity building in the RS sector, with an emphasis on the structural and organizational dimension of the geospatial sector. The findings are based on expert knowledge and on market surveys, conference and workshop reports, project reports, and newspaper articles found on the Web, and are presented as a broad overview. Topics discussed and presented include:

- remote sensing activity and capacity
- geospatial technical authorities/specialists
- initiatives and investments
- existing geospatial services
- training and capacity building
- existing or potential market drivers
- inventory of previously conducted surveys and related data collection/reports
- feedback on questionnaires on supporting RS needs in Africa

Sustainability of Remote Sensing Applications (at Regional Centers)

Sustainability is too often an afterthought rather than a guiding principle for the design and implementation of an information system or RS facility. Building a solid (sustainable) base for continental, or regional, RS applications in Africa revolves around the following elements: a) design and adaptation, b) user and policy orientation, c) education and training, d) outreach and communication, e) monitoring and evaluation, and f) funding.

To address the long-standing problem of sustainability, it would be constructive to take a hard look at past *failures*, bearing in mind that failure, used here, is relative. Several RS and/or geospatial information system projects, for instance, had a marked impact at the time; however, for one reason or another, the actual information systems (as designed) did not necessarily withstand the test of time. The inclination is to not take a hard (or hard enough) look at implementation failures. We tend to highlight successes to promote geospatial technologies; geospatial project reports tend to be glowing, and critical analyses of inadequate design, management, and communication are left by the wayside.

Sustainable RS applications and data dissemination activities need to be well-defined, well-directed, and not necessarily all-encompassing. For example, one of the factors that contribute to the success of FEWS NET operations is its focus on famine, early warning, and food security. FEWS NET does not venture into all types of disasters and emergencies, nor does it try to service too broad of a user community. If RS applications are meant, in a sense, to be generic, serving all, they face the challenge of not having a specific user community. Information products and services may not be adequately tailored to specific management concerns, and the user base could be limited.

In order to engender increased use of RS applications, one must have an understanding of what kinds of products and services are constructive. In the political arena, much more could be done to identify products that address policy and national concerns. The geospatial community has not been particularly effective in this area. A pertinent question is how policy-makers might use geo-information and spatial research in their setting? Too often, there is the "rationalist" assumption that "better information will lead to better decisions," as if the relationship between high quality geo-information and public policy is unproblematic, linear, and direct. In fact, the relationship at most is indirect, even ad hoc.

Another area that requires more understanding is how the media (newspapers, radio, television), as well as local non-governmental organizations (NGOs) and civil society organizations, might use geo-information and spatial research in their settings. To truly have wide user bases, which is an important element of sustainability, RS facilities must reach beyond technical communities. A concerted effort may be necessary to 'translate' raw data (and terminology) into appropriate information products. The overall RS infrastructure communication work plan must consider non-technology-specialist communities.

To properly address the capacity building element of sustainability, a strategic overview of ongoing training activities needs to be conducted. Capacity building is not something that one entity alone can take on successfully; rather, it is the combined contributions of organizations across the geospatial sector. Regional centers have been a mainstay for training and capacity building, but in the interest of sustainability, national universities could play a much greater role than they have in the past. Universities have a national mandate for education and research. Given that much of the RS activity in Africa is conducted by organizations in capital cities, and that capital cities usually have national universities, if more training opportunities were offered through universities, it could cut down the overall expense for training for potential candidates.

To stimulate market growth and sustain a regional RS information system, emphasis must be directed at 'freeing up' data from organizations, particularly from the public sector, which is the largest employer of 'geospatial labor' and holds most of the available geospatial data. A broad and continually growing set of usable geographic data must be available, which is the primary goal of spatial data infrastructure (SDI). A key component of SDI is a geo-service registry so that existing services can be catalogued.

Finally, the funding element of sustainability deserves (potentially the most) attention. Without funding, it is almost certain that RS applications will not be sustained. While many different business models need to be explored, ultimately, investment in RS infrastructure must come from African governments. Unfortunately, the dominance of donor funding for RS activities in Africa has, in some cases, created dependence upon continued donor support, instead of reliance upon government agencies. Government agencies need to recognize the utility and importance of RS applications for their national programs and interests, and they need to invest in and support the integration of interpreted RS data with other spatial data and models to address various needs. If RS and geospatial technologies are valued as a tool by government, then the value should translate into resources being expended on RS infrastructure. Funds could be used for strengthening RS education in African universities, funding key dataset production or imagery acquisition, coordinating and reducing the overlap of national and regional RS activities, or directly supporting RS research and applications.

Many equate sustainability with having a viable business model, and certainly the business model is critical, but the other elements mentioned require as much thought, and all these elements, from the onset, should receive as much attention and resources as those invested in the development of data products and services. To focus on the sustainability elements, a regional RS applications facility (or program) requires considerable pre-"design" analysis, and once under way, the facility should have a detailed education and training plan, outreach and communications plan, monitoring and evaluation plan, and a business plan, all with staff dedicated (full-time) to working on these elements.

Geospatial Portals, SERVIR-Mesoamerica, and "SERVIR-Africa"

We also present an evaluation of the Mesoamerican SERVIR portal, particularly with respect to its potential as a model for Africa, and the utility and appropriateness of implementing a SERVIR-like portal for Africa. We collaborated with NASA and Centro del Agua del Trópico Húmedo para América Latina y el Caribe (CATHALAC) staff responsible for the initiation, development, and implementation of the SERVIR portal for Mesoamerica. The review of SERVIR generally emphasizes the initiative as a whole rather than the functionality or offerings of any one component. SERVIR-Mesoamerica appears to serve a useful purpose as a one-stop data, information, and DSS portal for the region, and Africa regions could benefit greatly from similar one-stop (geo)data portals. However, Mesoamerica and Africa have many significant differences in current (data/RS) conditions and in implementation needs. Thus, to speak of "SERVIR-Africa" as a replication of SERVIR-Mesoamerica in Africa (either in content, or as an approach to development and implementation of such a portal) does not appropriately serve the objective of increased RS data utility and applications through one-stop data portals. Nevertheless, NASA has much to bring to a collaborative effort in supporting (further) development and implementation of such data portals. We think it would be useful to engage NASA and other agencies in a concerted effort to support development of RS and spatial modeling in Africa.

Some specific concerns regarding a SERVIR-like model for Africa are listed here:

- Africa regions already have existing regional centers with regional mandates (although very different in each region) and are currently involved in disseminating data and information to their clients and partners via websites (http://www.rcmrd.org, http://www.agrhymet.ne/eng/, http://www.sadc.int/) as well as through storage devices such as CDs, DVDs, and external drives. Recall that the only really effective distribution of the NASA-funded GeoCover Landsat dataset was achieved through direct involvement between EROS and the RCs. The RCs have redistributed the GeoCover Landsat dataset, as well as 90-m Shuttle Radar Topography Mission (SRTM) digital elevation models (DEMs) (in some cases) and MODIS and ASTER data as a result of this direct involvement.
- Africa regions are already onboard with in-house datasets and links to partners providing data, such as GeoNetwork (by FAO, World Food Programme [WFP], and United Nations Environment Programme [UNEP]), which is a metadata (and potentially a data) distribution system built upon USGS EROS' Environmental Monitoring and Information System (EMIS) clearinghouse development. See examples of Regional Center GeoNetwork nodes (and/or metadata/data servers) at http://41.206.33.118/geonetwork/srv/en/main.home and http://www.sadc.int/fanr/aims/index.php.

- Much data and information already exist (for Africa) for environmental monitoring, disaster management, weather monitoring, food security monitoring, and more, available via dissemination portals. For examples, see the USGS FEWS NET website (Africa Data Dissemination Service [ADDS]) at https://earlywarning.usgs.gov/adds, the FEWS NET website at https://www.fews.net (e.g., the Executive Overview Brief at http://www.fews.net/execbrief/?pageID=eobDoc&g=1001216), the NOAA FEWS NET weather briefing website at http://www.cpc.ncep.noaa.gov/products/fews/africa/briefing.html, and the USDA websites at http://www.pecad.fas.usda.gov/glam.cfm (USDA GLAM [Global Agriculture Monitoring]) and http://www.pecad.fas.usda.gov/cropexplorer (USDA Crop Explorer). All these Web portals disseminate data or information of Africa, for use in Africa. In addition, the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) and GEONETCast will disseminate data and information of Africa to Africa (some of it originating in Africa). [GEONETCast is a system for distribution of environmental satellite and in situ data and products of the Global Earth Observation System of Systems (GEOSS).]
- ICT (information and telecommunications technology) limitations (and variations) in Africa (and within regions) need to be recognized. Bandwidth to Africa and within Africa is a major constraint to RS data distribution and needs to be enhanced.
- Current RC websites should be the focal nodes through which all other data portals are accessed.
- Following are further questions, differences, and comments regarding SERVIR, or data portals, in Africa:
    - What strengths does the SERVIR model have over the GeoNetwork model (already widely launched in Africa by FAO, including at the RCs and CGIARs)? It appears that, for data portals at RCs in Africa, it is rather a question of strengthening existing portals.
    - Resources required to support a continent the size of Africa, or even (the large) regions of Africa, will be significantly greater than those required to support the same in Mesoamerica.
    - ICT policies and infrastructure (levels) vary greatly across Africa. For example, most countries in Africa have yet to come up with ICT policies that ministries can leverage as the anchor to full participation in the development and maintenance of a Web-based (or SERVIR-like) portal. Moreover, Local Area Networks (LAN) and Wide Area Networks (WAN) are deficient in Africa, with a large number of government ministries having none at all. Lack of such basic infrastructure would limit data and information sharing through the portal.
    - Levels of government buy-in within Africa, and within regions, vary greatly.
    - Levels of regional and institutional network functionality vary greatly in Africa (e.g., CILSS in West Africa; SADC and the Drought Monitoring Centre [DMC] in southern Africa; RCMRD and the Intergovernmental Authority on Development [IGAD] Climate Prediction and Applications Centre [ICPAC] in East Africa).
    - There exists a great diversity of cultures (language, religion, etc) within Africa, and within each region.
    - Currently, government ministries, institutions, and departments (e.g., Meteorological Departments) may sell their data to generate income for institutional sustainability. It may be easier for a Web-based data portal to be redesigned alongside this income generation strategy by the ministries than to expect ministries to offer free data through a centralized (or distributed) portal.

- Current bandwidth available throughout Africa (even at the regional centers) does not support a 3-D visualization type of application. Decision makers should be convinced of the utility of RS applications and (geo)data portals by presenting to them very real, useful, implementable (with current technology and resources) realizations of RS applications, with possibly <u>some</u> future-looking application so that they realize the potential and future directions to be pursued (with their support).

Thus, "one-stop geospatial data and information portals" should be further developed in, and for, each of the major regions of sub-Saharan Africa, and should include, in particular, portals developed in conjunction with the three regional centers discussed in this report, namely, the ARC in Niamey (Niger), the RCMRD in Nairobi (Kenya), and the SADC RRSU in Gaborone (Botswana). However, we also feel that, if resources are limited, or such models should be prototyped beforehand, that efforts should be applied to supporting the development of a "one-stop geospatial data and information portal" at the RCMRD in Nairobi, Kenya.

Also related to regional data portals in Africa is the great need (and potential) for SADC regional support from South Africa. The implementation of such support is "sensitive", because South Africa has many skills and much expertise to apply within the region (with respect to RS applications). However, because other SADC countries need to feel ownership of projects and results (which is common throughout Africa), and because of cultural differences in the region, South Africa's role has been greatly diminished, or noneffective (although this is improving). Both "sides" are aware of the sensitive nature of this imbalance and the need to rectify it. A one-stop portal in southern Africa could provide the impetus for increased cooperation and collaboration in the region.

Finally, we should also consider a greater involvement of, and reliance upon, the CGIAR consortium; their network could provide Internet 2 connections at key locations around the world.

<u>Recommendations</u>

Finally, we present nine major recommendations for increasing, improving, and/or achieving the “sustainability of RS applications in Africa.” These nine recommendations are crucial to the goal of realizing sustainable RS applications in Africa, and are listed in order of priority. Some of the recommendations involve support for the RCs (AGRHYMET, RCMRD, and/or RRSU); other recommendations involve support for universities. The bullets under each major recommendation provide details on suggested actions to attain each goal.

1) Secure (or nurture) government buy-in so that African governments provide national budgets for geo-information

- Develop products and conduct workshops to convince decision makers or policymakers of the importance, relevance, and appropriateness of using RS technology for specified applications
    - Expand the role that EROS has played in the development and implementation of workshops conducted jointly with the RCs
    - Specialize theme and content of workshops for each region as appropriate
- Develop products and workshops targeting specific applications (e.g., the RCMRD joint workshop with UNEP/Nairobi to support national-scale UNEP State of the Environment Reports)

  - Expand the role that EROS has played in supporting RCs to define specific applications, develop training material and datasets, and conduct workshops
  - Expand FEWS NET training on use of RS products for monitoring the growing season for early warning of food insecurity or vulnerable situations
  - Conduct information workshops on emergency response and the International Charter “Space and Major Disasters”
- Support participation in conferences such as CODI-V (Committee on development Information) and Geo-CODI, which address Africa-wide development (and subsequently support) of National Spatial Data Infrastructure (NSDI)

2) Institutionalize capacity building to support proficiency in the development of RS applications and awareness of new applications

- Support projects that result in building hands-on RS capacity in government institutions (via collaboration among RCs, U.S. institutions, and national governments) based upon competitive proposals to USAID
  - Fund competitive proposals from RCs, regional institutions, and/or government institutions which apply RS technology for societal benefit (in collaboration with USGS and NASA, as appropriate)
  - Support national collaborators in significant research and development (R&D) projects (e.g., NASA and the Southern Africa Fire Network [SAFNet], NASA/UMD/USDA/WRI/etc and CARPE [Central African Regional Program for the Environment]). [UMD is University of Maryland; WRI is World Resources Institute.]
- Support refresher courses, or specific application courses, via RCs, universities, and partners (e.g., USGS EROS, International Institute for Geo-Information Science and Earth Observation [ITC])
- Support training on the International Charter “Space and Major Disasters” for emergency and disaster response.
- Support RCs in conducting in-country training workshops for member States (as opposed to training at RCs), which is more cost-effective and provides benefit from training more nationals (as opposed to bringing one or two nationals to the RCs for training)
- Support exchange between universities in the region and RCs (e.g., for hands-on applications via internships)
  - Implement for other universities in the region, as it has already been implemented in some cases with universities in the same city (Nairobi universities with RCMRD, Niamey university with ARC)
- Explore/support distance learning and video conferencing
  - Support video conferencing capacity for RCs and country partners
    - Provide capacity for RCs and partners to access training opportunities in the United States (USGS EROS, universities)
    - Provide capacity for country partners to access training at RCs

3) Improve data availability, access, and distribution by inexpensive or no-cost data

- Provide no-cost data (from U.S. institutions)
  - (USGS) provide mid-decadal Landsat data (to extend GeoCover Landsat coverage for c.2005) and MODIS products (e.g., normalized difference vegetation index [NDVI] processed by FEWS NET)
  - (NASA) provide ASTER data and MODIS products (e.g., real-time fire incidence, fire scar, land cover, red tide, as appropriate for the region)

- (NOAA) provide climate data (e.g., 7-day Global Forecast System (GFS) data, daily rainfall estimates processed by FEWS NET)
- Develop database management capacity and capability at RCs
  - See recommendation 7 ("Improve Infrastructure…" – 3rd bullet)

4) Expand and extend data and information portals

- (RCs) finalize data and information needs for their respective regions (based on this report and previous surveys and analyses)
- Support the RCs to convene meetings with key partners (e.g., USGS EROS, FAO [GeoNetwork], NASA [SERVIR, etc.], ESA [Global Monitoring for Food Security (GMFS), GeoNetcast]) to define Web portal implementation (including roles of each institution)
- Support the technical implementation of regional data and information portals, i.e., address minimum hardware, software, and bandwidth needs
- Develop Web portal user interface and structure
- Populate Web portal with regionally relevant data and information (and maintain updated data and information)
  - Use existing regional data and information
  - Develop regional and national baseline datasets
  - Develop additional international and regional datasets to feed the RCs' websites
- Emphasize decision support system information
  - Use existing (food security) products, such as the following FEWS NET products: Executive Overview Briefs, regional bulletins, weekly weather hazards assessments, Food Security Outlooks, etc.
  - Develop specific regional and national DSS products (using locally implemented tools such as the FEWS NET GeoWRSI [geospatial water requirements satisfaction index], the NOAA Climate Prediction Center (CPC) rainfall estimation algorithm, and the USGS improved rainfall estimation and Climate Outlook Forum forecast interpretation tool)
  - Maintain, or develop, involvement in Africa-wide and regional newsletters, such as SDI-Africa
- Build capacity at the RCs in the development and maintenance of the portals' data and information.
- Support awareness creation and capacity building in the RCs member States in the use and maintenance (including updating) of the regional portals.
- Develop (or link to) introductory and Web-based resources on use of RS for different applications.
- Support website promotion and publicity via workshops in major forums in Africa (e.g., CODI, AfricaGIS 07, AARSE 08)

5) Develop or enhance RS capacity and RS curricula at universities and other tertiary institutions in Africa

- Establish agreements with software vendors for the provision and maintenance of GIS, RS, and image processing software for universities
- Increase access to e-libraries
- Strengthen R&D at African universities, based on USAID priorities
  - Support scholarship programs for postgraduate students for studies at African universities (e.g., at RS programs in Africa)

    - Support U.S.-based scientists on sabbatical to African universities (e.g., one to three months)
- Explore/support distance learning
    - Support establishment of video conferencing capacity for African universities (with collaborating U.S. universities)
- Strengthen collaborations with outside institutions (e.g., with other universities, RCs, USGS EROS, NASA, ITC)

6) Improve access to regional and international RS communities
- Support participation in regional and international meetings (RCs and universities)
- Support participation and membership in professional organizations
- Maintain, or develop, involvement in CEOS (Committee on Earth Observation Satellites), as appropriate

7) Improve infrastructure for data access, analyses, and distribution, including information technology, hardware, software
- Establish agreements with software vendors for the provision and maintenance of RS and image processing software
- Support increased bandwidth (e.g., paying for more service, installation of VSAT (very small aperture terminal) capacity, support efforts for trunk line [Internet 2])
- Improve servers and storage capacity (purchase, maintenance, and systems and data administration capacity)

8) Strengthen regional coordination
- Strengthen and encourage collaboration between RCs and regional institutions (through better linkages to universities, institutions, and partners in the region) so that RCs are informed on all RS applications and needs in the regions
    - Strengthen capacity at RCs to maintain knowledge and understanding of current and potential RS applications at all institutions in their respective regions, in order to coordinate appropriate workshops or training to share RS knowledge and applications, and meet training needs
- Strengthen and encourage collaboration among RCs; formalize network among RCs in Africa
- Support workshops in major forums in Africa (e.g., CODI, AfricaGIS 07, AARSE 08)

9) Plan for future activities
- Implement monitoring and evaluation of RS programs and applications
- Conduct further evaluation on
    - RS business models
    - Sustainability
    - Role of other regional institutions, associations, partnerships (CGIARs, UNEP, EIS-Africa, NEPAD, and others)
- Develop an implementation plan with 5- to 10-year goals and milestones.

Acknowledgements

We would like to acknowledge a number of people, in particular, for their contributions to this document which include provision of content, data collection, editorial review, document preparation, and other support (see Appendix 1). Of great benefit were our lengthy discussions with staff from various African institutions, without whose input many of the recommendations in this document would have been overlooked. We would also like to acknowledge and thank all individuals who responded to our request to provide input and information via the hardcopy and online versions of the "Questionnaire supporting remote sensing needs in Africa."

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Appendix 1 – Acknowledgements

CSIR - Meraka Institute (Council of Scientific and Industrial Research - African Advanced Institute for Information & Communication Technology), Pretoria, South Africa
Philip Frost
Andrew Terhorst
Dechlan Pillay

ARC – ISCW (Agricultural Research Council – Institute for Soil, Climate and Water), Pretoria, South Africa)
Talita Germishuyse
Dirk Craigie
Harold Weepener
Dawi van Zyl

EIS-Africa (Pretoria, SA)
Sives Govender

SAC (Satellite Applications Center), Pretoria, South Africa)
Corne Eloff, Manager
Helmut Neumann
Wolfgang Luck
French fellow

SADC RRSU (Southern African Development Community Regional Remote Sensing Unit), Gaborone, Botswana
Kennedy Masamvu, Director
Blessing Siwela
Tamuka Magadzire
Elijah Mukhala (now with WFP Sudan, not with RRSU)

Ministry of Agriculture – Cartography, GIS and Remote Sensing Section, Division of Land Utilisation, Gaborone, Botswana
Leonard Matlhodi
Basuti Mathangwane
Tshwenyego Malesela

Department of Meteorological Services, Gaborone, Botswana
George O Keotsene
Penny Lesolle
Isaac Kusque
Donald Dambe

Botswana College of Agriculture – Agricultural Engineering and Land Planning Department, Gaborone, Botswana
Rejoice Tsheko
Mataba Tapela
Nnyalauzi Batisano

University of Botswana, Gaborone, Botswana
Budzanini Tacheba
O. Areola
Musisi Nkoimbrue
Reuben deBego
Akintayo Adedoyin
Opha P. Dube

National Working Group on Space Science and Technology (at South African Astronomical Observatory [SAAO]), Cape Town, South Africa
Peter Martinez
Helena Bosman (collaborating from SunSpace)

Sunspace, Stellenbosch, South Africa
Sia Mostert, Director
Helena Bosman

Additional Interviews/Discussion
Gray Tappan, USGS EROS, Sioux Falls, SD
Wilber Ottichilo, RCMRD, Nairobi, Kenya
Dan Irwin, NASA Marshall Space Flight Center, Huntsville, AL