Review of Remote Sensing Needs and Applications in Africa

29 Jun 2007

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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 undertake 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 a 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), as well as the needs of 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 uses a multi-sectoral approach to geo-information and sustainable development, and RRSU supports primarily 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 with a

legal status, financial autonomy, and an international status. Primary objectives of the ARC are:

- 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 (agroclimatology, hydrology, 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 primary objectives of the Centre are:

- 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, GIS, and agrometeorology, in support of food (in)security early warning, natural resources management, disaster management, and environmental change monitoring.

This report also reviews, for each of the regional centers

- collaboration with 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 EIS-Africa website and the GSDI-Africa newsletter. This report also benefited from input from USGS FEWS NET regional scientists hosted at the RCs, and from staff at many institutions in Africa (e.g., CGIAR centers throughout Africa, the Satellite Applications Center 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, 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 MODIS, ASTER, or high resolution data (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, GLCF (Global Land Cover Facility, University of Maryland), etc. Offline distribution of free data from the RCs was also common – e.g., 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 re-distributors, and was more prominent in the acquisition of high-resolution data, since free sources of these data don't 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, which is more than 3 times the size of the conterminus U.S.), 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., NEPAD, AARSE) realize, accept, and embrace, the utility of (and need for) RS applications, national governments in Africa have generally not supported RS applications. 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."

- "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 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 cost 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 when existent. There is a lack of appropriate skill set 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 regional coordination of RS activities was subsequently very limited. Nevertheless, specifically because of the historical lack of communication, and the paucity and degradation of ground-based observations/data, there is increased need for developing, maintaining, Fand 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 into application, include: NOAA's Office of Global Programs, NASA's Applied Sciences program, and the Global Monitoring for Environment and Security program (European Space Agency and European Commission). These programs may, in the long term, greatly increase the demand for climate 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, there exists a lack of information about African uptake and usage of geospatial technologies. 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 the rest of the world (Daratech, 2006), so presumably this estimate holds for Africa. Anecdotal information does support this trend. A NOAA-sponsored global remote sensing survey conducted in 2005 reported that eight percent 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).

This report provides 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 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 (and Portals and 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 continent-wide, 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 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. One of the factors that contributes 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/emergencies, nor does it try to service too broad 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 NGOs/civil society organizations, might use geo-information and spatial research in their settings. To truly have a wide user base, which is an important element of sustainability, a RS facility 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.

In order 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 tackle; 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 have a national university, if more training opportunities were offered through universities, it could cut down the overall expense for training for potential candidates.

In order 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 there are many different business models that 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 the 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 as the business model, 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. In order to focus on the sustainability elements, a regional RS applications facility/program requires considerable pre-"design" analysis, and once underway, 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 and SERVIR-Mesoamerica

We also present an evaluation of the Mesoamerican SERVIR portal, in particular, with respect to its potential as a model for Africa, and the utility and/or appropriateness of implementing a SERVIR-like portal for Africa. We collaborated with NASA and 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 / DSS portal for the region, and Africa regions could benefit greatly from similar one-stop (geo)data portals. However, there are so many differences between Mesoamerica and Africa, both in current (data/RS) conditions, and in implementation needs, that 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/or 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 already/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, external drives, etc. 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 re-distributed the GeoCover Landsat dataset, as well as 90-m SRTM DEMs (in some cases), and other MODIS and ASTER data as a result of this direct involvement.
- Africa regions are already on-board with in-house datasets and links to partners providing data, such as GeoNetwork (by FAO, WFP, UNEP), which is a metadata (and potentially a data) distribution system – built upon 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 exist already (for Africa) for environmental monitoring, disaster management, weather monitoring, food security monitoring, etc., 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., DSS information example, 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, 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 and/or information of/for/to Africa. In addition, EUMETSAT and GeoNetcast will disseminate data and information of/to Africa).

- The need to recognize ICT (information and telecommunications technology) limitations (and variations) in Africa (and within regions). 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.
- Some questions/differences/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 (immensely) greater than those required to support the same in Mesoamerica.
    - ICT policies and infrastructure (levels) vary greatly across Africa. For example, most counties in Africa are yet to come up with ICT policies that ministries can leverage on 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 / information sharing through the portal.
    - Levels of government buy-in within a region will/may vary greatly.
    - Levels of regional/institutional network functionality will/may vary greatly in Africa (e.g., CILSS in West Africa; SADC and DMC in southern Africa; RCMRD and ICPAC in East Africa).
    - There exists a great diversity of cultures (language, religion, etc) within Africa, and within each region.
    - Currently, government ministries/institutions/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, rather than expecting that ministries offer free data through a centralized (or distributed) portal.
- Current bandwidth available throughout Africa (and 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/or (geo)data portals, by presenting to them very real, useful, currently-implementable, realizations of RS applications, with possibly SOME 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 proto-typed 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", as

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), but also because of cultural differences in the region, South Africa's role has been greatly diminished, and/or non-effective (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.

Recommendations

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 (i.e., 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 (and/or nurture) government buy-in, such that African governments provide national budgets for geo-information

- Develop products and conduct workshops to convince Decision-Makers or Policy-Makers of the importance, relevance, and appropriateness of utilizing RS technology for specified applications.
    - Expansion of the role that EROS has played in the development and implementation of workshops conducted jointly with the RCs.
    - Specialization of workshops for each region as appropriate.
- Develop products and workshops targeting specific applications (e.g., RCMRD experience with joint workshop with UNEP/Nairobi to support national-scale UNEP State of the Environment Reports).
    - Expansion of 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 EW of food insecurity and/or vulnerability.
    - Information workshops on emergency response and the International Charter "Space and Major Disasters".
- Support participation in Conferences such as CODI-V and Geo-CODI, which address Africa-wide development (and subsequently support) of 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 SAFNet [Southern Africa Fire Network], NASA/UMD/USDA/WRI/etc and CARPE [Central African Regional Program for the Environment])
- Support refresher courses, and/or specific application courses, via RCs, universities, and partners (e.g., USGS EROS, ITC, etc);
- Support training on the International Charter "Space and Major Disasters" for emergency/disaster response.
- Support RCs in conducting in-country training workshops for member States (as opposed to training at RCs);
    - More cost-effective, more nationals benefit from the training (as opposed to bringing 1 or 2 nationals to the RCs for training)
- Support exchange between universities in the region and RCs (e.g., for hands-on applications via internships)
    - Already implemented in some cases with universities in the same city as the RC (e.g., Nairobi universities with RCMRD), but should be implemented for other universities in the region
- Explore/support distance learning and video conferencing
    - video conferencing capacity for RCs and country partners
        - capacity for RCs and partners to access training opportunities in the U.S. (USGS EROS, universities)
        - capacity for country partners to access training at RCs

3) Improve data availability, access, and distribution (i.e., inexpensive or no-cost)

- U.S. institutions provide no-cost data
    - USGS provide mid-decadal Landsat data (to extend GeoCover Landsat coverage for c.2005) and MODIS products (e.g., FEWS NET processed NDVI)
    - 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, FEWS NET processed daily rainfall estimates)
- Develop database management capacity/capability at RCs
    - See recommendation 7 ("Improve Infrastructure…" – 3rd bullet)

4) Expand and extend data and information portals

- Based on this report, and previous surveys and analyses, RCs finalize data and information needs for their respective regions;
- Support the RCs to convene meetings with key partners (e.g., USGS EROS, FAO [GeoNetwork], NASA ["SERVIR", etc.], ESA [GMFS, GeoNetcast]) to define web portal implementation (including roles of each institution)
- Technical implementation of regional data / information portal (i.e., address minimum hardware, software, bandwidth needs)
- Develop web portal user interface and structure
- Populate web portal with regionally relevant data and information (and maintain updated data/information)
    - Existing regional data and information
    - Development of regional and national baseline datasets

    - Development of additional international/regional datasets that will feed the RCs' websites.
- Emphasize decision support system/information (DSS)
    - Existing (food security) products (e.g., FEWS NET products: Executive Overview Briefs, regional bulletins, weekly weather hazards assessments, Food Security Outlooks, etc)
    - Development of specific regional and national-scale DSS products (using locally-implemented tools such as FEWS NET's GeoWRSI [geospatial water requirements satisfaction index], NOAA CPC's Rainfall Estimation algorithm and USGS Improved Rainfall Estimation, Climate Outlook Forum Forecast Interpretation Tool, etc.)
    - Involvement in, or development of, Africa-wide and regional newsletters (e.g., SDI [Spatial Data Infrastructure]-Africa, etc.)
- 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 (e.g., updating) of the regional portals.
- Develop (or link to) introductory and web-based resources on use of RS for different applications.
- Support website promotion/publicity via workshops in major fora in Africa (e.g., CODI, AfricaGIS 07, AARSE 08, etc).

5) Develop/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 post-graduate 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., 1 to 3 months)
- Explore/support distance learning
    - 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/international meetings (RCs and universities)
- Support participation/membership in professional organizations
- Involvement in CEOS (Committee on Earth Observation Satellites)?

7) Improve infrastructure for data access, analyses, and distribution – 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 capacity, support efforts for trunk line [i.e., Internet 2])

- Improve servers and storage capacity (e.g., purchase, maintenance, and systems and data administration capacity)

8) Strengthen regional coordination

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

9) Plan for future activities

- Implement monitoring and evaluation of RS programs/applications
- Conduct further evaluation on:
    - RS business models
    - Sustainability
    - Role of other regional institutions, associations, partnerships (e.g., CGIARs, UNEP, EIS-Africa, NEPAD, etc.)
- Develop an implementation plan with 5- to 10-year goals and milestones.

1. Introduction

USAID has requested USGS EROS to undertake a review of current and potential capabilities at regional centers (RCs) in Africa to use remote sensing (RS) technology for societal benefit. In addition, USAID requested an evaluation of the utility of a web-based data- and decision support system-portal such as the SERVIR model (currently implemented for Mesoamerica) for implementation in Africa.

This activity was initiated by Larry Tieszen (USGS EROS) and Carrie Stokes (USAID), with the primary objective of developing an implementation plan for sustainable project activity at the African regional remote sensing centers for the "acquisition, maintenance and archiving, dissemination and distribution, and application (and training) of remote sensing data". Because of our historical collaboration with three regional remote sensing centers in Africa, namely

- The AGRHYMET Regional Center (ARC) in Niamey, Niger;
- The Regional Center for Mapping of Resources for Development (RCMRD) in Nairobi, Kenya;
- 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 (Erick Khamala and Blessing Siwela, respectively) spent time at EROS working with the evaluation team. However, for a broader understanding of RS applications and needs in Africa, we also solicited, and received, input from various African institutions through field visits, email contacts, questionnaire responses. USGS FEWS NET regional scientists seconded to each of the three regional institutions mentioned above (namely, Alkhalil Adoum at AGRHYMET, Tamuka Magadzire at SADC RRSU, and Gideon Galu at RCMRD) provided input and support for this evaluation. Unfortunately, a very short timeline has limited our in-depth analysis to these three regional centers.

We also received direct input from staff members at CGIAR centers throughout Africa, as well as the Satellite Applications Center (SAC) in Pretoria, South Africa, in order to capture the most appropriate, and up-to-date, information on the status of such activities, and needs, in African institutions.

In order to assess the SERVIR portal model, we collaborated with NASA staff responsible for the initiation, development, and implementation of the SERVIR portal for Mesoamerica. For more information on SERVIR, please visit their websites at http://servir.nsstc.nasa.gov/ and http://servir.nasa.cathalac.org/.

In this report, we will address the needs of the regional RS centers, as well as the needs of their constituent partners, including the needs for hardware, software, internet connections and information technology (IT), training, etc. We solicited general information on RS needs in Africa via an online questionnaire which was distributed via the RCs, via the GSDI-Africa newsletter, and “advertised” on the front page of the EIS-Africa website.

A review of previous surveys and assessments was undertaken. Furthermore, we contacted coordinators of the MAFA (Mapping Africa for Africa) and SunSpace surveys currently being undertaken and published.

Note: for this discussion, and throughout this report, we define the terms "application of RS technology" and "RS applications" in a broad manner to include:

- The acquisition of remote sensing (satellite) data,
- The maintenance and archiving of RS data,
- The dissemination and distribution of RS data,
- The analysis and interpretation of RS data,
- The integration of interpreted data with other spatial data and models,
- Training in all aspects of the abovementioned activities.

Furthermore, we limit our discussion to include primarily sub-Saharan Africa, i.e., "Africa" will refer, in most cases, to sub-Saharan Africa only.

1.1 Problem Analysis and Justification

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, which is more than 3 times the size of the conterminus U.S.), 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., NEPAD, AARSE) realize, accept, and embrace, the utility of (and need for) RS applications, national governments in Africa have generally not supported RS applications. 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."
- "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 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 cost 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 when existent. There is a lack of appropriate skill set 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 regional coordination of RS activities was subsequently very limited. Nevertheless, specifically because of the historical lack of communication, and the paucity and degradation of ground-based observations/data, there is increased need for developing, maintaining, Fand supporting RS applications in Africa.

1.2 Participating African Regional Centers

There are many African continental, regional, and national institutions, organizations, initiatives, and networks involved in geospatial data and information distribution. An evaluation of all such geospatial data activities is beyond the scope of this evaluation.

In the following sections, we concentrate on the three regional RS centers mentioned above. Note that different mandates, different funding mechanisms, and different sizes, of the three RCs results in different levels of RS applications at each of the centers. For example, a large part of AGRHYMET's activity supports training in the domain of hydro-meteorology, water control & management, and vegetation protection training, whereas RCMRD is mult-sectoral in its geo-information and sustainable development approach, and RRSU supports primarily food security issues.

1.2.1 Regional Centre for Mapping of Resources for Development (RCMRD), Nairobi, Kenya

About RCMRD

The Regional Centre for Mapping of Resources for Development (RCMRD), previously known as Regional Centre for Services in Surveying, Mapping and Remote Sensing, (RCSSMRS), was established in Nairobi, Kenya in 1975 under the auspices of the United Nations Economic Commission for Africa (UNECA) and the then Organization of African Unity (OAU) now renamed African Union (AU). It is an intergovernmental organization, currently with 15 contracting member States drawn from the eastern and southern Africa sub-region (see Figure 1.1). 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.

Figure 1.1. RCMRD contracting member countries – Botswana, Comoros, Ethiopia, Kenya, Lesotho, Malawi, Mauritius, Namibia, Seychelles, Somalia, Sudan, Swaziland, Tanzania, Uganda, Zambia; non-contracting member countries – Angola, Burundi, Madagascar, Mozambique, Reunion, Rwanda, South Africa, Zimbabwe.

The current mission of the Centre is *"To Promote the Development and Use of Geo-information in Sustainable Development of Africa".* The main geo-information technologies promoted by the Centre are Geographic Information Systems (GIS), Satellite Remote Sensing (SRS), Global Positioning System (GPS) and Database Development Systems (DBDS). This is achieved through capacity and capability building, and provision of advisory and consultancy services to member States and other clients. The Centre is also vigorously involved in the promotion of the development of National Spatial Data Infrastructure (NSDI) in its member States and Africa in general. In undertaking all these, the Centre is guided by its vision of becoming a premier Regional Centre of Excellence in the promotion of geo-information application in the sustainable development of Africa by the year 2010.

The key objectives of the Centre are:

- 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.
- To collaborate with member States' national institutions and other partners in undertaking projects for creation of spatial information system suitable for development planning at regional and community levels.
- To strengthen and harmonize the fragmented regional and African data using accurate geodetic GPS techniques and research into the field and data processing methodologies.
- To develop capability and capacity in the maintenance of surveying and mapping equipment and offer advisory and maintenance services to the member States.
- In collaboration with national and international institutions, undertake research and training in the application of geo-information in land resources and urban development mapping and assessment for sustainable development.

The Centre's functional programmes have moved away from service technology framework (e.g. remote sensing, geodesy, cartography etc) to problem solving applications in natural resource development and environmental management. Implementation is done through four core programmes, namely: Remote Sensing and Environmental Management, Resource Mapping, Engineering and Human Resources Development.

The Centre prides of enormous capacity and capability that is mainly drawn from its highly qualified staff and associate consultants; its experienced strategic partners; its long and wide experience in implementing environmental projects; and in its ultra-modern facilities.

Collaboration with USGS/EROS

RCMRD has been working closely with USGS/FEWS NET in the promotion and application of geo-information technologies in Africa. Due to this close collaboration, RCMRD hosts at its premises two scientists, the USGS Regional Agro-Climatologist and the USGS Regional Hydrologist.

Key activities of collaboration between the two institutions have been/are:

- Distribution of low, medium and high resolution satellite data, both free and priced datasets. Free datasets constitute low to medium resolution images (NOAA, MODIS,

RFE) and the GeoCover Landsat data that were distributed in collaboration with UNEP, FAO, and the University of Maryland.
- Preparation of a monthly early warning bulleting for food security in the Greater Horn of Africa, in collaboration with FEWSNET, FAO, WFP, LEWS (on-going)
- Capacity building in Africa in the application of remote sensing data, in collaboration with AGRHYMET Regional Center, Niamey, Niger and Southern African Development Community (SADC) Regional Remote Sensing Unit, Gaborone, Botswana, (Pretoria, 2004 & Bamako, 2006)
- Validation of the USGS hydrological model on the Nzoia river basin in Kenya (2004 – 2005)
- The preparation of the Clearing house via the Environmental Monitoring and Information System (EMIS) initiative (2003 – 2004)
- Promotion of the National Spatial Data Infrastructure in Africa
- Visiting scientists program at USGS/EROS Data Center

Collaboration with other institutions

RCMRD has also established strategic collaborations / partnerships with public and private institutions across the world. The key areas of collaboration include capacity building, early warning systems, data distribution, project implementation, software, and research and development as specifically listed below:

Capacity building
- USAID in 1979 funded the setting up of the Remote Sensing Facility at RCMRD (then called the Regional Centre for Services in Surveying, Mapping and Remote Sensing (RCSSMRS)).
- International Institute of Geoinformation Science and Earth Observation (ITC), Enschede, Netherlands - jointly with RCMRD offer courses in Africa in the use of geo-information technologies in natural resources management.
- UNEP – training in the use of geo-information technologies in environmental management
- The Nile Basin Initiative – Use of geo-information technologies in water management

Early Warning Systems
- FAO - Qualitative analysis of CCD for food security assessment in the IGAD countries. Funded by the Japanese Government through FAO in the project GCPS/RAF/231/PJN (1988 – 1993)
- FAO - Qualitative analysis of CCD and NDVI in the IGAD countries and Rwanda and Burundi. Funded by the French Government through FAO in the project GCP/RAF/310/FRA (1996 – 1997)
- Environmental Analysis & Remote Sensing (EARS) - Qualitative end of season crop yield forecasting and environmental analysis in the IGAD countries using Evapotranspiration data derived from Meteosat satellite. Co-executed by RCMRD and EARS and funded by the Dutch Government.

Data Distribution/Sharing
- SPOT Image – distribution of SPOT satellite data
- ESA – distribution of Meris and ASAR data
- Maps geosystems – distribution of QuickBird, Ikonos, and Orbview satellite data
- US Department of Agriculture, Forest Service - Distribution of Landsat images

- UN Economic Commission for Africa (ECA) - Promotion of National Spatial Data Infrastructure (NSDI) in Africa

Project implementation
- Member States – projects identified by the member States governments
- UN-HABITAT – Mapping urban areas in Africa using high resolution QuickBird imagery
- UNEP – use of geo-information technologies in environmental management
- USAID – funded various projects that have been implemented at RCMRD.
- IUCN – use of geo-information technologies in conservation

Software
- ESRI – Training in ESRI software for member States
- Clark University – Training in Idrisi software for member States
- Pixoneer Geomatics – Training in PG-Steamer

Remote sensing projects and data
RCMRD has undertaken various projects in the areas of early warning, land use / land cover / natural resources mapping, urban mapping, digital spatial database development, and promotion of Spatial Data Infrastructure. These include:

Early warning systems
- FAO - Qualitative analysis of CCD for food security assessment in the IGAD countries. Funded by the Japanese Government through FAO in the project GCPS/RAF/231/PJN (988 – 1993)
- FAO - Qualitative analysis of CCD and NDVI in the IGAD countries and Rwanda and Burundi. Funded by the French Government through FAO in the project GCP/RAF/310/FRA (1996 – 1997)
- Environmental Analysis & Remote Sensing (EARS) - Qualitative end of season crop yield forecasting and environmental analysis in the IGAD countries using Evapotranspiration data derived from Meteosat satellite. Co-executed by RCMRD and EARS and funded by the Dutch Government.
- USGS, FEWSNET, FAO, WFP, LEWS – Food Security Monitoring and Early Warning in the Greater Horn of Africa (2001 – Present)

Land use / land cover / natural resource mapping
- Mapping Gum Arabic and other dryland resources in Karamoja region, Uganda – a presidential initiative on poverty reduction in Karamoja, funded by the Government of Uganda and jointly implemented with the Network for Natural Gums and Resins in Africa (NGARA). (September 2006 – Present)
- Mapping Gums and Resins in the Greater Horn of Africa (GHA) – funded by FAO and jointly implemented with the Network for Natural Gums and Resins in Africa (NGARA). (March 2004 - September 2004)
- Land use / Land cover Mapping of the Amboseli National Park in Kenya, jointly implemented with the African Conservation Centre (ACC) (September 2004 - September 2005)
- Wetland mapping of the Kenya Portion of Lake Victoria Basin – sub-contracted to RCMRD by SMEC International of Australia (March – May 2005)
- Forest cover mapping and change detection of the Loita Purko Forest, Kenya – funded by the World Conservation Union (IUCN) and implemented in collaboration

with a Maasai Community Based Organization (CBO) called the Loita / Purko Naimina Enkiyo Forest Project (2005)
- Mapping of Plantation and Indigenous Forest on Mt. Kenya – Funded by UNEP (August 2005 – December 2006)

Urban mapping
- Mapping of the City of Nairobi Using High Resolution QuickBird Imagery – jointly implemented with Maps geosystems, United Arab Emirates (2003 – 2005)
- Urban Mapping of 10 State Capitals of South Sudan – Funded by USAID and jointly implemented with Creative Associates International Inc., USA (August 2005 – January 2006)
- Mapping Nasir town in Northeastern part of Southern Sudan – implemented in collaboration with Norwegian People's Aid and USAID (April – August 2006)
- Mapping 17 towns along the shores of Lake Victoria for water and sanitation planning – funded by UN-Habitat and was implemented in collaboration with Local Authorities of the towns (April 2006 – February 2007)
- Baseline mapping of Hargeisa city, Somalia using high resolution Quickbird imagery – implemented for UN-Habitat (2004)

Digital database development
- Digital database development of southern Somalia – funded by USAID and implemented for FEWS NET (2002)
- Digitization of urban physical plans for 5 towns in Kenya – implemented for the Physical Planning Department (2002 – 2003)
- Development of baseline GIS Database for Djibouti – funded by USAID (July – August 2005)
- Conflict mapping in South Sudan – funded by USAID (April – September 2006)

Spatial data infrastructure (SDI)
- Environmental Management and Information System (EMIS) for Africa – implemented in collaboration with USGS
- Establishment of Geo-network node at RCMRD
- Distribution of various satellite datasets (Landsat, SPOT, QuickBird, Ikonos, Orbview, etc)

Existing capacity of remote sensing
RCMRD has a fairly good remote sensing capacity in the areas of skill set, data, facilities, hardware, and software although this still requires further improvement, mainly by way of upgrading / modernization.

Skill set
RCMRD has a team of 6 professional geo-information staff holding degrees ranging from Bachelor's to Doctorate. The professional staff supported by a team of 12 geo-information technicians. RCMRD also maintains a pool of consultants, both at professional and technician level, whom it calls upon on need basis. In addition, RCMRD works closely with its partners, benefiting from their expertise when undertaking projects jointly.

Data
Various remote sensing datasets are available at RCMRD. These include:
- A large archive of Landsat images covering all its member States

- An archive of SPOT imagery covering specific sites where projects have been undertaken
- An archive of QuickBird images covering various urban areas across eastern and southern Africa where projects have been undertaken using the same
- An archive of Ikonos images covering specific sites where projects have been undertaken using the same
- An archive of Orbview images covering specific sites where projects have been undertaken using the same
- An archive of NDVI data covering eastern Africa acquired from 1981 to present
- An archive of RFE data covering eastern Africa acquired from 1996 to present
- 90m resolution SRTM data covering the entire continent of Africa

Facilities

RCMRD has the following facilities that support its geo-information activities:

- Three computer training rooms, each equipped with 15 to 30 computers
- A remote sensing lab with 6 computers
- A photogrammetric lab with 2 computers
- A GIS lab with 8 computers
- A fire-proof data archive room
- A satellite data receiving station for Meris and ASAR data
- A library equipped with geo-information books and publications
- A satellite data distribution office
- A printing / scanning room

Hardware

The key geo-information hardware available at RCMRD include:

- Approximately 200 medium to high-end computers (about 100 computers are dedicated to geo-information activities)
- 7 laptop computers
- 2 network printers and 9 stand alone, 2 being wide format color plotters (36 and 42 inch)
- 2 wide format color scanners (36 and 42 inch)
- 2 sets of high accuracy (surveyor's) GPS units
- 12 handheld GPS units
- 2 photocopiers with speeds of over 25copies per minute

Software

Geo-information software available at RCMRD include:

- ArcGIS 9.2 multi-user licenses (15 licenses)
- One copy ERDAS Imagine software (with full photogrammetric suite)
- Arcview 3x multi-user licenses
- Geovis software (developed by FAO Africover Project)
- Idrisi Andes multi-user license

Internet, local area network and data dissemination system

RCMRD has the following Internet, local area network and data dissemination system:

- Broadband Internet connectivity- 1024 kbps downlink, 512kbps uplink.
- A Local Area Network of 100mbps connecting all computers
- 6 servers

- A satellite based ESA Data Dissemination System (DDS) – offers multicast dissemination of Envisat MERIS RR and ASTER products as well as geospatial products generated from the Global Monitoring for Food Security (GMFS) project.
- GeoNetwork opensource node – a standardized and decentralized spatial information management environment, designed to enable access to geo-referenced databases, cartographic products and related metadata from a variety of sources, enhancing the spatial information exchange and sharing between organizations and their audience, using the capacities of the internet
- The good Internet connection allows RCMRD to receive and disseminate low to high resolution satellite images from the Africa Data Dissemination Service, the USGS based Earthexplorer, and the SPOT Image servers.
- RCMRD receives and disseminates the Vegetation Productivity Index (VPI) data from the GMFS.

1.2.2. Southern African Development Community (SADC) Regional Remote Sensing Unit (RRSU), Gaborone, Botswana

About RRSU

The RRSU is a Centre of technical expertise facilitating training programs and technical support in the field of Remote Sensing, Agrometeorology and GIS in support of early warning for food security, natural resources management and disaster management. The RRSU operates under the Agriculture Information Management System (AIMS), which falls under the Food, Agriculture and Natural Resources (FANR) Directorate, based at the SADC Secretariat in Gaborone, Botswana (see Figure 1.2 for SADC member states).

Figure 1.2. SADC Member States – Angola, Botswana, Democratic Republic of Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe.

RRSU started its operations as a project in June 1988 with funding from the Government of Japan and technical assistance from the UN Food and Agriculture Organization (FAO). The first phase came to an end in 1992, after which the operational activities continued

with support from the FAO Technical Cooperation Programme. Additional details on funding are provided in a subsequent section specifically dedicated to this topic.

Collaboration with USGS/EROS

USGS/FEWSNET supplies dekadal NOAA NDVI and rainfall estimates (RFE) via e-mail throughout the year. Additional datasets (WRSI, daily RFE, potential evapotranspiration, radiation, and temperature) are also available for download from the USGS EDC FTP server. These datasets form the backbone of seasonal monitoring in the early warning community of southern Africa. The RRSU incorporates this information into season monitoring reports and also distributes the datasets and derived products to other users in the SADC region.

USGS/FEWSNET and RRSU have jointly organized and hosted capacity building workshops that have mainly addressed training in the handling of course to medium resolution remote sensing datasets (particularly NOAA NDVI, MODIS and ASTER data).

Staff from the regional centers were trained at EROS on the handling of these datasets prior to the regional workshops. This training focused on enabling the staff at the regional centers to acquire, process and archive medium to high resolution datasets, and to be able to conduct training on the same.

The USGS has developed and implemented a stream flow model that simulates stream flow based on rainfall, elevation derivatives, soil, and land cover among other inputs. This model was previously implemented for Southern and Eastern Africa at EROS. Staff at RRSU were trained in order that they could better understand the operation of the model. Meetings have also been held with various stakeholders in order to better promote the model and attempt to get wider acceptance of the same.

The USGS has also developed a methodology for estimating flooded area at different stream levels using a digital elevation model. Staff at RRSU were trained by USGS/FEWSNET on the implementation of this technique, and it has been successfully used in Mozambique and Zimbabwe in collaboration with SADC RRSU, USGS/FEWSNET and the relevant partners.

Collaboration between USGS/FEWSNET, USAID and RRSU has also seen the development of the Southern Africa Flood & Drought Network website. This is a SADC website that is intended to facilitate the exchange of technical and other useful information that can be used by the disaster and technical communities in preparing for and responding to the occurrence of cyclones, floods and droughts. It is provided as a service by the SADC regional meteorology, hydrology, food security and disaster communities to its Member States.

Joint regional flood and drought reports have been prepared and issued by the RRSU and USGS/FEWSNET. These are *ad hoc* situational reports that concentrate on providing information on flood and drought threats that develop in southern Africa.

USGS and UCSB have developed the FEWSNET AgroClimatology ToolKit (FACT) and the Forecast Interpretation Tool (FIT), a set of tools for converting the Probabilistic Climate Forecasts issued regularly by regional and national meteorological organizations, into more quantifiable products. The USGS/FEWSNET has provided training to the RRSU staff members on the use of the FACT/FIT. In addition, the RRSU and USGS/FEWSNET

has provided training to staff members of national institutions on the use of this tool, and has also used the FACT/FIT in interpreting the SADC regional probabilistic forecasts and providing applied information to readers of the RRSU bulletins.

The USGS developed the GeoWRSI, a stand-alone application for doing crop-specific water balance calculations and deriving water requirements satisfaction index (WRSI) using gridded rainfall estimates. The RRSU was involved in the testing of the GeoWRSI, with one of it's staff members actively testing the model and providing feedback during the development phase. During training sessions held between 2004 and 2006, some training has been provided in the SADC region on the use and application of the GeoWRSI. Efforts have also been made to integrate the GeoWRSI outputs with outputs from the Agrometshell, a crop-specific water balance model software developed by FAO for use with rain gauge data.

Collaborative work between RRSU and USGS/FEWSNET has benefited significantly from the deployment of a FEWSNET representative at the RRSU offices since 2000. The representative, a geo-information scientist, works with RRSU while also supporting the FEWSNET officers in the countries of southern Africa.

Available remote sensing datasets

Datasets available at RRSU are:

- NOAA NDVI dekadal GAC - 1982-2007
- NOAA NDVI dekadal LAC – 1985-1999
- CPC Rainfall Estimates dekadal – 1995-2007
- SPOT Vegetation NDVI 1km – 1998-2007
- SPOT Vegetation NDWI 1km – 1998-2006
- SPOT Vegetation (Vegetation) Productivity Indicator (VPI) data – 1998-2006
- LANDSAT GeoCover datasets for SADC countries
    - LANDSAT MSS - 1970s
    - LANDSAT TM – circa 1990
    - LANDSAT ETM+ - circa 2000
    - Plus other LANDSAT data collected from UNEP and USGS/FEWSNET
- MODIS NDVI (MOD13) 250m – 2003, 2004
- ASTER data
- SRTM 90m DEM data
- Daily RFE, PET, Temperature data

Existing capacity of remote sensing

The RRSU has agreements in place for regular access to fundamental season monitoring datasets. These include agreements for:

- supply of SPOT VGT NDVI dekadal and monthly data from FAO ARTEMIS
- supply of NOAA NDVI, CPC RFE, WRSI from USGS/FEWSNET
- supply of VPI data from the GMFS

The RRSU has an agreement with the Botswana Meteorological Department for access to METEOSAT Second Generation (MSG) datasets acquired via a receiver at the Botswana Meteorological Department.

The Centre has a long history of using remotely sensed datasets in combination with other datasets in the area of early warning for food security, stretching back into the late 80s.

Staff at the Centre have good skills in the handling of low to medium resolution remotely sensed data and have demonstrated the ability to manage GIS and remote sensing projects.

The Centre has extensive RS/GIS data processing skills and maintains a database of remotely sensed datasets for the entire SADC region. Significant training capacity exists at SADC RRSU. The Centre conducts annual regional training workshops and backstopping missions that mainly focus on agro-meteorology, remote sensing and GIS. These workshops are attended by staff from the national meteorology services in the SADC Member States, who learn how to apply remote sensing technologies in season monitoring. The Centre has prepared training materials and manuals and these get updated regularly. The Centre also has experience with the running of models which use remote sensing data as input. An example is a quelea breeding forecast model which uses daily rainfall estimates (http://gisdata.usgs.net/sa_floods/files/region/quel/latest.htm).

Staff at the Centre are familiar with the various software systems used for handling remote sensing datasets. These include IDRISI, WinDisp, and ESRI ArcView and ArcGIS.

Staff at the Centre also have software and web development skills that can contribute to RS/GIS software development. In-house tools have been developed to assist in the regular season monitoring efforts of the Centre.

1.2.3. AGRHYMET Regional Center, Niamey, Niger

About AGRHYMET
[This subsection is from http://www.agrhymet.ne/eng/center.htm on 12 Mar 07.]

The AGRHYMET Regional Center (ARC) was created in 1974. It is a specialized institute of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS) composed of *nine member States* shown on Figure 1.3.

Figure 1.3. CILSS Member States – Burkina Faso, Cape Verde, Chad, Gambia, Guinea Bissau, Mali, Mauritania, Niger, Senegal.

It is an interstate public institute with a legal status and financial autonomy. It has an international status and is based in Niamey, Niger.

The primary objectives of the AGRHYMET Regional Centre are:

- 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 (agroclimatology, hydrology, crop protection…).

It is a regional institute specialized in the science and techniques applied to agricultural development, rural development, and natural resource management.

Over the years, the AGRHYMET Regional Centre has asserted itself as a regional Centre of Excellence in:
- training officers from Sahelian countries and elsewhere;
- regional agrometeorological and hydrological monitoring;
- agricultural statistics and crop monitoring;
- regional databases;
- management and dissemination of information on natural resource monitoring across the Sahel;
- documentation on agrometeorology, crop protection, environmental monitoring, desertification, natural resource management, etc;
- maintenance of meteorological instruments and electronic equipment;
- strengthening interstate co-operation by sharing methodologies and technologies.

Accordingly, the expertise of officers of the Centre is increasingly sought after by bilateral and multilateral organizations (USAID, FAO, WHO, IRD, CIRAD, etc.). The AGRHYMET Regional Centre also takes part, in conjunction with the CILSS system, in international meetings on food security, sustainable development, natural resource management, and desertification control.

Collaboration with USGS/EROS

A USGS FEWS NET regional scientist has represented FEWS NET at the ARC since 2000. The presence of FEWS NET at the ARC strengthens collaboration and creates synergy especially in research activities. Collaboration between the two institutions is varied and multiform and concerns all three departments of AGRHYMET: the department of training and research (DTR), the department of information and research (DIR), and the department of technical support (DTS). In this symbiotic relationship ARC supports FEWS NET by providing an ideal work frame and a multidisciplinary work-conducive environment. Moreover, AGRHYMET is an environment where issues most important to West Africans and Sahelians in particular are brought to the table and dealt with. In return, the FEWS NET regional scientist provides substantial support to ARC activities, namely growing season monitoring, training, and research. A few examples of such collaboration that has been beneficial to both FEWS NET and AGRHYMET include (for both the DTR and DIR):
- Teaching agrometeorology courses to two classes of 'techniciens supérieurs' at the associate degree level, and one course of general meteorology to a class of 'engineers' at the master's degree level.
- Supporting short term training courses or workshops to the benefit of tens of Sahelians involved in food security issues (e.g., training in WinDisp, ArcGIS, and methods and products developed by FEWS NET to improve growing season monitoring and food security assessment.

- Organizing and supporting training that introduced the geospatial stream flow model (GeoSFM) to the region and allowed its adoption by Sahelian hydrologists.
- Introducing the application of the dot-grid method using high-resolution images to estimate cropped area of rain fed crops in Senegal and recessional sorghum in south-east Chad (contributing to AGRHYMET's natural resources management program), including publications and presentations at different CILSS fora.
- Contributing to the regional seasonal outlook by introducing the Forecast Interpretation Tool (FIT) to the PRESAO (Prévision Saisonniere en Afrique de l'Ouest [le Tchad et le Cameroun]) forum, supporting end-of-season food security outlooks.

Collaboration with other institutions
The AGRHYMET Regional Center is engaged in close collaboration with a multitude of research institutions at both regional and international levels. One can list among others: USGS/EROS, FAO, IRD, ABN, ACMAD, CRESA, EAMAC, ICRISAT, CSE, CBLT, OMVS, CEDEAO, UEMOA and the AGRHYMET National Components in all CILSS member countries. Collaboration with USGS EROS, in particular, has supported the creation of ecological zone mapping, as well as numerous workshops on land cover and land use change throughout the Sahelian region.

Remote sensing projects and data
Before assessing the needs it is important to know what AGRHYMET currently has. The following is a list of all MODIS, ASTER and LANDSAT data that are part of the ARC data base.

Landsat image data base of ARC consisted of MSS, TM and ETM scenes. These data are mostly provided by USGS. They are in GeoTIF format and provide complete CILSS spatial coverage for the years 1984-1990 and 1999-2000.

The LANDSAT MSS, TM and ETM+ images have been provided as part of the LU/LC project implementation for the whole West Africa but only in false color composition RGB 543.

The Center holds a data archive for MODIS 16-day composite vegetation indices for the CILSS region for 2000–06. In addition, for 2006, the Center has MODIS 8-day composite vegetation indices and MODIS fire products.

The Center has Corona satellite photographs for years 1965 to 1972, available at the ARC in both analog and digital GeoTIF formats for the whole CILSS area. The tile size is approximately 200 km by 20 km at a nominal resolution of 2 - 4 m. Images are of very good quality; however there are missing tiles.

Existing capacity of remote sensing
The Center utilizes 23 servers for its computer hardware, telecommunication, information sharing, and GIS/RS infrastructure, comprised of 8 UNIX and 23 Windows servers.

2. Assessments of African Capacity Needs

2.1. Examples of External Efforts to Increase the Use of Satellite Remote Sensing Information 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 into application, include: NOAA's Office of Global Programs, NASA's Applied Sciences program, and the Global Monitoring for Environment and Security program (European Space Agency and European Commission). These programs may, in the long term, greatly increase the demand for climate 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. There are a variety of scales at which different types of decision makers are located and the complexity of the types of organizations in which they belong. Meeting the needs of all these individuals requires a complexity of products and delivery systems.

NOAA's Office of Global Programs
The Office of Global Programs (OGP) leads the NOAA Climate and Global Change Program. OGP assists NOAA by sponsoring focused scientific research aimed at understanding climate variability and its predictability. Through studies in these areas, researchers coordinate activities that jointly contribute to improved predictions and assessments of climate variability over a continuum of timescales from season to season, year to year, and over the course of a decade and beyond. OGP sponsors focused scientific research, within approximately eleven research elements, all aimed at understanding climate variability and its predictability. Through studies in these areas, researchers coordinate activities that jointly contribute to improved predictions and assessments of climate variability over a continuum of time scales from season to season, year to year, and over the course of a decade and beyond.

The National Oceanic and Atmospheric Administration (NOAA) is increasingly challenged to meet the needs of the nation's decision makers (on a national, regional, state and local level) for climate products and services. In the past, existing products and services have been underutilized and numerous opportunities for provision of new services missed. NOAA's Climate Program Office's Regional Decision Support (RDS) program focuses on research that creates practical, user-friendly climate products and services. These products and services enable NOAA to contribute to the mitigation of adverse impacts and maximize economic and social benefits from variations in climate.
The Regional Decision Support program has three capabilities. Research on decision maker needs is principally conducted through focused competitive grants programs and at the university-based Regional Integrated Sciences and Assessments (RISAs). Transition of the results of research through the NOAA Climate Transition Program (NCTP) is responsible for the transition of climate services and products research into operations. Finally the operational production and delivery of services program focuses on delivery of products and services throughout the US. Although the regional decision support

program is focused on US decision makers, the OGP provides a mechanism to transfer knowledge developed in other RISAs into Africa. NOAA's web page on its applied sciences program is http://www.research.noaa.gov/programs/ogp.html.

NASA's applied sciences program

The Applied Sciences Program enables the use of results from NASA Earth science research in operational decision support systems1 (DSS) that organizations employ to serve their management, business, and policy responsibilities. The overarching purpose of the Applied Sciences Program is to showcase the value of NASA Earth science research and technology and to maximize the societal benefits of the nation's investments in the NASA Earth science research program. NASA defines decision support systems as interactive, computer-involved systems that provide organizations with methods to retrieve and summarize information, analyze alternatives, and evaluate scenarios to gain insight on critical factors, sensitivities, and consequences of potential decisions. Types of decision support systems might include early warning systems, planning tools, forecasts, resource allocation tools, etc.

The Program supports projects that have national impact, including regional and international activities, if they have U.S. national importance. The Program primarily supports projects involving organizations with national perspectives that have established networks to broad sets of end users and established constituencies at regional, state, local, and tribal levels. Examples of international organizations in Africa that have been supported by the applied sciences program include USAID's Famine Early Warning System Network, and its Central African Regional Program for the Environment (CARPE), the global FIRMS or Fire Information for Resource Management System. The Program partners with a given national organization to identify, make, and quantify improvements to the DSS, and the partner extends the DSS and/or the improvements broadly to its constituents.

During the past five years, NASA's Applied Sciences Program has distributed over $30 million dollars annually for projects in the US and internationally. As projects that have influence in Africa increase, this investment can become a significant driver for expansion of the climate data market. Although NASA's applied sciences program is significantly behind ESA's Tiger program in involving and partnering with viable and interested African decision support systems, it is increasing its focus on supporting sustainable development in Africa. NASA's applied science program can be found at http://science.hq.nasa.gov/earth-sun/applications/.

ESA/EU GMES and TIGER initiatives

GMES (Global Monitoring for Environment and Security) is a joint initiative between ESA and the European Commission (EC) to build a global monitoring capability in support of Europe's environmental and sustainable development goals. ESA has worked on the development of GMES pilot services in close conjunction with a large community of operational users. ESA is also working on multi-mission facilities and ground segment operations and is preparing the Space Component for GMES with a series of studies and preparatory activities for the development of a series of satellites missions (the Sentinels) and the integration of national and European missions to guarantee continuity of data and services.

ESA has also launched the TIGER Initiative in response to the World Summit on Sustainable Development (WSSD), which took place in September 2002 in

Johannesburg, South Africa. TIGER aims at applying Earth Observation to supply water-related geo-information in support of the practice integrated water resource management for sustainable development. Since its initiation two years ago more than 200 African organizations – including water and basin authorities, technical centers, universities and regional organizations - have become involved in different projects around the continent. The hope is to develop a technical, human and institutional capacity to bridge Africa's water information gap using satellite data.

The projects span the African continent as well as the various stages of the water cycle. Recognizing the utility of satellite data for water resource management elsewhere and the urgent need for action in Africa expressed at the WSSD, the European Space Agency in the context of the Committee of Earth Observation Satellites (CEOS) WSSD follow-on program, launched in 2002 the TIGER initiative aimed at: "assisting African countries to overcome problems faced in the collection, analysis and dissemination of water related geo-information by exploiting the advantages of Earth Observation (EO) technology".

The achievement of this objective requires a long-term strategy pursuing three main categories of results. The first is to support improved governance and decision-making by developing, implementing and assessing a cost-effective sustainable model to improve decision-making and governance (at regional, national and local scales) by using space-based information to provide accurate and timely geo-information for the integrated water resource management process. The second goal is to contribute to enhancing institutional, human and technical capacity through support of the consolidation of a critical mass of technical centers in Africa with the skills and capabilities to derive and disseminate space-based water relevant information to water authorities and the relevant stakeholders for integrated water management at regional, national and local scales. Finally, sustainability will be fostered by the development of strategy for strengthening and sustaining EO-supported water management information and decision-support systems in the long term. The ESA web page on TIGER is http://www.tiger.esa.int/home.asp.

AMESD initiative

The most significant initiatives in terms of the availability and ultimate use of satellite imagery in Africa are TIGER and African Monitoring of Environment and Sustainable Development (AMESD)[1]. The AMESD project (EDF-funded, 21 million EURO over 4 years) should start in mid-2007 and is designed to help African countries introduce EO information to better manage their water and land resources. The project is meant to focus on five thematic areas: water resources management; crop and rangeland management; agricultural and environmental resource management; mitigation of land degradation (including forest) and conservation of natural habitats; and marine and coastal management. AMESD also will provide resources to maintain and upgrade the PUMA satellite receiving station network. GMES Africa would be a continuation of the AMESD project. However, although initial steps and endorsements have been made, GMES Africa will take several years to take shape.

[1] http://www.tiger.esa.int/pdf/w2005_4_6.pdf

2.2. Overview of the Remote Sensing sector: Organizations, Initiatives, Investments, Services, and Capacity Building

Remote Sensing (RS)/earth observation (EO) is a relatively young and evolving technology sector (or industry) in Africa[2]. However, one of the main difficulties in writing about this sector is the lack of information about African uptake and usage of geospatial technologies. 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 the rest of the world (Daratech, 2006), so presumably this estimate holds for Africa. Anecdotal information does support this trend. When a NOAA-sponsored global remote sensing survey was conducted in 2005, eight percent 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 the market share for commercial satellite image sales, are reported. South Africa, for instance, only just makes the grade, with 0.2% of global sales ($2.4 million)] (Fortescue and Ntisana, 2005, p.12). 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 (ibid, p.17). Medium and particularly high-resolution imagery is the main contributor to the satellite image growth (ibid, p.21).

In an attempt to shed light upon RS/EO activity in Africa, this section analyzes the principal users, programs, initiatives, and investments. The emphasis is on the structural/organizational dimension of the geospatial sector/industry. The findings are based on expert knowledge and on market surveys, conference and workshop reports, project reports, and newspaper articles found on the web. It is however, worthy to note that the contents in this section constitute only a broad overview.

In order to provide a comprehensive analysis of the African RS/EO community, a structured survey, backed up with interviews and correspondence, would need to be conducted. It is strongly recommended that the methodology for a rigorous baseline analysis of the sector be explored, and then a baseline established. Global Marketing Insights, Inc., having completed the second phase of an Asian RS market study for NOAA, has expressed its interest to NOAA to extend the second phase to Africa. This could be one way to acquire market information that could be comparable between countries, sectors, and sensors. Also, the Secretariat of the South African National Working Group on Space Science and Technology has been contracted to conduct an audit of space science and technology activities in Southern Africa. The results will be made available to interested parties, and the methodology potentially could be used for assessing Africa's other sub-regions. National RS/EO market analyses have been conducted for South Africa, Tunisia, and Morocco (Fortescue and Ntisana, 2005; International Market Analysis Research Group, 1997), and these, too, provide an idea on how to proceed. These were the only national market studies for African countries we were able to uncover.

[2] Here, industry is used as a generic term for a distinct group of establishments engaged in similar activities, product development, and/or services. The term market is used to denote producers and consumers interacting to exchange goods and services (potentially for money, but not necessarily).

Ultimately, whatever methodology is used, the sector analysis would benefit from being complemented by a survey of African publication outputs in peer review journals and conference proceedings (grey literature), providing a quantitative (traceable over time) proxy for activity (e.g., research by application area, research by country). Surveying the literature might also help in determining the productivity of African RS research centers, as well as identifying the earth observation data upon which the authors most frequently rely. Furthermore, a bibliometric review that takes note of funding acknowledgements quoted in the papers could provide details on sources of financial support for African RS research, as well as other international collaboration patterns.

2.2.1 Remote sensing activity and capacity

As summarized in Table 2.1, remote sensing activities in Africa have been characterized into four broad areas:

- Geospatial technical authorities/specialists
- Projects, initiatives, and investments
- Thematic networks
- Existing geospatial services

To keep the report more readable, some details are provided in appendices. The details hopefully will be useful for follow-up scoping work of the African geospatial sector.

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Table 2.1 Structure of overview of remote sensing activity in Africa

Category		Details
Geospatial technical authorities/specialists	Government organizations (e.g., African remote sensing authorities)	Appendix 1 – National geospatial "entry points"
	National research institutes	
	Universities	
	Regional technical centers	
	Private sector	
Projects, initiatives, and investments	Regional initiatives	Appendix 2 – Projects, initiatives, investments
	Bilateral aid projects	
Thematic Networks	Communities of practice; research domains	Appendix 3 – Thematic networks
Existing geospatial services	Metadata clearinghouses	Appendix 4 - Geospatial services
	Other services and portals	

The table above is not comprehensive. It only provides an overview. There is no 'one-stop-shop' for information on remote sensing/earth observation activities in Africa, so one must spend considerable time identifying projects and programs in different market and domain segments, key partners, as governments restructure and leadership changes, and reliable and effective services, as technologies evolve. Given the scope and depth of activity taking place, a 'one-stop' mechanism enabling queries on '*who is doing what where- and who is funding it*' would be very useful, saving many different parties the effort of doing their own, individual sector surveys.

2.2.2. African geospatial technical authorities/specialists

Government organizations (e.g., African remote sensing authorities)
In the last five years, a number of African space programs have flourished. Prior to this, space technology was considered expensive, and consequently few African nations had space initiatives. In 1999, the Nigerian government established a fully functional National Space Research and Development Agency (NASRDA), under the Federal Ministry of Science and Technology (FMST). At the same time, the National Space (NSC) was established as the apex organization responsible for overseeing NASRDA and all other space technology activities in the country. The Nigerian president himself serves as the chairman of the National Space Council, and space technology is seen as a catalyst for economic transformation. In 2006, the South African cabinet gave the green light for the establishment of South Africa national space agency. Pontsho Maruping, the chief director responsible for frontier programs in South Africa's Department of Science and Technology said, "This is not just about prestige. There is recognition that space is an essential tool for decision making and it is a useful tool for developing countries (Zim Observer News, 2006)."

Across Africa, there are more than twenty national space agencies (and national remote sensing agencies) (Table 2.2), as well as regional centers and universities with special expertise in geospatial technologies. Presently, a number of Africa countries are members of the Group on Earth Observations (GEO): Algeria, Cameroon, Central African Republic, Egypt, Guinea-Bissau, Mali, Mauritius, Morocco, Niger, Nigeria, Republic of Congo, South Africa, Sudan, Tunisia, Uganda[3].

African satellite engineering teams have begun to design and develop earth observation satellites and set up ground receiving stations in Africa (see Table 3). Algeria launched its first earth observation satellite, AlSat-1, in 2002, and Nigeria soon followed with NigeriaSat-1, in October 2003 (though not without some controversy, given the expense and the poverty in the country[4]). With the successful launches of AlSat-1 and NigeriaSat-1, and the media attention that went with it, there has been a significant increase in the awareness of decision makers and civil society in the applications of geospatial technologies. Other countries, too, soon will join the ranks of Algeria and Nigeria. Egypt's first earth observing satellite, Egyptsat-1, will be launched this year (2007), as will South Africa's SumbandilaSat. Algeria also has invested in two small high-resolution satellites, which will be launched in 2008, and Nigeria already has a second generation satellite underway, NigeriaSat-2, which is scheduled for launch in 2009 and will deliver higher-resolution imagery. Fifty-five Nigerian engineers are undergoing training in China, which is part of Nigeria's plan to eventually be able to manufacture and launch its own satellites.

[3] http://www.earthobservations.org/membership/members.html
[4] Nigeria's satellite launch. Boon or a boondoggle? The Economist, September 11, 2003, http://economist.com/World/africa/displayStory.cfm?story_id=2055248

Table 2.2 African national remote sensing authorities or facilities.

Country	National remote sensing authority or facility
Algeria	Centre National des Techniques Spatiales (CNTS)
Benin	National Center for Remote Sensing and Forest Cover Monitoring (CENATEL)
Botswana	Department of Surveys and Mapping, Ministry of Lands & Housing – tender currently being implemented to establish remote sensing infrastructure
Cameroon	Centre de Teledetection et de Cartographie Forestiere (CETELCAF), Office National de Developpement des Forets (ONADEF)
Dem. Rep. of Congo	Agence Nationale de Meterologie et de Télédétection par Satellite (METTELSAT), Ministère des Transports et Communications
Egypt	National Authority for Remote Sensing and Space Sciences (NARSS)
Ethiopia	Ethiopia Mapping Authority (EMA)
Ghana	Center for Remote Sensing and GIS, (CERSGIS) (formerly the Remote Sensing Applications Unit), University of Ghana
Ivory Coast	Centre de Cartographie et de Télédétection (CCT), Bureau National d'Etudes Techniques et du Développement (BNETD)
Kenya	Department of Resource Surveys & Remote Sensing (DRSRS), Ministry of Environment and Natural Resources; Kenya Institute of Surveying and Mapping (KISM), Survey Department, Ministry of Lands
Libya	Libyan Center for Remote Sensing and Space Science (LCRSSS)
Mauritius	National Remote Sensing Centre, Ministry of Agriculture
Morocco	Royal Center For Remote Sensing (CRTS)
Mozambique	Centro Nacional de Cartografia e Teledetecção (CENACARTA)
Namibia	National Remote Sensing Centre, Department of Forestry
Niger	Département de Photogrammétrie et Télédétection, Institut Géographique National du Niger (IGNN), Ministère de l'Equipement, du Transport et de l'Amenagement du Territoire
Nigeria	National Space Research and Development Agency (NARSDA)
Rwanda	Centre for GIS and Remote Sensing (CGIS), National University of Rwanda (NUR)
Senegal	Centre de Suivi Ecologique (CSE)
South Africa	CSIR Satellite Applications Centre (SAC); CSIR Earth Observation Data Centre (EODC), Institute for Satellite and Software Applications (ISSA); (National Space Agency soon to be established)
Sudan	Technical Authority for Remote Sensing
Tunisia	Centre National de Télédétection
Zimbabwe	Geo-Information and Remote Sensing Institute (SIRDC)

Table 2.3 African satellites and ground receiving stations[5].

Country	Technology	Year of launch	Details of satellite or ground receiving station
Morocco	Satellite	2001	Maroc-Tubsat[6] - earth RS and vegetation detection with medium resolution of c.300m. Cooperation between CRTS Morocco & Institut für Luft-und Raumfahrttechnik in Berlin (Moroccan side responsible for payload & launch; German side for satellite bus).
Algeria	Satellite	2002	AlSat-1 – research
	Satellite	2008	AlSat-2 – fully operational, not only research. Approx. 25 Algerian aerospace engineers with EADS Astrium for 32 months, as part of contract between EADS Astrium and Algerian space agency (ASAL) for production of two small high-resolution EO satellites. Alsat-2 spacecraft[7], with scheduled five-year service life, will utilize Myriade small-satellite platform and provide B&W images with 2.5-meter ground resolution for CNTS (Centre National des Techniques Spatiales)
Nigeria	Satellite	2003	NigeriaSat-1
	Satellite	2009	NigeriaSat-2
S. Africa	Satellite	2007	SumbandilaSAT
Egypt	Satellite	2007	EgyptSat-1, high resolution multispectral imager, built by NARSS in collaboration with Ukraine (Ukraine providing technical expertise and training). Total price: US$ 30 million[8].
	Ground receiving station	1999	Ground station in Aswan, built by NARSS to acquire & record data from SPOT constellation, as well as ERS-2 and LANDSAT-7 satellites. Data collected in Aswan are transferred to processing facility in Cairo for image archive, catalogue, and high-quality image generation in standard product formats. Footprint for reception is 2500 km diameter, covering northeast Africa, Mediterranean, and parts of Asia. Construction cost of ground receiving station estimated at LE15 million (in 1999). The station, at the time, was the 2nd in Africa – the 1st being in South Africa.
Rwanda	Ground receiving station	2006	METEOSAT 8 (2nd generation) installed at CGIS-NUR. National Meteorological Service & National University of Rwanda (NUR) Faculty of Science main partners in this effort. Ground station receives complete coverage of Rwanda each 15 minutes with high spatial and spectral resolution. ITC provided technical support
Senegal	Ground receiving station	2005	Reception of radar satellite images, since December 2005. Collaboration between Centre de Suivi Ecologique (CSE) and European Space Agency.

[5] In addition, the German Remote Sensing Center installed an 8-m transportable antenna ground receiving station at the ESA Equatorial center in Gabon. It collects ERS SAR data in support of the ESA "Trees" and Central African projects. The ESA station originally was installed in Gabon in 1987.

[6] http://fred.unis.no/AGF218/lecture4_2_MAROC_LAPAN.pdf; http://www.ilr.tu-berlin.de/RFA/MAROC-TUBSAT/MAROC-TUBSAT.htm; http://www.ilr.tu-berlin.de/RFA/index.htm; http://www.ilr.tu-berlin.de/RFA/archive_date.htm

[7] http://www.space.com/spacenews/archive06/Algeria_020606.html; http://www.magharebia.com/cocoon/awi/xhtml1/en_GB/features/awi/features/2005/12/14/feature-01

[8] Source of estimate: Shaltout, M. A. Mosalam, 2004. Space Misions in the Arab Countries. Abstract submitted to COSPAR, 18-25 Jul 04, Paris, http://www.cosis.net/abstracts/COSPAR04/00488/COSPAR04-A-00488.pdf

Kenya	Satellite tracking station	1964	Malindi, Kenya (Broglio) space centre / San Marco Project, owned by the Agenzia Spaziale Italiana (ASI). ASI employs 230 workers, of whom 20 are Italians. The Italian staff are backed by several Kenyan technicians who are trained and based at the facility. One of the satellites monitored at the station covers the Horn of Africa region from Djibouti to Madagsacar. All remotely sensed data archived at the facility are available free of charge to the Kenyan research community and relevant government institutions.

By pursuing this route of launching their own EO satellites, Africa is demonstrating that it is prepared to join the league of 'sensing' countries, moving out of the former class of being a totally 'sensed' continent. An African real-time EO infrastructure is emerging, one that is "based on African priorities, brain attraction rather than brain-drain, and African industry development (Woldai and Lance, 2007)." This is in line with the proverb of 'teaching a man to fish,' rather than just giving him fish. In the past, much geospatial capacity development work in Africa focused on improving the dissemination of U.S. and European imagery in Africa, appealing to African scientists' open arms for free data. However, more emphasis now can be directed at building Africa's own EO infrastructure, including potential market mechanisms for sustaining imagery availability.

Furthermore, African countries are working together to employ space technologies. South Africa, Algeria, Nigeria, and Kenya jointly are part of the African Resource Management (ARM) constellation. Their cooperation is resulting in a critical mass of micro-satellite engineering, and other countries also are poised on the 'sensing' horizon. This regional approach will facilitate the coordinated reception of imagery, as well as product development on a continent-wide basis. Figure 2.1 provides a continental view for data reception (still hypothetical). Regarding product development, Nigeria's recently tabled plans to receive MODIS data could enable the adoption and extension of products from the highly successful CSIR SAC-developed Advanced Fire Information System (AFIS) (Fortescue and Ntisana, 2005, p.107).

Nigeria organized the 1st African Leadership Conference on Space Science and Technology for Sustainable Development (Abuja, Nigeria, November 23-25, 2005). Similar such gatherings of African space technology representatives are likely to follow, especially if the proposed African Institute for Space Science (AISS) is established[9]. The NEPAD Office of Science and Technology (2006, p.36) recognizes that "space science provides a unique vantage point from which to study the natural environment on the grandest possible scale and from which to deliver communications. By its very nature, space provides a platform for addressing problems of a regional perspective." Therefore, NEPAD currently is exploring the feasibility of establishing AISS. AISS would be aimed at grouping existing space science activities and facilities into a network that focuses on greater collaboration within Africa to increase the capability of countries to harness space technology for development, without crippling investments for any individual country.

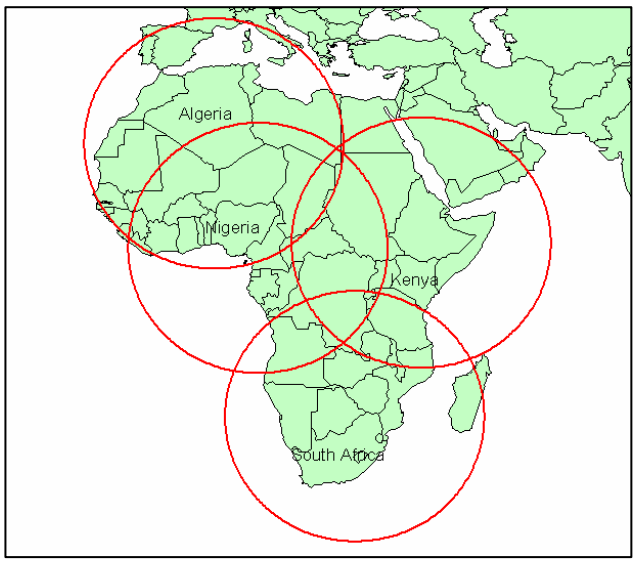
Other African national technical institutes

In addition to the operational space centers and specific national remote sensing authorities, a wide range of other institutions are immediate users of RS/EO imagery or are end-users of derived products. Most users of imagery or derived products are within

[9] http://www.nepadst.org/platforms/aiss.shtml

specialized thematic research centers[10], such a meteorological offices[11], agricultural institutes[12], and water institutes. National offices for geological survey also are a major user group. These research centers tend to work through separate networks; the scientists attend domain specific conferences (e.g., climate outlook forums, biodiversity conservation symposiums, water management workshops, etc.) and do not interact across-theme as much as they could. Rather than list a jumble of institutes at this time, Appendix 1 provides a list of national associations and committees (and mapping organizations known to be advocating spatial data infrastructure) that focus on improving cross-domain dialogue between national geospatial technical specialists. These are potential national "points of entry" in the geospatial arena. Countries without information at this time do not necessarily mean that a mechanism for communication is lacking, rather details were not known.

Figure 2.1 Hypothetical reception for the African continent with coordinated reception activities in South Africa, Algeria, Nigeria, and Kenya (Fortescue and Ntisana, 2005, p.107)



African universities (and national training facilities)

Many universities are actively engaged in remote sensing research. While not exhaustive, Table 2.4 gives an indication of some universities involved. The proceedings of the 6th African Association of Remote Sensing of the Environment (AARSE) Conference[13], held in Cairo, Egypt, October 30-November 2, 2006, provide details of African researchers and

[10] For information on individual institutes, the following links may be of use: ESA EO applications development unit - data users, http://dup.esrin.esa.it/usersintro.asp; National Research Council, 2002: Table 3-2; Table 3-3; Table 3-4 - Organizations, Programs, and Activities Using Geographic Data.

[11] http://www.icpac.net/Contact_Info/contact_info.html

[12] e.g., Centre National de Recherches et de Développement Agricole (CNARDA) (Mauritania), Institut Togolais de Recherche Agronomique (ITRA) (Togo), Institut du Sahel (INSAH) (Mali), Institut d'Economie Rurale (Mali), Laboratory for Remote Sensing and Geographical Information System, Agricultural Research Institute- INERA (Burkina Faso); Laboratoire de Farcha (Chad), Kenya Agricultural Research Institute (Kenya), etc.; further information on institutes agricultural institutes at http://www.secheresse.info/rubrique.php3?id_rubrique=122

[13] http://www.narss.sci.eg/aarse2006/pdf/program.pdf

their university affiliation, as well as the research being conducted. The Réseau Télédétection de l'Agence Universitaire de la Francophonie also provides information[14].

Table 2.4. Sample of African universities involved in RS research/application development.

Country	African University
Botswana	Department of Environmental & Geographical Science, University of Botswana (Dr. Pauline Dube)
Cameroon	Centre Universitaire de Recherche et d'Application en Télédétection (CURAT), Université de Cocody-Abidjan, http://centre-curat.salifa.com/
Democratic Republic of Congo	Ecole régionale post-universitaire d'aménagement et de gestion intégrés des forêts et territoires tropicaux (ERAIFT), University of Kinshasa, http://www.unesco.org/mab/ecosyst/forest/eraift.shtml
Mali	Département de Géographie, Université du Mali
Mozambique	Department of Geography, Eduardo Mondlane University
Nigeria	Space Applications and Environmental Science Laboratory (SPAEL), Obafemi Awolowo University, Ile-Ife, http://www.spaeloauife.org/
Nigeria	Federal University of Technology (Dr. Peter Adeniyi)
Rwanda	Center for GIS, National University of Rwanda
Senegal	Laboratoire d'Enseignement et de Recherche en Géomatique (LERG) de l'Université Cheikh Anta Diop de Dakar
South Africa	School of Architecture, Planning and Geomatics, University of Cape Town (Dr. Heinz Ruther)
	Department of Electrical and Electronic Engineering, Stellenbosch University (Dr.Sias Mostert)
Swaziland	Department of Geography and Environmental Science, University of Swaziland
Tanzania	Department of Geology, University of Dar es Salaam (Dr. Evelyne Mbede)
Tunisia	Space Information System and Remote Sensing Laboratory (LTSIRS), National Engineering School of Tunis
Uganda	Geography Department, Makerere University

South Africa's Stellenbosch University and its commercial subsidiary, SunSpace, is developing a range of three types of low cost microsatellites costing up to $15 million, using miniaturised optics and compact electronics. They are the 35kg High Spectral Resolution satellite, MXsat, with a 4m resolution; the High Temporal Resolution Satellite, 2.5m resolution MSMIsat, a 100kg microsatellite, available for launch in 2007; and 6.5m resolution, 60kg Mobile Multispectral Satellite, MmSat, being proposed for an African Resources Management satellite constellation.

Several universities are playing a leading role in improving spatial data infrastructure at the national level. For instance, in June 2006, Makerere University held a national spatial data infrastructure workshop and initiated an effort to form a GIS association, as did the Polytechnic of Namibia, when it hosted the 1st Namibian GIS User Conference in October 2005. Similarly, the University College of Lands and Architectural (UCLAS) organized a national spatial data infrastructure workshop in 2003 where remote sensing, GIS, and statistical data specialists discussed issues of data standards, data access, and data coordination. The Center for GIS at the National University of Rwanda, an inter-faculty unit, aims to develop a GIS and RS curriculum for instruction and assist national

[14] Réseau Télédétection de l'Agence Universitaire de la Francophonie, created in 1988 by the Agence Universitaire de la Francophonie, http://www.reseautd.auf.org/article.php3?id_article=48

institutions by providing training in the application of GIS tools to current problems in Rwanda. They also are establishing links between universities, research institutes, government and non-government organizations to improve data sharing and the coordination of activities, and part of their effort is to establish a geospatial metadata/data portal. The Institute of Computer Sciences, University of Nairobi (Kenya), Department of Environmental & Geographical Science, University of Botswana, Department of Geography, National University of Lesotho, and University of Zambia also have played important roles in metadata training of technicians in national agencies.

Universities also have been central to strengthening thematic networks, such as fire monitoring (SAFNet[15], University of Bostwana). In the early 2000's, the SADC EIS Training and Education Sub-program (SETES) received support to encourage networking among universities involved in GIS/remote sensing, but this was one of the few initiatives directly centered on universities. Recently, though, there has been renewed interest in the role that universities play (or can play). For example, the main aim of the newly established University Network for Disaster Risk Reduction in Africa (UNEDRA)[16] is to forge interaction amongst universities in Africa with interest in teaching on disaster risk reduction, through information sharing, capacity building and collaborative research. The Association of African Universities (AAU), currently has funding for an initiative entitled, 'Capacity Development Project for the Revitalisation of African Higher Education Institutions (AAU-CADRE).' Also, DFID's new Development Partnerships in Higher Education (DELPHE)[17] initiative is an indication that greater attention is being given to strengthen universities to stimulate research, facilitate dialogue, and promote science and technology. Universities are seen as key engine rooms of the fight against global poverty; therefore addressing Africa's development challenges requires the creation of a new generation of universities that focuses on solving community problems (Juma, 2005). A report from ISNAR stressed that "in an increasingly competitive world, universities cannot afford to be seen as purely academic institutions only; they are also expected to organize their considerable human and material resources in order to contribute materially to national research and development objectives (Michelsen et.al., 2003, p.1)."

African regional technical centers

While universities serve as engine rooms at the national level for RS research, regional technical centers have been major kingpins. Regional centers have been the mainstay for imagery distribution within Africa, training and capacity building, and to some degree research. The most prominent regional geospatial centers are listed in Table 2.5. With more time, the activities and outputs of the centers could be itemized and compared, but that was not possible during the time available for this overview. Some details are mentioned in the sub-section on "Training and capacity building".

In addition to the centers listed in Table 2.5, there also are a number of regional technical centers with RS/GIS labs under the auspices of international organizations, and these often are staffed in part with African scientists. Among these centers are those of the CGIAR, such as the International Water Management Institute (IWMI) in South Africa; International Crops Research Institute for Semi-Arid Tropics (ICRISAT) Mali, International Institute of Tropical Agriculture (IITA) in Nigeria, International Livestock Research Institute, Kenya and Ethiopia, and the World Agroforestry Center in Kenya. The Coopération

[15] http://safnet.firetab.net/
[16] http://www.itc.nl/unu/dgim/unedra/default.asp
[17] http://www.dfid.gov.uk/news/files/pressreleases/pr-15m-higher-education.asp

Internationale en Recherche Agronomique pour le Développement (CIRAD) also has a research center in Africa with RS expertise.

Table 2.5 African regional technical centers.

Country	Regional center
Algeria	African Organization of Cartography and Remote Sensing (OACT)
Botswana	SADC Regional Remote Sensing Unit (RRSU)
Burkina Faso	Centre SIG et Télédétection Adjaratou
Chad	Remote Sensing Unit, Lake Chad Basin Commission
Congo	Observatoire Satellital des Forêts d'Afrique Centrale (OSFAC)
Egypt	Center for Environment and Development for the Arab Region and Europe (CEDARE)
Niger	Sahelian Agricultural, Hydrological and Metrological Centre (AGRHYMET)
Niger	African Centre of Meteorological Application for Development (ACMAD)
Kenya	Regional Centre for Mapping of Resources for Development (RCMRD)
Kenya	IGAD Climate Prediction and Applications Centre (ICPAC), formerly known as the Drought Monitoring Centre Nairobi (DMCN)
Kenya	Institute for Meteorological Training and Research (IMTR)
Morocco	African Regional Centre for Space Science and Technology Education (CRASTE-LF)
Nigeria	Regional Centre for Training in Aerospace Surveys (RECTAS)
Nigeria	African Regional Centre for Space Science and Technology Education (ARCSSTE-E) (2005 Annual Report)
Tanzania	Southern and Eastern African Mineral Centre (SEAMIC)
Tunisia	Centre Régional de Télédétection des États de l'Afrique du Nord (CRTEAN)
Zimbabwe	SADC Drought Monitoring Centre

In addition to the centers listed in Table 5, there also are a number of regional technical centers with RS/GIS labs under the auspices of international organization, and these often are staffed in part with African scientists. Among these centers are those of the CGIAR, such as the International Water Management Institute (IWMI) in South Africa; International Crops Research Institute for Semi-Arid Tropics (ICRISAT) Mali, International Institute of Tropical Agriculture (IITA) in Nigeria, International Livestock Research Institute, Kenya and Ethiopia, and the World Agroforestry Center in Kenya. The Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) also has a research center in Africa with RS expertise.

Private sector

Recent investments in digital mapping products and services in African countries lend support to the growth and potential of the geospatial market. Private companies (e.g., TRAXmap, LeadDog) are developing road/street databases for African users. These foreign companies have entered the African market presumably because they have determined that their efforts will reap adequate return. African-owned companies also are tapping into the market, in both product and service development (e.g., MapIT[18], CEASER-MAP[19]). South Africa-based MapIT has signed a license and distribution agreement with Tele Atlas. MapIT is trying to build a seamless street-level map of the whole of Africa to support the development of location base services. The company already established an office in Nigeria, and will eventually open in Ghana and Kenya as well. Other African companies enter the market via distribution and sub-reseller

[18] http://www.map-it.co.za/
[19] http://www.ceaser-web.com/

agreements with various image suppliers, typically in the high-resolution sector, and with various software vendors. For instance, ABSYS-STAR Informatic[20], based in Burkina Faso, has become a distributor of STAR software in 12 Western African countries.

Quality Standards Information Technology (QSIT), a Cairo-based ICT consulting company and also the ESRI distributor for Egypt, focuses upon developing specialized, custom, enterprise-level GIS, cadastral and telecom applications. The company's future target is to "penetrate more markets in Northern and Eastern Africa, in addition to the Gulf area, such as Libya, where we already have a branch, Sudan, Namibia, KSA, Bahrain, United Arab Emirates and others."

Several foreign companies have set up offices in Africa. MAPS geosystems[21], headquartered in Munich, Germany, has production facilities and subsidiaries in Conakry and Dakar. The company covers all geographic data development stages, from satellite imagery, aerial photography and field survey by its own teams, to asset mapping, in-house software development and system integration. It is the exclusive distributor of QuickBird satellite imagery for sub-Saharan Africa, and a reseller and system integrator for major GIS and geo-spatial industry software providers.

When the Regional Director of U.K.-based ImageAfrica[22] was interviewed about the company's decision to establish a site in East Africa (Sipkes, J., 2005), the Regional Director said:

> "It was felt that there existed a strong need for a set-up like this, and a huge potential for growth. We are an independent company, resellers for Space Imaging and have full access to all other satellites like SPOT, Landsat, Ikonos, QuickBird, IRS & Eros, ASTER, ENVISAT, MERIS, MODIS and RADARSAT and many more. For aerial imagery we work closely with a local company with good expertise here, so we cover the whole image-market sector. On top of this, we are the representatives for ENVI and IDRISI software. We consider Kenya a stable country and an ideal local hub from which to penetrate the whole region. Besides, a lot of agencies in our field have their offices here, such as HABITAT and UNEP. Our long-term vision is to spread out, with other offices, into various parts of Africa. You must have noticed that we called our company ImageAfrica, not Image East Africa, which indicates our long-term strategies."

After East Africa, ImageAfrica intends to set up offices in South Africa. Their plans for West Africa have yet to be worked out. Most satellite imagery demand is coming from project-related developments financed by outside sources with donor money, such as the individual governments of donor countries, World Bank, the European Union, United Nations agencies, the African Development Bank and others. ImageAfrica anticipates that as African economies further develop, more demand will come from the private sector, like the big, worldwide operating mining houses and multinational agro-businesses. At the moment, the company is aiming at agriculture and forestry, risk evaluation and hazards, mineral and water exploration, clients linked to environmental aspects and, last but not least, cartography for utilities and urban planning.

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[20] http://www.absysbf.com/; http://www.star.be/FR/pdf/STAR_Press_Release_46.pdf
[21] http://www.maps-geosystems.com
[22] http://www.imageafrica.com/

African networks (user groups)
Immediate users and end users need to be clearly defined (Rijks et. al., 2003). In a Kenyan survey of the geospatial community, demand for 'digital imagery' was lower than the demand for 'land cover' (Highland Surveyors, 2003), demonstrating that immediate and end users are distinct communities (and also that there is a larger user base for derived products). However, for the purpose of this overview, a distinction was not made. Time was invested in assembling information on the various thematic networks (communities of practice) that rely upon digital imagery (see Appendix 3). With more time, the specific needs of these individual networks could be explored (see, for example, Section 4, Table 15), as well as the outputs and outcomes of these networks, given their use of satellite imagery.

2.3. Projects, Initiatives, and Investments

Over the past decade, significant investment in geospatial technologies has been made in Africa, both from central governments and international development partners (banks, aid agencies) (Geographical Survey Institute, 2004; Cristiansen and von Teeffelen, 2003; National Research Council, 2002; Abiodun, 2000). The latter is the most important source of funding for RS activity in most African countries. A 2005 UNESCO study reported that approximately 60% of funds for research (in general) in Africa came from external sources (UNESCO, 2005). This is likely the case for Africa's remote sensing activity; in fact, this percentage would be much higher if North Africa and South Africa were analyzed separately from the rest of Africa.

Although there is a diverse set of international contributors to RS activity in Africa, particularly from Europe, when one reviews the fields of the multilateral and bilateral aid project databases, it is difficult to identify RS/EO projects. The project metadata is not sufficiently detailed to single out project components dealing with geospatial technologies, although in some cases, it is quite clear that the whole project is "geo-oriented." Appendix 3 highlights, in a very coarse way, a number of recent RS/EO/geospatial investments in Africa.

Government investment
African governmental sources contribute to sustaining RS/EO capacity through the provision of salaries for geospatial specialists[23], and to some degree core support to institutions. Government commitment to RS varies considerably between countries, but data currently available are too limited to establish any clear pattern in this respect.

The only information we have to address the topic of government investment in geospatial technologies is from the NOAA survey results for African public sector (government) investment. It is very difficult to provide figures on government investment in geospatial technologies, because the data are not available. Slightly better information is available on estimates of government investment in ICT, and geospatial can be viewed as a portion of that amount. However, investments in geospatial technologies often are considered part of an agency's programmatic budget, not ICT budget.

[23] Although salaries are covered, 92.1% (median) of African scientists characterize their salaries as inadequate (UNESCO, 2005).

Surveys indicate that the number of 'geospatial' employees within agencies is expected to rise between 2005 and 2010, and clearly salaries would need to cover this added staff (Global Marketing Insights, Inc., 2005). Approximately 37% of the respondents relied upon free data in 2005, and 22% on free software; 70% of the respondents anticipate spending more funds on data and software by 2010. The NOAA 2005 remote sensing survey indicated that the most anticipated impact, come 2015, on the geospatial community is that remote sensing data will become a commodity (Global Marketing Insights, Inc., 2005).

2.4. Existing Geospatial Services

Moving beyond the organizations involved in producing and using RS/EO data, this section delves (a bit) into existing data discovery services (metadata clearinghouses), map services, and application services (decision support tools) that are available in Africa. Details are provided in Table 2.6 and Appendix 4. The emphasis is on services that have been developed by African initiatives, as opposed to global geospatial services that also make a significant contribution. Note as well that some services listed are those that provide an information product (i.e., bulletins or briefs) in the form of a pdf file, as this product may be more appropriate for some users than an interactive geo-service.

Table 2.6. Sample catalog, data, portrayal, and decision support services

Service / Provider	**Service Description / Link**
Système de Gestion Intégré de l'Information Agricole et Rurale (Algeria)	http://www.sgiiar.org/ http://www.sgiiar.org/geodataaccess/
SWALIM (Somalia)	http://geonetwork.faoswalim.org:8080/geonetwork/srv/en/main.home
ICRAF GeoNetwork	http://geonetwork.worldagroforestrycentre.org/icraf/srv/en/metadata.show?id=185
ILRI GeoNetwork	http://geonetwork.ilri.org/ilri/srv/en/metadata.show?id=317
CARPE	http://maps.geog.umd.edu/metadataexplorer Metadata Explorer
Global Forest Watch	http://www.globalforestwatch.org/english/index.htm Statistics on natural forests and the trends in deforestation. The site provides gobal data with specific data for Cameroon and Central Africa. Map maps are available.
Africover	http://www.africover.org/ Harmonized land cover products; satellite imagery; image interpretation/Land Cover Classification System
Mapping Malaria risk in Africa (MARA)	http://www.mara.org.za/
East Africa Livestock Early Warning System (LEWS)	http://glews.tamu.edu/africa/

Desert Locust Early Warning System[24]	http://www.fao.org/ag/locusts/en/info/info/index.html
Humanitarian Early Warning System	http://www.hewsweb.org/
Famine Early Warning Systems Network	http://www.fews.net Timely, early warning and vulnerability information, Images, Tabular, Data - NDVI, RFE, WRSI - Atlas of Limpopo Basin, reports
African Data Dissemination Service	http://earlywarning.usgs.gov/adds/ NDVI (Normalized Difference Vegetation Index), moisture, rainfall, malaria and other imagery for Africa
East Africa an operational crop yield monitoring and forecasting system (CYMFS)	http://www.edpsciences.org/articles/agro/pdf/2005/01/a03021.pdf
Mapping malaria risk	http://www.mara.org.za/
Rift Valley Fever Monitor	http://www.geis.fhp.osd.mil/GEIS/SurveillanceActivities/RVFWeb/indexRVF.asp
EUMETCast	http://www.eumetsat.int/Home/Main/What_We_Do/EUMETCast/index.htm?l=en
Global Land Cover Facility (GLCF)	http://glcf.umiacs.umd.edu/index.shtml Develops and distributes remotely sensed satellite data and products concerned with land cover from the local to global scales.
Country and Region-Specific Food Security Monitoring Systems, (FIVIMS)	http://www.fivims.net/

The developers of these different spatial decision-support systems are talking to each other, discussing the different bulletins, and trying to identify what gaps exist in the models, tools, and products (Tefft et. al. 2006; International Research Institute for Climate and Society, 2006; U.N. International Strategy for Disaster Reduction, 2006; Hendrickx and Rosema, 2004; Heimo and Holecz, 2004; Rijks et. al., 2003). Some have proposed the need for an integrated continental early warning system for Africa (Cilliers, 2005). Also, there are discussions on how to better integrate earth observation systems in Africa (Saloum, 2005).

Training and capacity building

Collecting comparable data on training efforts is a significant challenge. The quality of information available from individual organizations varies, and there are considerable omissions.

Over the years, a number of regional training centers (see Table 2.5) have established comprehensive training programmes in remote sensing and other aspects of space science. Courses for post-graduate diplomas, as well as short courses (several days) are

[24] Ceccato, P., Cressman, K., Giannini, A., Trzaska, S. (2007). The Desert Locust Upsurge in West Africa (2003-2005): Information on The Desert Locust Early Warning System, and The Prospects for Seasonal Climate Forecasting. International Journal of Pest Management, 53(1): 7-13.

offered. The fact that these centers have sustained activities indicates both that there is demand for the training and that governments, bilateral programs, and foundations are willing to invest in training.

Between 1975 and 2003, through its Training and Research Department, AGRHYMET has trained 820 Higher Technicians and Engineers in Agro-meteorology, Hydrology, Instrumentation and Crop Protection (Dieye, 2005). Table 10 provides a bit more detail as to the number of those trained by country and year at Regional Centre for Training in Aerospace Surveys (RECTAS). Such details were not readily available for the other training centers. We also provide details of training conducted at the International Institute for Geo-Information Science and Earth Observation (ITC)[25].

RECTAS was established in 1972 under the auspices of the UN Economic Commission for Africa (UN) with a mandate for training, research, consultancy and advisory services in geoinformatics. The Centre is supported, in part, through contribution from member states: Benin, Burkina Faso, Cameroon, Ghana, Mali, Niger, Nigeria, and Senegal. Table 2.7 shows number of students trained at RECTAS in the past 10 years.
The courses are bilingual, English and French, and are conducted at several levels:

- Technician Diploma Course (18 months)
- Technologist Diploma Course (18 months)
- Post-Graduate Diploma Course (12 months)
- Short courses (one day to several weeks)
- Masters Programme (two years in collaboration with ITC in the Netherlands)
- Web-Based Distance Learning (planned).

Table 2.7. Students trained at RECTAS in the past 10 years, at technician, technologist and post-graduate diploma levels (combined).

Country	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Total**
Benin	3	5	6	6	2	6	2	8	3	8	49
Burkina Faso	3	2			2	4	2	4	6	6	29
Cameroon	4	3	7	12		17	2	21	1	1	68
Ghana		3	4	2	1	3	1	5	3	4	26
Mali	1	4	3			2	1	1		1	13
Niger						1		1		2	4
Nigeria	32	27	20	14	10	25	10	19	9	15	181
Senegal	2	1	3	3		11	2	7		10	39
Year total	45	45	43	37	15	69	20	66	22	47	409

ITC, based in The Netherlands, is an internationally recognized center of excellence in international education. ITC aims at capacity building and institutional development of professional and academic organizations and individuals specifically in countries that are economically and/or technologically less developed (see Figure 2.8).

Some countries evidently have received more training support. In part, this is because the Dutch government has provided scholarships according to a selected set of countries.

[25] http://www.itc.nl/

Table 2.8. New registrants at ITC, by year

Country	2000	2001	2002	2003	2004	2005	Total
Algeria	1						1
Angola		1					1
Benin	1						1
Botswana	3	2	8	2	6	6	27
Burkina Faso	1	1		2	1	1	6
Cameroon		4	1	3	3	1	12
Cape Verde	1				1		2
Chad						1	1
Congo-Brazzaville	1					2	3
Côte d'Ivoire		2					2
Egypt	28	45	39	17	12	2	143
Eritrea	4	3				1	8
Ethiopia	15	41	39	42	24	31	192
Gambia			1			1	2
Ghana	17	14	14	10	11	28	94
Guinea	1						1
Guinea-Bissau	1						1
Kenya	10	7	7	13	9	12	58
Lesotho			4		3	1	8
Liberia						1	1
Libya	5			11		1	17
Malawi	4	10	3			1	18
Mozambique		1	2	1	7	3	14
Namibia	4	3	8	5	2	5	27
Nigeria	2	10	3	2	5	9	31
Rwanda	1	1			3	5	10
Senegal					1		1
Sierra Leone	2	2	4		1		9
South Africa	11	5	2	3		4	25
Sudan	6	5	5	1		1	18
Swaziland	1	1					2
Tanzania	20	13	20	14	21	26	114
Uganda	13	10	13	26		12	74
Zambia	14	7	16	17	7	12	73
Zimbabwe	15	11	6	6	2	7	47
Year total	182	199	195	175	119	174	1044

In a 2005 user requirements analysis, conducted in Nigeria for the national geospatial data infrastructure, an attempt was made to capture the current level of staff training and the areas of skill needed. As shown in Figure 2.2, image processing and database development came out strongly as areas where additional skills are needed.

At the moment, this overview of training and capacity building is limited to spotty information on training programs and initiatives. It would be useful to conduct a detailed analysis of the various efforts (their structure, content, etc.) and assess their impact, in order to begin to understand what the optimal training mechanisms are. Such a survey

also would identify the investments that are being made in training and the disparities between countries, and the different types of training schemes (e.g., bachelor versus master versus doctoral degrees, short courses, training attachments in overseas laboratories, individual research grants; team-based grants, training center institutional support, equipment upgrades, etc).

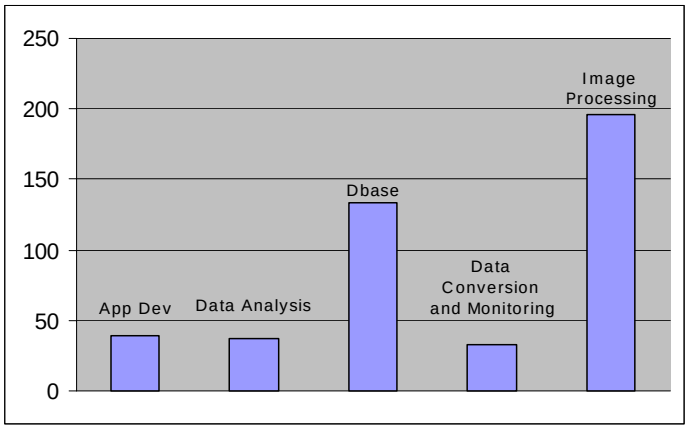

Figure 2.2. Nigerian data infrastructure user skill requirements (GML Projects (& JV) Ltd., 2005).

More emphasis also needs to be placed on coordinating training and capacity building efforts in Africa, particularly those by UN and international organizations (see Tables 2.9 and 2.10). At its 2005 annual meeting, the CEOS Working Group on Education, Training and Capacity Building (WGEdu) reviewed progress made in education and capacity building programs, educational tools and activities of ESA, EUMETSAT, NOAA, UNESCO, UNESCO-IOC, UN-OOSA and USGS and discussed ways of making these resources more widely available, particularly to developing countries (Camacho, 2005). More recently, the Group on Earth Observations (GEO) Capacity Building Working Group has tried to assemble information on many, varied efforts, and put forth a capacity building strategy [26]. The Capacity Building working group has an ongoing survey[27], to capture information on capacity building activities within the EO community.

The Joint Board of Geospatial Information Societies (JBGIS)[28] comprising ISPRS, FIG, ICA, IAG, IHO, ISCGM and IMTA, has set up a committee to advise the Board on capacity building activities in Africa. The mission of the committee is to co-ordinate the capacity building activities in Africa of the members of the Joint Board and to advise the Joint Board on policy issues relating to education in Africa. As part of its activities, the Joint Board is compiling information on capacity building organizations in Africa.

[26] GEO Capacity Building Strategy, http://www.earthobservations.org/docs/GEO-III/Plenarydocs/13-Capacity_Building_Strategy.pdf; http://www.earthobservations.org/roles/cmtes_wgs/cbc.html
[27] http://www.itc.nl/itc_worldwide/geoss.aspx
[28] http://www.fig.net/jbgis/

Table 2.9. Examples of UN 'geospatial' programs in Africa

Organization	Activity
Food and Agriculture Organization (FAO)	Global Land Cover Network - Land Cover Network aimed at proving and developing capacity for harmonized land cover products at National, Regional and Global level. Provide training and workshop to national staff who are involved in the project and capacity is built in the fields of image interpretation, Land Cover Classification System, data management and GIS.Provide internships to University students and provide guidance and assistance in research topics. http://www.glcn.org/
	Africover, http://www.africover.org
	Global Terrestrial Observing System (GTOS) http://www.fao.org/gtos/
	GeoNetwork portal, metadata catalog describing geospatial data, system for searching, editing and publishing geospatial informationhttp://www.fao.org/geonetwork/
UN Economic Commission for Africa (ECA)	Harnessing information for development; CODI-Geo http://geoinfo.uneca.org/
United Nations Environment Program(UNEP)	Africa Environmental Information Network (AEIN), a multi-stakeholder capacity building process, aims to strengthen the capacity of African countries to use quality information on environmental assets to make informed investment choices at sub-national and national levels, and manage these assets on a sustainable basis. http://www.unep.org/dewa/africa/aeoprocess/aein/aein.asp
	DEPHA, http://www.depha.org
United Nations Office for Outer Space Affairs (UNOOSA)	Organizes workshops on disaster management, GNSS capacity building, tele-health, natural resources management, and space law.
UN Educational, Scientific and Cultural Organization (UNESCO)	Global Oceans observing system (GOOS)-AFRICA GOOS are a permanent global system for observations, modeling and analysis of marine and ocean variables to support operational ocean services worldwide. GOOS will provide accurate descriptions of the present state of the oceans, including living resources; continuous forecasts of the future conditions of the sea for as far ahead as possible; and the basis for forecasts of climate change. http://gosic.org/goos/GOOS-AFRICA_program_overview.htm
	UNESCO Crosscutting Project on the Applications of Remote Sensing for Integrated Management of Ecosystems and Water Resources in Africa
UN Office for the Coordination of Humanitarian Affairs (OCHA)	Southern Africa Humanitarian Information Network (SAHIMS), http://www.sahims.net
	Reliefweb, http://www.reliefweb.int/
UN HABITAT	Global Land Tool Network (GLTN), http://www.gltn.net/
	Global Urban Observatories http://ww2.unhabitat.org/programmes/guo/
World Food Program (WFP)	Food Insecurity and Vulnerability Information and Mapping System, http://www.fivims.net
World Health Organization (WHO)	Second Administrative Level Boundaries (SALB) http://www3.who.int/whosis/gis/salb/salb_home.htm

Table 2.10. Examples of activities of international 'geospatial' NGOs in Africa.

Organization	Activity
Global Spatial Data Infrastructure Association (GSDI)	SDI-Africa Newsletter (monthly); GSDI Small Grants (annual); SDI-Africa: an implementation guide; Global Map/GSDI ESRI software grants.
Institute of Electrical and Electronic Engineers: Geoscience and Remote Sensing (IEEE)	GEOSS II Workshop at Africa GIS2005.
International Association of Geodesy (IAG)	Support to the African Reference Frame (AFREF).
International Cartographic Association (ICA)	Mapping Africa for Africa (MAfA).
International Council for Science - Regional Office for Africa (ICSU)	Promotes all activities of the ICSU family: IHDP, IGBP, WCRPD, IVERSITAS, START; host of workshops focusing on data archiving.
International Federation of Surveyors (FIG)	Workshops (e.g., Expert Group Meeting on Transparency in Land Administration – a Capacity Building Programme for Africa, Nairobi, Kenya, 29-31 January 2007)
International Society for Photogrammetry and Remote Sensing (ISPRS)	Rallying 'sister-society' support for joint capacity building efforts in Africa
International Steering Committee on Global Mapping (ISCGM)	Global Map/GSDI ESRI software grants; regional capacity building workshops.
International Union of Geodesy and Geophysics (IUGG)	Geoscience in Africa (GIA), http://www.cig.ensmp.fr/~iahs/smallads/2006GIA.pdf

Existing or potential market drivers

Broadly, there is demand in Africa for EO data in all EO market segments:

- Natural Resources Management: water resources, agriculture, energy and mineral resources, forest resources, environmental monitoring.
- Security: national/international security, humanitarian crisis management, law enforcement, public health.
- Disaster Management: natural disasters, technological disasters, disaster response/damage assessment.
- Asset Management: mapping, urban planning, land use change, infrastructure.
- Meteorology: professional users, commercial users.

Much attention is still given to basic mapping or fundamental datasets, as opposed to thematic or sector specific datasets. Table 2.11 gives an indication of what some countries (Nigeria, Namibia, South Africa, Botswana, and Kenya) perceive the fundamental datasets to be. The demand, arguably, is greatest for these datasets. Imagery was considered a fundamental dataset in three of the five countrie.

In an effort to consolidate user needs for imagery, and to inform decision-making on which sensors should be supported within the public sector, the South African Chief Directorate of Surveys and Mapping conducted a user needs analyses in 2003 and 2004 with the assistance of CSIR Satellite Applications Centre. The user needs for satellite imagery and the desired specification were determined through a number of workshops and a questionnaire survey. The results are provided in Table 2.12.

Table 2.11. Fundamental geospatial datasets of several African countries [Source: HSRC & EIS-Africa, 2006; Highland Surveyors, 2003].

	Nigeria	Namibia	South Africa	Botswana	Kenya
Transportation	X	X	X	X	X
Administrative boundaries	X	X	X	X	X
Hydrography	X	X	X	X	X
Settlements/Population Centres				X	
Topography/Physiography	X			X	X
Elevation/Hypsography	X		X	X	X
Land Cover	X	X	X	X	X
Land Use	X	X		X	X
Geodetic Control	X			X	X
Cadastre and Tenure	X		X	X	X
Imagery	X		X		X
Geographic/Place Names					X
Geology	X	X			
Demography	X				
Utility networks			X		

Recommendations for future community assessment / market study

There is no consensus on the definition of the geospatial industry, but one definition states:

> "The geospatial industry acquires, integrates, manages, analyzes, maps, distributes, and uses geographic, temporal, and spatial information and knowledge. The industry includes basic and applied research, technology development, education, and applications to address the planning, decision-making, and operational needs of people and organizations of all types (Geospatial Industry Workforce Information System, 2007)."

Assessing the geospatial industry in Africa is challenging, because there are no mechanisms to monitor what is taking place. Although many, across a wide spectrum of economic sectors, are using geospatial technologies, they may not characterize their work as 'geospatial'. Surveyors or cartographers may be properly identified. But a civil servant in a ministry of environment or ministry of agriculture doing image processing, in terms of his or her occupation, may be categorized as an environmental scientist or hydrologist, not a 'geospatial specialist.' Businesses involved in software or imagery sales or training are not necessarily identified as being 'geospatial.' Over time, 'remote sensing and earth observation' need to be integrated into job titles and occupational codes. For the time being, though, 'geospatial' professionals remain obscure.

For the US, the Geospatial Information & Technology Association (GITA), a nonprofit educational association, publishes an annual Geospatial Technology Report[29], which independently surveys technology users for detailed project information across the full spectrum of GIS users. The report includes benchmarking metrics and workforce statistics for each of six defined markets: electric, gas, water, pipeline, and telecommunication utilities, as well as the public sector. Information in each industry section focuses on land base accuracy, sophistication, maintenance cycles, application

[29] The 2006 Geospatial Technology Report is provided free of charge to users who completed surveys that provided the data, is available for $299 for GITA individual members and $449 for nonmembers.

usage, and interfaces, as well as the top 10 applications and technologies. In addition, information regarding budgets, data-sharing capabilities, and the top three geospatial issues faced by each market are addressed (Geospatial Information & Technology Association, 2006).

Table 2.12. Satellite imagery user needs (Fortescue and Ntisana, 2005, p.94).

Application	Spatial resolution	Spatial accuracy	Spectral resolution	Temporal resolution
GENERAL MUNICIPAL MANAGEMENT				
Map informal settlements in urban areas	0.6 m	Best possible	RGB	1 – 2 years
Informal dwellings in rural areas	1 m	Geo-referenced	PAN	Every 2 years
Municipal services	1:10 000	<1m	VISIBLE	Annually
DISASTER MANAGEMENT				
Monitor fire/floods	10 m	10 – 20m	RGB, NIR	On request
AGRICULTURAL APPLICATIONS				
Time series/impact studies	3 m	Geo-referenced	All bands	Annual
Degradation of vegetation	5 m	Geo-referenced	All bands	Summer/winter
Agricultural development	5 m	Geo-referenced	All bands	Summer/winter
Subsistence farming	10 m	10 – 20m	All bands	2/year
CLIMATIC APPLICATIONS				
Climatic change analysis	3m	Geo-referenced	All bands	Dependent on time series
INFRASTRUCTURE PLANNING				
Rural development	0.75 m	Geo-referenced	PAN	None
Spatial development framework	15 m (PAN), 30 m (MS) & 60 m (TIR)	Geo-referenced	PAN, RGB, IR	Annual
GIS – erven, roads, buildings, dwellings	1 m (PAN), 4 m (MS)	Geo-referenced	PAN, RGB, IR	Annual
Roads, road markings, encroachment	0.08	0.05 m	Color	1-2 years
WATER USE MANAGEMENT				
Identification and quantification of irrigation	15 – 30 m, otherwise 5 – 10 m	2 – 5 m	All bands	2 per year – winter & summer
LAND USE MANAGEMENT				
Identification of informal settlements	1:20 000	30 m	RGB, TIR, IR	6 monthly

Cary and Associates, a geospatial technology consulting firm, publishes a report on Geotechnology Business Opportunities with Government[30]. This report assesses the size of the industry largely by means of analyzing geotechnology initiatives and budget Information of federal and state government agencies that have a requirement for one or more of the geospatial technologies (GIS, GPS, photogrammetry, remote sensing or surveying) either hardware or software or data or services. In addition to the text of the report, the annual publication also includes up-to-date contact information for people in federal and state agencies that have mapping responsibilities (Cary and Associates, 2006).

Daratech, Inc., a market research and technology assessment firm, publishes an annual report that includes detailed charts and tables illustrate market size, market share, market segmentation, vendor market share within segment, revenue growth forecasts and other vital market data. The report also includes prevailing views of the industry's leading executives (Daratech, 2006).

Another survey sought to clarify the State & Health of the European and Canadian EO Service Industry. It looked at the status of the products and services on offer, working practices, market impact, and underlying economic health of the EO industry. The industrial review aimed to give a comprehensive picture of how the EO Value-Adding Companies operate (development, production, marketing, sales, strategy) and the challenges they face. The financial research was primarily targeted at quantifying revenue sources (sales and development), profitability, expenses and costs within the industry. From this approach a coherent picture of the industry emerged. This study represents the industry over the three-year period from 2000-2002 and sets the foundation for future examination of trends and monitoring of progress towards identified goals (Vega Group PLC and Booz Allen Hamilton, 2005).

Clearly, there are different approaches, and it would be both timely and valuable to consider these approaches towards establishing routine assessments of the RS/EO sector in Africa. Without such assessments, it will not be possible to evaluate the impact of any aid/development interventions or track the natural evolution of the market.

2.5. Questionnaire on Supporting Remote Sensing Needs in Africa

A questionnaire seeking to assess the existing remote sensing capacity, capability, potential and challenges in Africa was prepared by USGS and circulated to the regional centers and other remote sensing data users in Africa via websites, newsletters, and email. The questionnaire is shown in Appendix 5. Subsequently, two of the Regional Centers circulated the questionnaires to their national focal points. Appendix 6 provides a detailed summary of responses for RCMRD.

Response was a little less than hoped for. It was noted by a visiting scientist from Africa that numerous similar surveys have been circulated in recent years and that in addition to burnout, there is some discouragement over a lack of tangible actions resulting from survey results.

[30] A license allowing up to 100 people in one organization to have access to Cary and Associates report, Geotechnology Business Opportunities with Government, is priced at $399.

The feedback from the two Regional Centers' focal points and a general summary of the data collected from the remaining respondents are given below.

Feedback from RCMRD focal points

RCMRD distributed the questionnaire to all its member States' focal points during its Governing Council Meeting held November 2006 in Mangochi town, Malawi. The national focal points of RCMRD are government ministries responsible for lands, surveys, environment and natural resource management. The member States in attendance during the November 2006 meeting were: Botswana, Ethiopia, Kenya, Lesotho, Malawi, Namibia, Sudan, Swaziland, Tanzania, Uganda, and Zambia.

By the time of compiling this report, 8 out of the 11 member States that were given the questionnaire sent feedback. RCMRD also filled the questionnaire.

The key highlights of the feedback are:

- Six out of 8 national focal points reported that they use remote sensing data in their work and research. The two national focal points not already using remote sensing data however, like all others, reported that they would use the data if they had access to the data.
- Access to remote sensing data still remains low. 6 countries reported that they had access to Landsat data through direct purchases, RCMRD and the Satellite Application Centre (SAC), South Africa. 5 countries reported that they had access to high resolution data (mainly QuickBird satellite data) through RCMRD and other agents. All countries did not have access to MODIS and ASTER satellite data. Only one country reported that it had access to other data, citing that it had access to SPOT data.
- All the countries, except two stated that they needed or desired to access Landsat, MODIS, ASTER, high resolution image data and other satellite datasets such as SPOT and AWIFS among others. The two countries left this question unanswered.
- All countries reported that they had problems accessing the remote sensing data, citing poor marketing of the data, high data prices and limited financial resources as the main reasons for this situation.
- Whereas high speed Internet connectivity was seen to have potential to improve access to remote sensing data, some of the countries reported that this had to go hand in hand with making the datasets and Internet connectivity affordable and further making online purchases possible in the countries.
- Other key limitation to use of remote sensing data were:
    - Cost of source data
    - Lack of / limited number of software licenses per institution
    - High cost of software and software upgrades
    - Lack of adequate training in software utilization
    - Inadequate well trained personnel
    - Need for clarity on the applicability / limitations of various remote sensing datasets
    - Need for computers with higher processing capacities that can handle remote sensing data
    - High turnover of remote sensing personnel

- Remote sensing data was mainly used for environmental monitoring and land use / land cover change. Other uses cited are deforestation, biodiversity, urban mapping, map updating, hydrology, watershed management and geology.
- To improve remote sensing data access in the countries and in Africa, the following were proposed:
    - Need for capacity building in ICT and remote sensing data applications
    - Reduction of satellite data costs
    - Establishment of remote sensing committees
    - Increase access to relevant software
    - Increasing the number of local institutions that distribute the remote sensing data
    - Development of African based and operated acquisition systems
    - Upgrading Internet connectivity speeds
- Countries were keen to having timely and affordable (possibly free) access to remote sensing data

Feedback from RRSU focal points

RRSU distributed the questionnaire to clients that are not part of the main contacts points in the Member States. The reason for this was that the needs for RS/GIS applications and support for the national contact points are regularly communicated to the RRSU, and these have been included in other sections of this document. This summary looks at the responses of those who responded to the questionnaire from the SADC region.

There were 15 respondents who all indicated that they use remote sensing products in their work, obtained from one or more of the following sources:

- USGS
- Satellite Applications Centre, South Africa
- RCMRD, Kenya
- RRSU, Botswana
- FFM Botswana (supplier of mainly ESRI products)

Most of the respondents mentioned the need for Landsat, MODIS and ASTER datasets, with access to MODIS mainly hampered by poor internet connectivity.

Respondents mentioned that the uses of the data include topographic map compilation and revision, agriculture (e.g. crop estimates used in food security early warning, biomass production estimations, determining grazing capacity), socio-economic analysis, weather forecasting, geology applications, environmental monitoring (e.g. identifying bush encroachment areas, natural resource inventories), biodiversity applications, land use / land cover change mapping, forestry applications, hydrological modeling, and research in various fields (including some mentioned here).

The responses revealed significant differences in capacity to handle remote sensing data across different institutions in the region. While some sited lack of expertise in handling remote sensing datasets, some indicated that they were comfortable with handling of datasets but pointed to problems in access to data as a major hindering factor. Problems to access to datasets were mainly attributed to data costs and poor internet connectivity. Other problems mentioned are listed below:

- Limitations in ICT hardware capacity (high performance computers and sufficient storage media)
- Poor infrastructure, including receiving stations and communication facilities

- Poor political understanding of the usefulness of remote sensing (this has led to lack of government support in many cases)
- Lack of training in applications for specific needs
- Few RS graduate students due to funding limitations and perceived hard work in RS training
- Lack of RS data in appropriate resolutions to suit target applications
- Low level of awareness of RS related activities

Respondents suggested the following ideas for the improvement of use of remote sensing products:

- Lowering the cost of ICT technology with the aim of improving ICT infrastructure
- Encouragement of younger generations, e.g. through formulation of networks
- Improving access to relevant software by lowering costs or provision of freeware
- Funding programs to facilitate exchange and exposure to RS related activities;
- Setting up a forum for updates on technology and events relevant to use of remote sensing data
- Improving collaboration/linkages between private and public sectors
- Setting up and promoting a web-based clearinghouse facility for relevant datasets
- Establishing local data distribution agents to facilitate easier distribution of remote sensing datasets (national remote sensing centre or other equipped institution could assume this responsibility
- Appraising government authorities on how RS can contribute to national development and achievement of targeted development goals, which will promote government buy-in.

At the time of this survey, stakeholders in Zambia were in the process of establishing a national remote sensing centre and expressed the need for assistance in this effort. Their major needs included access to RS datasets relevant to Zambia and capacity building for data processing.

General feedback

The following is a summary of all of the remaining responses which came from online or hardcopy questionnaires and covers all regions of Africa as well as international respondents.

Nearly all of the respondents use remote sensing data in their work (93%) or feel that access to it would assist in their work (98%). Most (88%) had access to Landsat, with only half or fewer having access to MODIS, ASTER, or high resolution image data (46%, 41%, and 46%). Fewer had access to other RS data (25%). Of those without access, the majority felt the need to access those data (Landsat - 66%, MODIS - 47%, ASTER - 60%, and hi resolution imagery - 79%).

Sources for these data were quite varied, but most could be grouped into three broad categories: freely downloaded from the Internet, made available through participation in specific projects, or direct purchase. Free Internet downloads came from the handful of well known sources: USGS/EROS, NASA, GLCF, etc.. Off-line distribution of free software was also common from sources such as the Regional Centers (e.g., distribution of the GeoCover dataset). Purchasing was not as centralized and included both original source providers and a variety of re-distributors. The purchasing approach was more prominent in the acquisition of high resolution data, since free sources of these data don't yet exist.

Two thirds or better had some type of problem accessing RS data (69%) with 73% agreeing that high speed Internet would improve that access. Cost (84%), available software (48%), and capacity (21%) were significant problems, but others included (see previous sections for additional constraints):

- required datasets not available
- limited preprocessing capabilities
- regional bodies reluctant to provide data
- outdated data
- unnecessarily complicated procurement systems
- lack of government financial support

The entire gamut of uses of RS data was listed. Responses to those explicitly listed in the questionnaire included biodiversity (41%), environmental monitoring (58%), landuse / landcover change (81%), and quantifying deforestation (44%). Other uses included:

- topographic mapping, map updating
- emergency response
- geology
- disease risk assessment
- urban planning
- water resources management
- climate change vulnerability assessment
- crop estimates, food security assessment
- fire monitoring

From a wide range of suggestions for improving data access in Africa, several stood out

- high speed internet access
- improve ICT infrastructure, reduce cost (imagery, software, hardware, and training)
- provide better delivery systems, e.g., national or regional portals or clearinghouses
- improve technical support from existing regional centers; increase financial support to existing regional centers
- better access to more obscure datasets (e.g., ASTER, Corona)
- improve awareness, to general public and government decision makers of the utility of using RS for national management and development
- increase government support for RS , both in government institutions and universities (government “buy-in”)
- much greater development of local (national) capacity to effectively use RS data (universities, workshops, short courses)
- make it easier to share data across institutions (relaxed licensing restrictions)
- development of geospatial data infrastructure

As expected, the RS education and experience of the respondents ranges the gamut from self-taught technicians doing occasional image interpretation to PhDs in spatial technologies in charge of national RS departments. Education in RS was received in both Africa in European universities or less formally in workshops and short courses. Training often combined RS and GIS with greater emphasis on the latter. Some sit on Africa-wide boards such as CODI-Geo or AARSE. Many have been working with remote sensing for well over 10 years. Several have come out of the surveying field. Several use RS as just one of many sources of data for their jobs, e.g., geologists. Most however, are using it in

environmental monitoring or landcover change assessment. It is clear that there is a pool, albeit small, of talented, well educated practitioners in Africa.

2.6. Regional Centers' Needs

2.6.1 AGRHYMET

Background on funding
AGRHYMET is funded by contributions from CILSS member countries; however, the essential budget of the institution is covered by funding from donors such as MIFRAC (Mission Française de Coopération), USAID, the Italian Cooperation, and the Danish Cooperation. AGRHYMET has also managed, to a limited measure, to generate funds by the provision of paid services.

Contribution of the member countries
Originally, member-country contributions were intended to provide the primary funding to support the Center activities. Unfortunately, a large number of countries do not fulfill their obligation suitably or appropriately. Consequently, member contributions represent only about 10% of the total budget. Donor contributions are primarily from USAID, MIFRAC, the Italian Cooperation, and DANIDA (Danish Cooperation)

Needs in remote sensing data/products
Given that the mandate of the Center includes natural resources management, desertification control, growing season monitoring, etc., it is essential for AGRHYMET to have at its disposal all remote sensing data (all resolutions and channels), as well as derived products, and ensuring complete regional coverage. This is a necessity for ARC to improve its capacity to optimize remote sensing usage in the region and adequately ensure the role of a regional node.

Needs in telecommunication infrastructures
It has been determined through this data inventory that the volume that constitutes a regional cover of West Africa of remote sensing data of medium and high resolution is extremely important. To transfer such a volume, and to make the data and derived products accessible to users in the region, it is necessary for ARC to equip itself with sophisticated telecommunication means.

One could think of several options regarding telecommunication means adequate to a role of a regional node. However, according to specialists the best option would consist of equipping ARC with worthy reception, data management, and dissemination systems consisting of:

- A reception system with high-speed bandwidth. [USGS (and others) should send data through a telecommunication satellite that will retransmit the data to AGRHYMET through its reception station.]
- A database management system (including pre-processing, processing, archiving and dissemination)
- Improved Internet connections to facilitate accessibility of ARC site to different users.

Needs in computer hardware and software for data reception and database management

Acquisition of the following software is necessary:

- data flow reception
- pre-processing of data
- management and diffusion of image data on the Internet and diffusion of metadata (i.e. a web interface for data and metadata updating, browsing, printing and downloading)
- software library creation for remote sensing activities: a software ensemble to be used to extract some products from the data
- GIS software such as ArcGIS, Idrisi, and Erdas for both AGRHYMET and its National Components in the nine CILSS countries. Country training should take place at the time countries receive copies of GIS software

Training in remote sensing applications

To ensure an operational and sustainable system requires appropriate human resources and, thus, the requirement for training. Training needs are quite varied. Recommendations regarding training needs are summarized in Table 2.13.

Table 2.13. Training Needs

Type of training	**Beneficiaries**	**Software to master**
Image database management	System Engineers	Spatial database management oriented software
Creation of user oriented products	Remote sensing analysts System Engineers	IDRISI, ArcGIS
Usefulness of created products	Remote sensing analysts	IDRISI, ArcGIS

Training in database management intended for systems engineers should include:

- Training in the use of software for reception and pre-processing of data
- Training in development of software aimed at data use optimization
- Training in implementation and application management of web mapping
- Use of software library applications
- Training in Linux if a Linux server is installed

2.6.2 RCMRD

Background on funding

About 50% of RCMRD's annual budget is funded from member States contributions. The remaining 50% is funded through development partners and internally generated income through projects, consultancy and advisory services, training, and data distribution.

Whereas remittance of contributions by member States has tremendously improved since 2000, the key challenge here remains the timing of the remittances. Most countries do submit their remittances on time, i.e., at the start of the financial year. This in a way stifles

the operations of the Centre forcing it to rely on savings from the previous year, begin the year by implementing programs that require minimal funding, prepare and submit project proposals to development partners, and step up its effort in income generating activities.

The key challenges of sustainable funding of the Centre are:

- timely remittance of member States contributions
- Encouraging member States that do not remit their contributions to do so
- Remittance of contribution arrears from countries that are not up to date with their contributions
- Winning and sustaining member States and donor confidence through provision of quality services
- Embrace strategies and activities that will ensure increased and sustained revenue generation.

In order to meet these challenges, the Centre has adopted the following measures:

- Stepped up provision of services to its member States based on their (member States) priorities. This has helped in winning back the confidence of the member States in the Centre hence boosted remittance of contributions since the countries can 'see' value for their money.
- Moved away from service technology framework (e.g. remote sensing, geodesy, cartography etc) to problem solving applications in natural resource development and environmental management. Thus, rather than market its technologies alone, the Centre today, markets the applicability of the application of geo-information services in providing solutions to real world environmental and developmental problems facing Africa (e.g., environmental management, food security, disaster risk reduction, urban planning, etc). This move led to change of the institution's name from the technology-inclined name of Regional Centre for Services in Surveying, Mapping and Remote Sensing (RCSSMRD) to the applications-oriented name of Regional Centre for Mapping of Resources for Development. Thus, the move has not only helped in demystifying the applicability of geo-information technologies amongst potential users but has also worked well in attracting development partners interested in specific environmental and developmental areas.
- Widened its network through establishment of strategic partnerships that help deliver quality services to member States and clients. These partnerships are in the areas of training, projects (e.g., early warning, disaster risk reduction, etc), advisory services, and data dissemination.
- Diversified its service base based on existing opportunities – RCMRD started an Information Technology Training College in 2001 through a partnership with the Jomo Kenyatta University of Agriculture and Technology (JKUAT). This helped optimize the use of its then 'extra and idle' training facilities and further increasing revenue generation for the Centre. In addition, RCMRD has continued to target its 'non-traditional clientele' such as the corporate sector where it is beginning to make market entry by providing services such as training and geo-spatial database systems development.
- Stepped up its marketing activities through advertisements and increased participation in international fora to showcase the centre's capabilities. This move helped in boosting the exposure of the Centre to potential partners and donors.
- Continued to invest in facilities and equipment so as to continue offering high quality services and further attract more clientele.

It is important to note however that, in its endeavor to offer services through competitive bidding of projects, RCMRD, being an inter-governmental organization with diplomatic immunity (does not pay taxes), is walking the 'slippery' road of facing resentment from the private sector due to lack of level competition mainly due to the diplomatic status of the Centre.

Hardware needs
RCMRD has made considerable investment in its hardware in the last six years. Hardware investment has mainly been directed towards purchase of computers, printers/plotters, scanners, GPS receivers, servers, data storage hard drives, LCDs, digital cameras, high capacity generator, etc.

However, due to the dynamism in hardware technologies, there is always need for upgrade of the hardware. Besides the need for constant upgrading, RCMRD currently needs the following hardware:

- Storage servers and disks due to the voluminous nature of remote sensing data, especially the medium to high resolution data. More financial resources are always required to keep pace abreast with the ever growing data
- Security systems (fireproof anti-theft, etc). RCMRD has recently invested in a fireproof data storage room. However much more investment needs to be done to better the security and safety of the datasets available at the Centre. This includes the need to procure fireproof safes and other devices that will increase physical security of the data as well air-condition the data storage room(s).
- A second high capacity generator to supplement the current one. This is because the number of computers and electronic devices at RCMRD have grown

Software needs
RCMRD has endeavored to acquire key remote sensing and GIS software essential for its operations. However much more needs to be done especially with regard to meeting the challenges its growing volume and diversification of activities.

Today, RCMRD is in need of the following software:

- Additional licenses (preferably a multi-user license) of ERDAS Imagine (plus photogrammetric suite) so as to support its training activities and projects. Current there is only one copy of the same.
- ENVI software (there is none at the moment)
- ER Mapper (there is none at the moment)
- Google Earth Pro / Enterprise

Information technology needs
RCMRD requires the following information technology infrastructure to boost its geo-information operations:

- Higher bandwidth (than the current existing one) to support download and upload of large files such as QuickBird imagery, Ikonos, etc. which are some of the most commonly requested datasets today. To this end, a VSAT solution would be a suitable alternative.
- Fireproof data safes

Training in remote sensing applications
The key geo-information areas that capacity needs to be build / enhanced at RCMRD are:

- Internet mapping
- Radar remote sensing
- Hyperspectral remote sensing
- GIS programming
- Early Warning Systems for Food security and Disaster Management

Current and required operational products
Current operational products include:
- Land use / land cover mapping and database development
- Urban mapping and database development
- Hydrological mapping and database development
- Geological mapping and database development
- Early Warning bulletins
- Data automation and GIS database development
- Geo-information courses
- Research and Development in various areas of earth applications
- Satellite data dissemination

Required operational products include:
- Timely reception, processing and dissemination of early warning data/information
- Current medium to high satellite data such as gap filled Landsat, Aster, and SPOT (the most current Geocover data available id for 2000, 2001 and 2002 which is now outdated for current mapping).
- Continuous reception of MODIS and SPOT vegetation data

Current and required delivery systems
Current delivery systems at RCMRD are:
- GeoNetwork opensource node
- Email
- FTP
- CDs / DVDs

Required delivery systems at RCMRD are:
- Broader bandwidth at for delivery of large files
- Good internet connectivity at the focal points in the member States

Constituent integration
To enhance the integration of RCMRD's member States and clients, the following needs to be done:
- More frequent workshops / seminar for the member States to ensure technology transfer of the highly dynamic geo-information technologies.
- Encourage the formation geo-information user groups and strengthen the already existing ones for better data/technology/budget sharing.
- Bring on board other ministries beyond the traditional focal ministries of RCMRD (since application geo-information technologies has now broadened)
- Increase awareness campaigns on the application of geo-information technologies in the private / corporate sector (such as communications, tourism, industry, etc)
- Carry out regular surveys of the geo-information data, software, hardware, and training needs in the member States

2.6.3 SADC RRSU

Background of funding
RRSU started its operations as a project in June 1988 with funding from the Government of Japan and technical assistance from the UN Food and Agriculture Organization (FAO). The first phase came to an end in 1992, after which the operational activities continued with support from the FAO Technical Cooperation Programme.

In April 1994 the second phase of the project started with financial support from the Government of the Netherlands and technical assistance from the FAO. This phase terminated in June 1998, after which the project was integrated in the organizational structure of FANR as a Unit. The RRSU is currently operated with funding from the European Commission project GCP/INT/952/EC - "EC-FAO Food Security Information for Action Programme" implemented by FAO and SADC. The current funding arrangements started in May 2006 and are expected to run until mid-2009. The funding covers most of the operations for the RRSU including staff for salaries and all training programs.

It is expected that SADC, through its budget supported by Member States, will assume a bigger role in funding RRSU activities, such as contributing to staff salaries. As of March 2007, the support from SADC is mainly provision of office space and communication facilities (email, telephones, fax, Internet facilities). In May 2006, the issue of incorporating the RRSU into the new SADC FANR structure was raised and debated in the SADC decision making structures – namely the Integrated Council of Ministers and Council Meetings. A decision was taken that SADC must put into place measures to incorporate the RRSU funding into its budget. However, due to the nature of the decision-making process in SADC, the above plans are only likely to be in place towards the end of the current EU/FAO funding rather than within the next financial year (2007-2008).

Hardware
Huge volumes of datasets are handled by the Centre on a daily basis. The majority of this comes in the form of Meteosat Second Generation data collected from the receiver at the Botswana Meteorological Department. The RRSU collects 15-minute interval data from 8 channels of the Meteosat SEVIRI instrument. At 3-km resolution this amounts to roughly 3 GB per day, translating into close to 100 GB per month. Although this data is being archived on DVD there is a need to have monthly data on hard disk to allow for quick processing and derivation of other products, like cold cloud duration products (CCD) and NDVI. The RRSU also anticipates the regular acquisition of MODIS vegetation index data. Data to cover the entire SADC region makes around 10 GB for each 16-day period. Extra disk space will be required to cater for these acquisitions.

Software
The most widely used software at the Centre is WinDisp, which works well for the coarse resolution 8-bit datasets that are mainly handled at the Centre. WinDisp is found wanting when dealing with medium to higher resolution datasets, e.g., MODIS which has data types of more than 8-bit. These datasets are handled by other software, such as custom tools (MODIS Tool), ArcView 3.x, and ArcGIS for display. The Centre has access to one ArcGIS license, compliments of the USGS FEWS NET representative. An old version of IDRISI is available for a number of less regular applications. An upgrade of the IDRISI software (e.g., IDRISI Andes) would be desired.

Internet technology
The Centre operates on a wireless Internet system that has a bandwidth of 128k for both upload and download. This connection is shared by up to 50 users in the office, which makes it very difficult to download files in excess of 10 MB during office hours. Data downloads during the night are somewhat more effective though. A dedicated line would be ideal to accommodate data downloads, and it would assist in pulling METEOSAT data from the Botswana Meteorological Department, which is setting up an FTP service to transfer data to their users in the outer stations.

Internet connectivity for RRSU's counterparts in the region
Most of the national contact points for the RRSU have access to internet. A good number have departmental email systems while a few use public email services (Yahoo!, GMail, Hotmail, etc). This allows them to receive the low resolution RS datasets sent regularly from the RRSU, and also to send out some of their own publications, particularly bulletins. A few of the contact points have restrictions on attachment file sizes as low as 1.5 MB, which means that data/files both sent and received must be relatively small. To this end, almost all data is sent in a compressed format. The poor connectivity implies that bigger datasets have to be shipped on CD/DVDs to most recipients, with the exception of a few who have good download capacity.

About half of the contact points maintain websites, and some use these for publishing regular reports. Shrinking government budgets in some cases have led to the disappearance of some websites that were once well established. A number of these websites are not effectively serving the dissemination purpose that they are supposed to serve, due to a number of reasons, including poor design. The RRSU helped the Malawi Meteorological Services department enhance their website and intends to do more of the same with other countries.

Training needs for the regional center
The training needs of RRSU are:

- Training in archiving procedures consistent with management of huge volumes of data – with more medium to high resolution data being collected, the Centre faces pressures on the archiving and cataloguing of the multitude of datasets and could benefit from the experience of centers like USGS EROS in the handling of huge volumes of remotely sensed datasets
- Land cover map preparation, interpretation of high resolution data – the center could benefit from training on land use / land cover preparation maps in order to be in a better position to promote the use of the LANDSAT GeoCover datasets received
- Technology transfer to national counterparts – the center would benefit from training on more innovative ways of transferring technology to counterparts in countries served, recognizing the fact that opportunities to conduct training are few and far between
- Training in other applications relevant to season monitoring.

Current and required operational products (scheduled/consistent delivery)
Current products:

- Rainfall analysis products - rainfall maps, cumulative rainfall analysis e.g. rainfall graphs, percentage of average

- Vegetation monitoring – NDVI, vegetation condition maps, comparison with average, vegetation productivity indicator (VPI)
- Bulletins or reports on season progress with rainfall and vegetation analyses
- Quelea breeding forecasts based on daily rainfall estimates
- Water balance monitoring products – SOS maps, WRSI for crop monitoring and yield estimation

Required products:

- Maps of area under main crops,
- Maps of planted area for the current year
- Yield maps (quantitative)
- Crop emergence maps

Current and required delivery systems (data or products)

Current delivery systems:

- Low resolution datasets (NOAA NDVI GAC, RFE, SPOT VGT NDVI) are distributed regularly via e-mail to contact points in the region. Other stakeholders are also included in the delivery. Graphics of the main datasets are also sent to the website.
- SADC Hazards website (www.sadc-hazards.net) used in the dissemination of reports and exchange of information pertaining to floods and droughts. Hosted by FEWS NET at USGS EROS
- SADC GeoNetwork site (www.sadc.int/geonetwork) with metadata on some shareable products; data sharing portal hosted at the SADC Secretariat in Gaborone.

Required delivery systems:

- FTP distribution of data. SADC main web service does not feature an FTP service. GeoNetwork could address this to a certain extent if data are added as metadata on the portal; however, GeoNetwork is not an FTP-based service.

Constituent integration

Support to national counterparts is currently mainly achieved via annual training workshops and email correspondence. Email is used to disseminate regular products and receive information from national counterparts, mainly ground based information on crop performance and food security outlook. While this system has had some considerable success in integrating RRSU's contact points in the Member States, there is room for improvement. Ways to improve support and integration of counterparts in the Member States would include the following:

- maintaining a good number of annual workshops, at least twice yearly (high turnover in the region means that they are always news faces coming into the picture)
- electronic discussion forums covering several aspects including RS/GIS challenges being faced at the workplace, and cases of how participants are benefiting from workshops
- web hosting of products relevant to the Member States, including remote sensing and GIS products in easily accessible formats
- allowing transfer of expertise from one Member State to another by sponsoring backstopping visits
- circulation of memos or newsletters which serve to inform Member States of developments relevant to their work areas (more like the GSDI newsletter which informs of RS/GIS events – a good start may be to extract information from existing newsletters and forward it to counterparts in the Member States)

3. Potential Elements for Sustainability of RS and GIS Services in Africa

The sections below describe potential elements for sustainability pertaining to providing RS and GIS services in Africa. The elements should not be viewed as formulaic (i.e., "do a, b, c, and thus the initiative will be sustainable…"). Sustainability is much more complicated and problematic. The elements themselves are somewhat standard; prevailing reports commonly mention these same ideas. Yet, sustainability too often is an afterthought; rather than a guiding principle for the design and implementation of an information system or remote sensing facility. Every homebuilder knows that the most important part of building a home is the part that comes first - laying the foundation. Without a solid base, the most carefully built home soon will sag and crumble. Building a solid base for a continent-wide RS/GIS information system 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. With more time, these could be elaborated, but for this brief summary, the ideas are just introduced.

3.1. Design and Adaptation

The concept of sustainability often has been mentioned with respect to the design and implementation of information systems, yet without adequate consideration. In developing countries, failures of information systems by far outnumber successes. Failures are attributed to the gap between 'hard rational design' and 'soft political realities' (Heeks, 2002). A regional facility for visualization and monitoring cannot be designed and constructed as an engineering project; rather, the facility must be *cultivated*. Those involved must appreciate the social environment into which technologies are being seeded, as well as how the technologies then influence the people using them. Many give lip-service to "understanding users" and to "being sensitive to the social and political environment," but time and again, technology enthusiasts invest in information systems with a "build it, and they will come" mentality. Socio-technical relationships inevitably are poorly addressed.

A cultivation approach to sustainability recognizes that there are institutionalized ways of doing things, and this results in *lock-in* effects. Change is not a given and may not be desired by all; some may have an advantage with the established, old way. Thus, the design of an information system cannot be a straight-forward process with pre-configured start and end states; rather, it is an ongoing process of adaptation and enrollment, characterized by 'unanticipated effects'. Those involved must continually improvise. If an information systems manager lacks a healthy degree of skepticism, or if s/he is convinced of a tried and true approach, that is a sure sign that the person does not really understand what is at play. If it were so straightforward, why then have so many information systems not persisted after having been set up?

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 her, is relative. The following projects for instance had a marked impact at the time; however, for one reason or another, the actual information systems designed did not necessarily withstand the test of time. The Intergovernmental Agency on Development (IGAD) Regional Integrated Information System Project (IGAD-RIIS), jointly funded by the U. S. Agency for International Development and the Italian Cooperation from 1999-2001, suffered from

political fallout; few of the clearinghouses and map services established during the USAID-supported Mitch Project (Central America) have been routinely updated, and the SADC clearinghouse established through E-INFORM (Southern Africa) went off-line when SADC moved RRSU from Zimbabwe to Botswana, and it has not been available since. Also, the untimely death of E-INFORM's clearinghouse coordinator was a blow to continued efforts. FEWS/FEWS NET, in contrast to those mentioned above, has been heralded as a success[31], but it is important to recognize that the initiative has received funding for twenty years.

The inclination is not to take a hard (or hard enough) look at implementation failures. We 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. We can turn to recent analyses of e-government failures for some understanding (e.g., Learning from Experience in eGovernment: Why Projects Fail and Why They Succeed[32]; Twenty Five Steps towards e-Governance Failure (2006)[33]; Dangerous Enthusiasms: E-Government, Computer Failure and Information System Development (2006)[34]; and the upcoming special issue of the International Journal of Technology Intelligence and Planning (IJTIP) on Failure, Decision-Making and Technology Management[35]).

3.2. User and Policy Orientation

One of the recommendations from the IGAD-RIIS Project was that future efforts meant to enhance the sustainable production and dissemination of data should pursue a *sectoral approach* (e.g., water management, forest management, livestock management, etc.). A sectoral approach can be viewed as focusing on a *community of practice* or possibly a *policy network* (e.g., global warming and climate change policy). Communities of practice tend to fall under different jurisdictions and have a different breakdown of participating organizations. The members have similar objectives and norms that shape the formulation of management practices.

One of the factors that has contributed to FEWS NET operations has been its focus on famine and early warning. FEWS NET did not venture off into all types of disasters and/or emergencies, nor did it try to service too broad a user community. Furthermore, the initiative has been geared to specific management concerns regarding preparedness and planning. If a regional visualization and monitoring system is meant, in a sense, to be generic, serving all, it faces the challenge of not having a specific user community. Its information products and services may not be adequately tailored to specific management concerns, and the user base could be limited.

This constraint can be circumvented by having different 'entry points' to the information system. The portal could have a different front-end face, while the back-end still taps the same system. The term 'channel' has been used in some circles. Channels are a way to

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[31] http://africastories.usaid.gov/search_details.cfm?storyID=37&countryID=4&sectorID=0&yearID=3 ; http://www.usaid.gov/our_work/environment/climate/policies_prog/vulnerability_overview.html

[32] http://www.egovbarriers.org/downloads/June26Workshop/Workshop_report_26th_June_2006.pdf, from European Commission Modinis study workshop, Oxford, U.K., 26 June 2006, http://www.egovbarriers.org/?view=Events&type=pastevents&EventID=3

[33] http://www.developmentgateway.org/egovernment/rc/filedownload.do~itemId=1068126

[34] http://www.scoop.co.nz/stories/ED0607/S00093.htm, Otago University Press, http://www.otago.ac.nz/press/booksauthors/2006/dangerous_enthusiasms.html

[35] http://www.inderscience.com/browse/callpaper.php?callID=253

organize data, applications, users, and reference material by theme or topic. If there is an existing community of practice that already has built up a network, the community could serve as both the 'entry point' to the system and the custodian of a channel. The community could integrate the products and services of the visualization and monitoring system into its own website. This potentially may help communities of practice "own" the channel and keep its content current. The community could encourage topical experts to include their own data and/or products in the community channel. Dialogue could be regularly stimulated to identify which products best serve the community and what gaps potentially are present in existing products. Also, detailed evaluation of the products is essential [see for example, studies supported by the Drought Monitoring Center (Zimbabwe): Walker et. al., 2001; Hochobob, 2002].

Another way to engender more usage of a visualization and monitoring system is to have a solid understanding of what kinds of data products and services are constructive. In the political arena, much more could be done in liaising with politicians to identify products that address policy and national reporting requirements (PRSPs, Millennium Development Goals, environmental treaties) (Bedi et. al., 2006; Global Climate Observing System Secretariat, 2006; Sherbinin, 2000). The geospatial community has not been particularly effective in this area. A pertinent question is how might a policy maker use geo-information and spatial research in his or her 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. According to a public administration scholar:

> " ... Information is only one basis upon which policy actors take their positions. Although there are occasions when information is critical, it is usually outweighed by two other factors that carry higher emotional loadings: ideology and interests. To ignore these influences, or to regard them as illegitimate or as irrational components of resistance to the truth and beauty of research is to misread the nature of democratic decision-making. [...] The real world of information processing in the domain of public policy making [...] is characterized by several types of information (manipulated statistics, gossip, editorial comments, evaluation reports, corridor analysis); information pathologies (faulty receptors, failures in communication, information overload, systematic biases) and information politics (manipulation, non-registration, withholding, biased presentation, adding other information, timing, leaking and so on). When looking with an information processing perspective on policy making, it is not surprising at all that one comes up with such a metaphor as a "garbage can" (van de Donk, 1998)."

To begin to make headway in garnering political use of (and support for) geospatial technologies, a better appreciation of political spheres is required. Geospatial information can have some rationalizing effect on policy making, but it remains to be seen in what contexts and at what levels of the policy food chain this will happen.

Another area that requires more understanding is how the media (newspapers, radio, television), as well as local NGOs/civil society organizations, might use geo-information and spatial research in their settings. To truly have a wide user base, which is an important element of sustainability, an RS/EO facility must reach beyond technical communities of practice. A concerted effort may be necessary to 'translate' raw data (and

terminology) into appropriate information products. Reaching media outlets is key, given that a World Meteorological Organization survey found that mass media by far is the major communication channel through which the public receives weather information, forecasts and warnings (World Meteorological Organization, 2000, cited in Walker et. al., 2001). So, the overall RS/EO infrastructure communication work plan must take non-technology-specialist communities into account.

Ultimately, if data dissemination efforts are to be not merely driven by technology, significant attention and sensitivity to sectoral market drivers are essential. Thus, another very basic element for sustainability is to know what the drivers are for use of satellite imagery and derived products [see, for example: Dendron Resource Surveys, Inc., 2004; H.R. Wallingford Ltd., 2004; NPA, 2003].

3.3. Education and Training

Across Africa, training opportunities have been increasing, and there does appear to be regional/geographic distribution of opportunities, but on the whole, the training offerings are fragmented. Also, the opportunities do not meet the growing demand, and there is not always open competition for the open (funded) spots. In order 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 tackle; rather, it is the combined contributions of organizations across the geospatial sector. It would be helpful to have a mechanism that allows for organizations offering training to 'register' (or market) their offerings. This registry would contribute to regular monitoring and review of the availability and geographic distribution of training programs. Further work also is needed to assess the effectiveness and impact of different types of training (e.g., workshops; training attachments in overseas laboratories; support for bachelor versus master versus doctoral degrees, etc.).

It appears that funding agencies do recognize the benefits of using local and regional training facilities. However, donors tend to support workshops in conjunction with projects (e.g., five-day TIGER workshop, ESA's Earth Observation Centre in Frascati, Italy, 24 to 28 July 2006[36]; USGS workshop, Applications of High to Coarse Resolution Satellite Imagery for Land Productivity, Bamako, Mali, February 6-17, 2006[37]). While filling a gap for the ever-growing demand for training, this potentially takes 'business' away from national or regional centers that offer training programs. For sustainability purposes, rather than offer free training through projects, it could be better to strengthen the institutional capacity of national and regional centers through direct operational support, so that these centers could provide courses of their own design on a regular basis. The free, project workshops may be taking away a potential revenue stream for the training centers. However, one could argue that for those receiving training, if the training were not offered for free, their institutions would not have authorized them to participate.

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; they also can reinforce cohesion amongst local geospatial community members. To varying degrees, African universities have the human resources to make significant contributions to RS application development. Given that much of the geospatial activity in Africa is

[36] http://www.esa.int/esaCP/SEM39Y715QE_index_0.html
[37] http://edcintl.cr.usgs.gov/bamako%5Fworkshop/

conducted by organizations in capital cities, and that capital cities have a national university, if more training opportunities were offered through universities, it could cut down the overall expense for training for potential candidates. Night and weekend 'continuing-education' courses, if need be could be offered. Furthermore, universities have been active in thematic networks (e.g., Regional Universities Forum for Capacity Building in Agriculture (RUFORUM)[38], African Network for Agroforestry Education (ANAFE)[39], University Network for Disaster Risk Reduction in Africa (UNEDRA)[40]). These networks are important for outreach to increase use of satellite imagery and derived products. If more emphasis were put on national universities for education and training, regional centers could focus more on supporting monitoring and evaluation of regional development and integration efforts for the likes of NEPAD, African Development Bank, African Union, and the regional economic communities. The African Union, for instance, is currently contemplating setting up its own in-house capacity for continental early warning system[41]. Instead, such a system could be operationalized through a network of regional centers.

Capacity-building in Africa primarily has been oriented towards technical competency, as opposed to other areas of competency that are needed, such as business, analytical, and inter-personal competencies (Gaudet et. al., 2003). Most geospatial capacity building programs have focused on systems, and secondly on technology strategy. Too few training opportunities are offered to geospatial managers on business processes and business strategies.

In order to 'grow the RS market', develop standards, or deal with joint agency data acquisition, geospatial professionals should be capable to: communicate across sectors, institutions and different interest groups; motivate (coax) people; 'follow the money'; prepare and negotiate projects; diagnose problems, assess needs, plan, set objectives, budget, monitor and evaluate, report; and keep abreast of new research and technologies. These capacities are different from those that conventional geospatial professionals have had. Capacity building programs, as well as hiring practices, must foster this new kind of professional. It is no surprise, then, that Laval University (Quebec) just started a new MBA program in Geomatics Management, jointly offered by the Business School and the Department of Geomatics Sciences[42]. This MBA in Geomatics Management may be the first of its kind. Similarly, ITC in the Netherlands recently established an MSc course together with the Faculty of Public Administration, University of Twente called Governance and Spatial Information Management (GSIM)[43].

3.4. Outreach and Communication

In a Nigerian survey of the national geospatial community, only 24% of respondents indicated that their data were publicly accessible (GML Projects (& JV) Ltd., 2005). If this is accurate, it indicates that either public servants do not wish to or do not know that they can share their data, or there are stringent restrictions on data and information disclosure. Meanwhile, globally, market growth has been driven by the increased availability of public

[38] http://ruforum.org
[39] http://www.anafeafrica.org
[40] http://www.itc.nl/unu/dgim/unedra/default.asp
[41] http://www.africa-union.org/root/UA/Conferences/decembre/PSC/17-19%20dec/Roadmap%20-%20Issue%20Paper%20n%201.doc; http://www.africa-union.org/root/UA/Conferences/decembre/PSC/17-19%20dec/Concept%20paper.doc
[42] http://www.scg.ulaval.ca/documents/Fiche_MBA.pdf
[43] http://www.itc.nl/education/fields/govspatmngt.aspx

and private data, which has benefited users with new applications at low incremental cost (Daratech, 2006)." In order to stimulate market growth and sustain a regional RS/EO information system, emphasis must be directed at 'freeing up' data from organizations, particular from the public sector, which is the largest employer of 'geospatial labor' and holds most of the available geospatial data.

A visualization and monitoring system must provide access to both imagery and 'other' data. Without the 'other' data, applications are limited. Population census data, for instance, is key to looking at the relationship between people, land use, and deforestation. In other words, quoting Onsrud (2006):

"No matter how elegant an aerial or satellite image might be, it can only show, for example, the physical presence of power lines, not what the attributes of those lines are in terms of age, carrying capacity, interconnection links, where they run underground, or other non-visual data. An aerial photo may show a house but won't show its assessed value, the age of the roof shingles or the number of inhabitants. In short, geographic imagery requires geographic attributes to become fully useful."

To sustain the visualization and monitoring system, a broad and continually growing set of usable geographic data must be available. This 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. To populate a service registry, a concerted effort must be made to keep track of 'who is doing what', to engage different parties, and to build consensus for a common registry.

However, outreach must also focus on understanding what services are needed. Are online geo-services being used, when research has shown that face-to-face exchange is the modis operandi? Respondents to a survey of 17 organizations in Uganda indicated office visits ('walk-ins') were the predominant method used by clients to access geographic information, even when online access was an option (Tukugize, 2005, p.35, p.42).

Another area that needs work, in terms of outreach and communication, is the strengthening of the African research community. In part, this could be improved by having an African RS Journal (which has been proposed by AARSE). Also, the African RS diaspora could be engaged to collaborate more with African institutions. It is important, as well, to facilitate access to current scientific literature (for free) to scientists in institutions who cannot afford journal subscriptions.

3.5. Monitoring and Evaluation

A key element of sustainability is the establishment of credible levels of accountability through regular monitoring of performance and reporting of outcomes (Lance et. al., 2005). Monitoring and evaluation are essential for maintaining the confidence of financial contributors, partners, and the user community.

A balanced approach to monitoring should cover a range of perspectives: 'platform improvements', 'operational', 'financial', 'beneficiaries', and 'learning and growth'. The 'platform improvements' perspective addresses the improved technical ability to share information and communicate; the 'operational' perspective refers to improved efficiency of day-to-day operating activities and supply/distribution channels; the 'financial' perspective refers to upgrades in economic control and improved allocation of resources

(benefits from financial management as opposed to those derived directly from the platform or operational perspective); the 'beneficiaries' perspective reflects the enhanced collaboration and commitment of stakeholders and the degree to which their needs are being met; 'learning and growth' addresses increased functionality, flexibility, and useful/future life of the RS/EO infrastructure. The classification is not watertight; the perspectives may overlap and there is ample room for interpretation, but together, the perspectives provide a framework for a comprehensive evaluation

Although rarely explicitly stated as such, monitoring and evaluation is inherently associated with information system success or failure. Successful development practice is founded on effective evaluation. Also, more than just compiling basic data that reflects what has been spent and for what purposes, measures can be established that determine the extent to which a visualization and monitoring system has been institutionalized. Institutionalization is the process by which a significant new structure or practice is incorporated into a system of existing structures and practices (Scott, 1995). When an information system is institutionalized, it becomes routine, and people are committed to using it consistently and across arenas, communicating its importance, and expecting that it legitimately will continue.

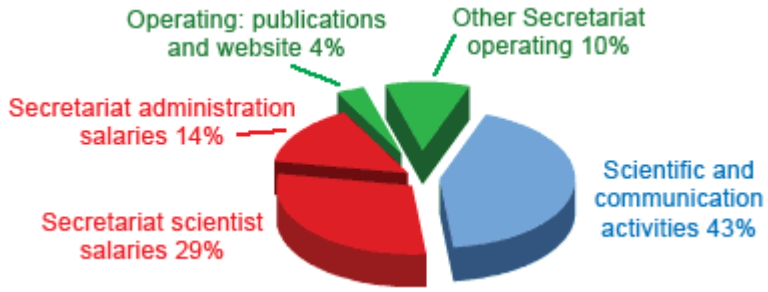
3.6. Funding

Although the funding element of sustainability has been saved for last, it deserves potentially the most attention. Without funding, it is almost a given that the information system will not be sustained. This summary cannot do justice to the kind of analysis that is needed on business models for a visualization and monitoring system in Africa. All that can be said is that much more work is needed in this area. One might begin by looking at the funding models of other initiatives, such as the International Geosphere-Biosphere Program (IGBP) Secretariat, UNOSAT, African Water Facility (AWF), South Pacific Applied Geoscience Commission (SOPAC), Regional Center for Training in Aerospace Surveys (RECTAS), and GEONETCast.

The International Geosphere-Biosphere Program (IGBP) Secretariat, the Scientific Committee (SC-IGBP) and some project activities are financed primarily by contributions from around forty countries[44]. Since the year 2000, these national contributions have been relatively steady at about US$1.5M per year. The national contributions typically represent 60–70% of the total central income. The remaining fraction of the income comes from specific grants to support IGBP projects (where funds are simply administered by the Secretariat), research activities and conferences. As shown in Figure 3.1, typically, around one-third of the unencumbered income is spent on Secretariat salaries (a significant fraction of which directly supports scientific activities), and around half is spent on non-salary scientific and communication activities. About 10% of the income covers Secretariat operating expenses, and the remainder (around 5%) funds IGBP publications and the IGBP website. The scientific activities funded include project activities, workshops and conferences, meetings, contributions to ESSP, GEO and IGOS and other partners, and integrative research efforts.

[44] http://www.igbp.net/page.php?pid=119

Figure 3.1. Spending distribution of IGBP funding.



UNOSAT[45] is a United Nations program created to provide the international community and developing countries with enhanced access to satellite imagery and GIS services. UNOSAT is funded on a non-for-profit basis, but must be self-supporting. Therefore their services carry a cost. However, UNOSAT has negotiated favorable pricing with many data providers for use in the humanitarian community. UNOSAT launched the Global Mapping Grant Facility (GMF), a global initiative aiming at gathering funding and capacity to transfer knowledge, imagery and skills to developing countries.

The African Water Facility (AWF)[46] was set up as a special fund, managed by its host institution, the African Development Bank (AfDB). The focus of the Fund is to foster Integrated Water Resources Management (IWRM) at the national level and Transboundary Water Resources Management (TWRM) at the regional level. AWF supports capacity building at both the national and regional levels and includes especially the development of national institutions and improving organizational capacity. In addition, support can be provided for national human resources development including applied research and formal education as well as river basin organizations and regional and sub-regional institutional capacity building activities. AWF supports policy, legal and institutional reform processes as part of its overall objective of developing the overall enabling environment in the water sector in Africa. Requests for funding project proposals are received and processed by the AWF team at AfDB throughout the year. Proposals should have clear performance indicators with clearly defined expected outcomes and measurable targets.

SOPAC[47] is an inter-governmental, regional organization dedicated to providing services to promote sustainable development in the countries it serves. It is funded by member-country contributions and supported by the following donors: Australia, Fiji Islands, Canada, France, Ireland, Japan, New Zealand, Office of US Foreign Disaster Assistance, Taiwan, the United Kingdom, the Commonwealth Secretariat, the European Union, and certain UN agencies.

In the case of the Regional Center for Training in Aerospace Surveys (RECTAS)[48], an ECA-sponsored regional center, the 2003-2005 biennial budget put forth that the Center must generate 28% of the budget while the member states are to pay 72% as their assessed financial obligation (Economic Commission for Africa, 2005). Management and

[45] http://www.unosat.org/
[46] http://www.afdb.org/portal/page?_pageid=533,8250477&_dad=portal&_schema=PORTAL
[47] http://www.sopac.org/tiki/tiki-index.php?page=SOPAC
[48] http://www.rectas.org/

staff of the Center put in a lot of effort to meet the target of 28%. Also, the continued support of the host country, Nigeria for the Center's capital development is part of the business plan. The Nigerian government has demonstrated a willingness to continue to host RECTAS.

GEONETCast[49], combines satellites operated by US, EU and China-based organizations, to create a global network that can beam data to users around the world. To receive data, users need to install a EUMETCast receiving station (components are commercially available, starting at approximately 1500 euros), as well as purchase an EUMETCast key unit and Tellicast software, which cost 100 euro together. The GEONETCast initiative proposes to set up arrangements between members of the Group on Earth Observations and commercial satellite providers in order to use the same infrastructure, in an expanded form, for disseminating data.

While there are many different business models that need to be explored, ultimately, for sustainability, investment in RS/EO infrastructure must come from African government budgets. Unfortunately, the dominance of donor funding for RS/EO activities in Africa, "has sometimes created a "no donor - no activity" mentality. Government agencies seek the support and funding of a donor to carry out their projects rather than relying on their own resources (Mbudzi et. al, 1997)." Instead, government agencies need to recognize that "bridging the 'EO knowledge gap' requires substantial research investment and should create specific funds to encourage academia to invest on problems related to the integration of satellite images with other types of geographical information (Câmara and Perondi, 2002)." Further echoing of this sentiment is in the recent editorial, "African states, not donors, must fund science (Chege, 2007)." While many in the RS community still express dismay at the lack of budgetary support for research and applications, some think there are grounds for optimism (Nature editorial, 2007). The January 2007 summit of Africa's leaders marks a deepening commitment to science and technology in the continent. The meeting's two main themes are climate change and the harnessing of science and technology for development. According to the incumbent president of the African Ministerial Council of Science and Technology, one of the major goals will be to push harder for each of the AU's 53 nations to commit one per cent of their total economic output, public and private, to science and technology (Chege, 2007).

If geospatial technologies indeed are valued as a tool by government, then the value should translate into resources being expended on RS/EO infrastructure. Considerable more investigation is needed to identify existing government resources and allocations in geospatial applications. Can we say that existing funds are efficiently being applied to sustain an RS/EO foundation for a diverse range of applications? Do we even know what investments currently are being made? For the most part, the answer to both questions is no. Mechanisms need to be established to track and align government geospatial investments, as well assess and communicate the outputs of these investments. Existing funds perhaps could be better used by strengthening RS/EO education in African universities, funding key dataset production or imagery acquisition, or coordinating and reducing the overlap of national and regional RS/EO activities.

On the donor side, individual donors (e.g., EU, USAID) are making efforts to improve data sharing between their own projects. These efforts could be extended with the establishment of an inter-donor forum dealing with harmonization aspects of data

[49] http://www.eumetsat.int/groups/cps/documents/document/pdf_br_e01_en.pdf

generated by projects. There already is a forum in many countries where donors meet to discuss common issues and exchange information to ensure program complementarily and coordination[50]. The environment is one sector where this occurs; information on environmental projects is compiled into a database, and something similar could be done for projects with a significant geospatial component. Ideally, donors would then meet and agree on best-practices and a standards-based approach for data collection, integration, and dissemination; they also would align their geospatial funding.

When one reviews the fields of the donor project databases, it is difficult to identify geospatial projects because the project metadata is not sufficiently detailed to single out project components dealing with data collection, data maintenance, standards, and data access. Ideally, donors would support the enhancement of the existing project registries so that the remote sensing community in Africa could specifically tracks GIS/remote sensing projects and programs. A 2006 summary from a World Meteorological Organization informal planning meeting (World Meteorological Organization, 2006) provides an examples of a compilation of funding efforts, and is a first step in tracking 'who is funding what'. With such information in place, it is possible to begin joint implementation (and funding) of RS/EO infrastructure

Some have suggested that international cooperation is one of the key issues in civilian earth observation (EO) programs. However, "much of the promises of international collaboration in earth observation remain unfulfilled, especially in relation to truly multilateral agreements involving countries from the G-7 and DSP1 (developing nations with active space programs) (Câmara and Perondi, 2002)." Initiatives such as TIGER, AMESD, FEWS NET, and CARPE need to be harmonized under a collective strategy. AMESD already intends to set up regional focus points, and TIGER is establishing an Executive Bureau in Africa. FEWS NET has offices in many African countries. At the same time, there are a number of scientific initiatives (e.g., AfricanNESS[51], TerrAfrica[52], and START[53]) with separate Secretariats that each require staffing and support. It is unlikely that Africa can sustain multiple regional centers and focal points for long. However, there is the real problem of each initiative being driven to have its own name. If this 'ownership' issue could be softened, then there is the very real potential to leverage resources and achieve economies of scale.

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 as the business model, 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. In order to focus on the sustainability elements, a regional monitoring and visualization facility requires considerable pre-"design" analysis, and once underway, 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.

[50] Aid Harmonization and Alignment, http://www.aidharmonization.org/
[51] http://www.igbp.net/documents/NL_66-5.pdf
[52] http://www.terrafrica.org/
[53] http://www.start.org/

4. Assessment of SERVIR Web-based Portal

4.1. Geospatial Portals and SERVIR-Mesoamerica

We present an evaluation of the Mesoamerican SERVIR portal, in particular, with respect to its potential as a model for Africa, and the utility and/or appropriateness of implementing a SERVIR-like portal for Africa. We collaborated with NASA and 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 / DSS portal for the region, and Africa regions could benefit greatly from similar one-stop (geo)data portals. However, there are so many differences between Mesoamerica and Africa, both in current (data/RS) conditions, and in implementation needs, that 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/or 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 already/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, external drives, etc. 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 re-distributed the GeoCover Landsat dataset, as well as 90-m SRTM DEMs (in some cases), and other MODIS and ASTER data as a result of this direct involvement.
- Africa regions are already on-board with in-house datasets and links to partners providing data, such as GeoNetwork (by FAO, WFP, UNEP), which is a metadata (and potentially a data) distribution system – built upon EMIS clearinghouse development. See examples of Regional Center GeoNetwork nodes (and/or metadata/data servers) at http://www.rcmrd.org/geonetwork (RCMRD) and http://www.sadc.int/geonetwork or http://www.sadc.int/fanr/aims/index.php (SADC RRSU).
- Much data and information exist already (for Africa) for environmental monitoring, disaster management, weather monitoring, food security monitoring, etc., 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., DSS information example, 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, 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 and/or information of/for/to Africa. In addition, EUMETSAT and GEONETCast will disseminate data and information of/to Africa).

- The need to recognize ICT (information and telecommunications technology) limitations (and variations) in Africa (and within regions). 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.
- Some questions/differences/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 (immensely) greater than those required to support the same in Mesoamerica.
    - ICT policies and infrastructure (levels) vary greatly across Africa. For example, most counties in Africa are yet to come up with ICT policies that ministries can leverage on 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 / information sharing through the portal.
    - Levels of government buy-in within a region will/may vary greatly.
    - Levels of regional/institutional network functionality will/may vary greatly in Africa (e.g., CILSS in West Africa; SADC and DMC in southern Africa; RCMRD and ICPAC in East Africa).
    - There exists a great diversity of cultures (language, religion, etc) within Africa, and within each region.
    - Currently, government ministries/institutions/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, rather than expecting that ministries offer free data through a centralized (or distributed) portal.
- Current bandwidth available throughout Africa (and 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/or (geo)data portals, by presenting to them very real, useful, currently-implementable, realizations of RS applications, with possibly SOME 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 proto-typed 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", as 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), but also because of cultural differences in the region, South Africa's role has been greatly diminished, and/or non-effective (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.

4.2. The “SERVIR” Model

This review is based on limited scrutiny of SERVIR’s components (Data, Online Maps, Decision Support, and 3D Visualization), with an emphasis on the initiative as a whole, rather than the specific functionality or offerings of any one component. In addition to the examination of the SERVIR website, the websites of several Mesoamerican institutions were visited to see whether they provided links to SERVIR, and a search was done to see the extent to which geospatial blogs were ‘talking about’ SERVIR. Several colleagues working in Central America also were contacted for their impressions about SERVIR. Finally, the review also looked at project reports available online that discussed the project’s objectives and progress. The review therefore addresses the following key issues: coordination, look and feel of the website, users, content, data and services, outreach and capacity building, finances and sustainability, performance measurement, and other issues of concern regarding the potential to setting up a SERVIR-like model for Africa.

4.2.1 Coordination

- SERVIR has been successful in multi-national environmental information management at a regional scale. The effort is unique in being jointly funded by NASA, USAID, and others.
- Multiple partners are working together to deliver joint or complementary services. For instance, USGS, NOAA, and NASA have contributed data, ESRI has contributed software, CATHALAC has provided facilities, the Central American Commission for Environment and Development (CCAD) has provided political support, and The Nature Conservancy and several universities have provided expertise.
- SERVIR incorporates elements of both an earth observation project and a development project.
- SERVIR has demonstrated that it is possible to establish a state of the art regional earth observation and environmental modeling system in a developing region. This same approach would be appropriate (and needed) for a similar endeavor in Africa.

4.2.2 Look and Feel

- The look and feel of the home page is quite presentable. The animated graphics and real-time maps spice up the look and feel of the website. Whereas these features are easily supported in Mesoamerica due to good Internet bandwidth, the case of poor

Internet bandwidth in most of Africa may not adequately support such animated graphics or real-time maps.

- If a similar portal were to be established in Africa, there will be need to keep a very good look and feel that will not be sacrificed by low bandwidths in Africa

4.2.3 Users

- SERVIR, as a regional facility, is commendable for providing access to satellite imagery and derivatives via a bilingual Internet portal.
- Products have been freely availed to the general public (e.g., information on fires, red tides, and climate change scenarios). The availability of satellite imagery and derivatives, however, does not mean that individual users will take advantage of this information, even if its use seemingly would be beneficial to them. In this regard therefore, two begging questions are brought to the fore: 1) to what extent are potential users accessing the data, products, and services available to them, and 2) how do they then use the data, products and services in actual human and resource management processes (i.e., ultimately, understanding "technology in use" by managers is key). These issues cannot be addressed adequately in this review, but there are some indications that the SERVIR user community is limited, despite the potential for a much wider user base.
- If a regional facility were established in Africa, much greater emphasis would be needed on understanding the user community, not only their data needs/specifications, but understanding the pathways for information to filter into management decisions. Typically, geospatial data are just a very small piece of the 'management puzzle.' Decision support must be viewed as a process, as opposed to a product.

4.2.4 Content

- SERVIR's current limited use also may be due to the portal's content. Those working at national and sub-national levels may rely more upon vector data than imagery. They may have determined that that MesoStor does not provide them with additional information that they did not already have. Much of the vector data available in MesoStor originally was provided by government agencies, so they need not access it from SERVIR. In fact, national agencies most likely have better information covering their own countries than what is available through SERVIR (e.g., the administrative boundaries for Costa Rica only go to the canton level).
- Another concern is the poor frequency of updating of the available vector data. The updating of the satellite data archive has faired better.
- Access to some of SERVIR's services may be limited to those with low bandwidth (e.g., local NGOs). SERVIR-VIZ 3-D Visualization Tool relies upon a 60 megabyte downloadable program, which could put it out of the realm of possibility for some interested users.

4.2.5. Data / services

- Although there are issues regarding SERVIR's user community, the concept behind SERVIR for having a "one-stop shop" for imagery, unified vector datasets, and other products and services has long been sought by the Mesoamerican geospatial community. SERVIR has made a marked contribution in this respect. However, some may find this component "glitzy," and less valuable when there are more basic data dissemination and data sharing needs.

- SERVIR is designed to be a regional visualization and monitoring system for Mesoamerica, providing free and open access to satellite and *other geospatial datasets*. It is this latter element that could be substantially improved. Just a small number of publishing organizations are included in the Data Portal: CATHALAC, TNC, Dartmouth Flood Observatory, WRI, USGS, Information Technology and Systems Center, University of Alabama (ITSC), and Science Systems and Applications, Inc. (SSAI).
- The GeoIntegrator provides access to geo-web services of several more agencies, but only to a limited subset of the existing web services in the region – largely those who were involved in specific World-Bank IABIN funded project to set up the services. Ideally, SERVIR would network more widely with those who have established geo-web services independent of the IABIN project, and would thus establish a regional registry of geo-web services (e.g., Mapache Mapping Tool[54]). This would be more of a 'bottom-up' approach, building upon those who have taken it upon themselves to serve data to the public.
- In Africa, a growing number of geo-web services exist, but they are not yet easily 'discovered'; these need to be included in a registry of services.
- The concept of the GeoIntegrator under Online Maps is quite good as it enables users to compile their own maps using data that is sitting in servers far apart in different institutions. Deployment of this function in its current setup may be very limited in Africa considering the low bandwidth and low web mapping capabilities (human resources and software) in most African institutions, worse still, in government ministries.
- The portal is too America-centric for implementation in Africa. There are other datasets from Europe, Asia, etc that are serving Africa very well. The portal should try to be all-inclusive by bringing on-board links to data providers outside the U.S., e.g., products from ESA, AWiFs, GMFS, etc.

4.2.6. Outreach and capacity building

- Initially, when SERVIR was launched, it received a good deal of press, which was important for making user aware of the available service. Over time, though, SERVIR needs to seek out more press opportunities. Also, more attention could be directed at encouraging more websites to provide links to SERVIR and getting individuals to spread the word through blogs. If SERVIR were to publicize their data offerings more, this could increase the user base.
- Publicity alone is not enough though. SERVIR could do much more with bringing capacity "down" to more national, sub-national, and local users.
- The SERVIR website provides information of only a handful of training workshops. Most likely more have taken place, but the details are not readily available, so it is difficult to assess.
- It does seem as though the training emphasis has been on the region's ministries of environment, whose membership comprises the CCAD.
- SERVIR also could put more focus onto its 'library' of scientific papers. The website could highlight work being done by Mesoamerican scientists, particularly if the work was based on data accessed from SERVIR or if the scientists relied upon SERVIR in some way.

[54] http://geo.garrobo.org/mapache/index.html

4.2.7. Finances / sustainability

- While a strong team of individuals from the region manages the SERVIR operational facility in Panama, it appears that U.S. scientists and specialists on the development end have done a considerable amount of work. It is unclear how much the Panama facility relies upon the technical expertise of those at Marshall Space Flight Center in Alabama. For instance, the current SERVIR website contact is listed as 'webteam@itsc.uah.edu', presumably based at the University of Alabama. Test bedding and rapid prototyping has been done at NASA Marshall Space Flight Center. Having a fully operational and independent SERVIR regional facility means that points of contact and future test bedding and prototyping would need to be handled locally, in the region.
- Certainly, future product development should rely heavily on the national counterparts. They must provide ongoing verification and validation and provide critical feedback to modify the products as appropriate.

4.2.8. Performance measurement and evaluation

- SERVIR has been distributing a questionnaire that aims to provide feedback on data needs and benefits / usage of the portal.
- Ultimately, the users determine whether particular services are useful or not. Value-of-information analyses are required to identify the highest-priority activities. Also, SERVIR must determine whether its services have been mainstreamed into the work of the environmental community. SERVIR (or any regional facility as such) should be conducting regular external peer reviews of all its components. At the moment, the principal metrics SERVIR is using include: 1) Feedback from Mesoamerican scientists, researchers, and environmental authorities (e.g. environmental ministers of the CCAD); 2) media statistics about SERVIR; and 3) number of unique web hits for SERVIR products (Sever and Irwin, 2006).
- NASA staff point out that it is necessary to put web hits into perspective; SERVIR products are developed for a niche user group, and web hits are seemingly low compared to other NASA web pages. This is an important point, and SERVIR ought to be clearer on whom it is designed to serve, especially if the products are developed for a niche user group.
- The SERVIR Project Plan: FY2003-FY2008 (NASA Earth Science Enterprise Applications Division, 2005) identifies a wider range of metrics, but reporting on this was not found on the web during the course of this review.
- Progress on the SERVIR project shall be assessed by:
    - Producing useful decision support products that provide high-quality information for decision-makers in Central America;
    - Incorporating feedback from CCAD and CATHALAC representatives into each development stage of SERVIR;
    - Providing close interaction with CCAD and CATHALAC to define decision support and sample products for assessment before finalizing production;
    - Measuring the number of SERVIR users, consumers, and data sets;
    - Measuring the number of products delivered;
    - Measuring the number of services rendered, delivery times etc.;
    - Measuring the degree of sustainability achieved by SERVIR node users as a result of successful training sessions;
    - Measuring the degree of automation of data (such as the degree of data distribution) for better weather forecasting, disaster prediction, health effects, agricultural efficiency and land-use effects;

- Measuring the number of data set citations in peer-reviewed journals or other publications;
- Measuring the number of and percent change of collaborations among CCAD data centers, researchers and end-users resulting in data set quality improvement;
- Completion of the SERVIR verification and validation/benchmark report.
- Acceptance of SERVIR as a functioning monitoring and visualization tool by the Governments and people of Central America and agreement to continue its operation beyond the fifth year of this five-year project.

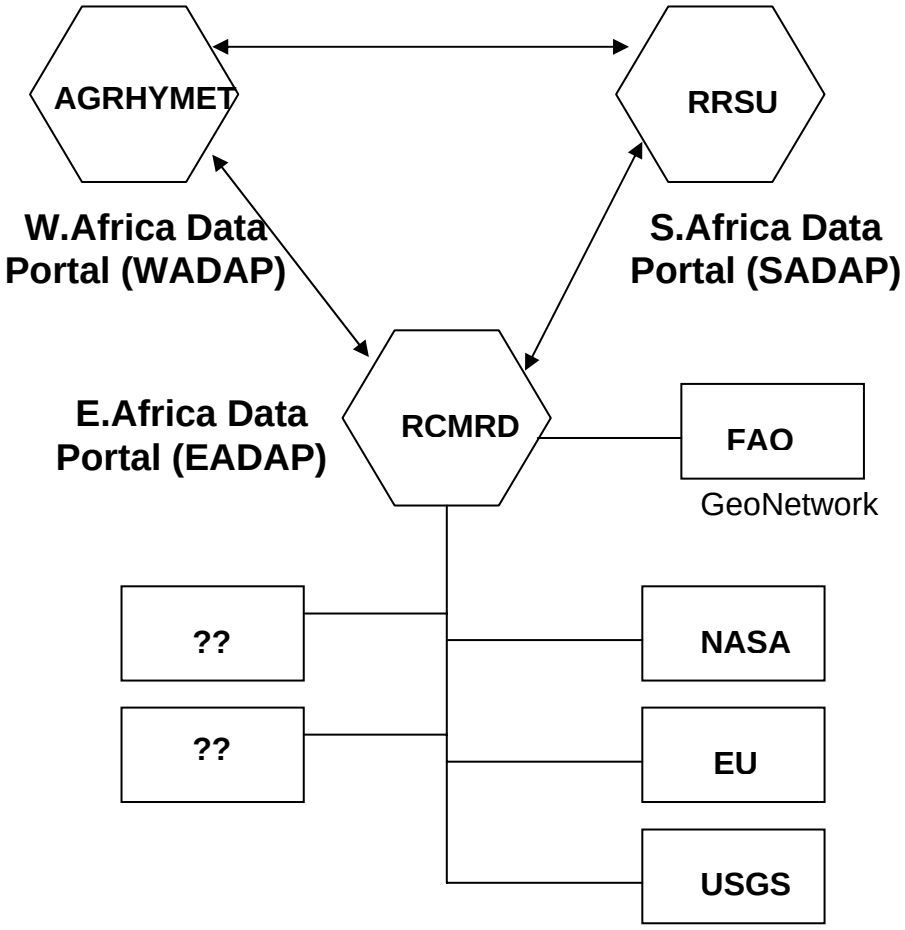
4.3. Conceptual Model for Regional Web-based Portals

The Regional Centers, through their existing data dissemination mechanisms, aspire to strategically position themselves as one-stop regional data dissemination portals. Already on board are their own in-house datasets and links to partners providing data, such as FAO's GeoNetwork.

This unique position and strategy by the RCs opens up opportunity for many partners with the noble intention of disseminating geospatial data and information in Africa. NASA's SERVIR model is one such example that disseminates data and information useful for environmental monitoring, disaster management, etc, for Mesoamerica. Other data dissemination portals such as the Africa Data Dissemination Service (ADDS), EUMETSAT, etc are making their mark in disseminating data and information to Africa.

Thus, in order to help the RCs consolidate their position as regional data dissemination nodes, and support the overall geospatial data and information needs of Africa, it is prudent that all key partners join the effort by developing data portals that serve specific regions in Africa, without duplicating effort, and of course, taking cognizance of the ICT limitations in Africa, so as to increase easy, timely, and affordable access to data on the continent. The websites of the RCs will be focal nodes through which all the other data portals will be accessed (see Figure 4.1).

Figure 4.1. Conceptual Model for implementation of Data Dissemination Portals in Africa.



5. Recommendations

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 (i.e., 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.

Secure (and/or nurture) government buy-in, such that African governments provide national budgets for geo-information

- Develop products and conduct workshops to convince Decision-Makers or Policy-Makers of the importance, relevance, and appropriateness of utilizing RS technology for specified applications.
    - Expansion of the role that EROS has played in the development and implementation of workshops conducted jointly with the RCs.
    - Specialization of workshops for each region as appropriate.
- Develop products and workshops targeting specific applications (e.g., RCMRD experience with joint workshop with UNEP/Nairobi to support national-scale UNEP State of the Environment Reports).
    - Expansion of 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 EW of food insecurity and/or vulnerability.
    - Information workshops on emergency response and the International Charter "Space and Major Disasters".
- Support participation in Conferences such as CODI-V and Geo-CODI, which address Africa-wide development (and subsequently support) of NSDI

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 SAFNet [Southern Africa Fire Network], NASA/UMD/USDA/WRI/etc and CARPE [Central African Regional Program for the Environment])
- Support refresher courses, and/or specific application courses, via RCs, universities, and partners (e.g., USGS EROS, ITC, etc);
- Support training on the International Charter "Space and Major Disasters" for emergency/disaster response.
- Support RCs in conducting in-country training workshops for member States (as opposed to training at RCs);

    - More cost-effective, more nationals benefit from the training (as opposed to bringing 1 or 2 nationals to the RCs for training)
- Support exchange between universities in the region and RCs (e.g., for hands-on applications via internships)
    - Already implemented in some cases with universities in the same city as the RC (e.g., Nairobi universities with RCMRD), but should be implemented for other universities in the region
- Explore/support distance learning and video conferencing
    - video conferencing capacity for RCs and country partners
        - capacity for RCs and partners to access training opportunities in the U.S. (USGS EROS, universities)
        - capacity for country partners to access training at RCs

Improve data availability, access, and distribution (i.e., inexpensive or no-cost)

- U.S. institutions provide no-cost data
    - USGS provide mid-decadal Landsat data (to extend GeoCover Landsat coverage for c.2005) and MODIS products (e.g., FEWS NET processed NDVI)
    - 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, FEWS NET processed daily rainfall estimates)
- Develop database management capacity/capability at RCs
    - See recommendation 7 ("Improve Infrastructure…" – 3rd bullet)

Expand and extend data and information portals

- Based on this report, and previous surveys and analyses, RCs finalize data and information needs for their respective regions;
- Support the RCs to convene meetings with key partners (e.g., USGS EROS, FAO [GeoNetwork], NASA ["SERVIR", etc.], ESA [GMFS, GEONETCast]) to define web portal implementation (including roles of each institution)
- Technical implementation of regional data / information portal (i.e., address minimum hardware, software, bandwidth needs)
- Develop web portal user interface and structure
- Populate web portal with regionally relevant data and information (and maintain updated data/information)
    - Existing regional data and information
    - Development of regional and national baseline datasets
    - Development of additional international/regional datasets that will feed the RCs' websites.
- Emphasize decision support system/information (DSS)
    - Existing (food security) products (e.g., FEWS NET products: Executive Overview Briefs, regional bulletins, weekly weather hazards assessments, Food Security Outlooks, etc)
    - Development of specific regional and national-scale DSS products (using locally-implemented tools such as FEWS NET's GeoWRSI [geospatial water requirements satisfaction index], NOAA CPC's Rainfall Estimation algorithm and USGS Improved Rainfall Estimation, Climate Outlook Forum Forecast Interpretation Tool, etc.)
    - Involvement in, or development of, Africa-wide and regional newsletters (e.g., SDI [Spatial Data Infrastructure]-Africa, etc.)

- 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 (e.g., updating) of the regional portals.
- Develop (or link to) introductory and web-based resources on use of RS for different applications.
- Support website promotion/publicity via workshops in major fora in Africa (e.g., CODI, AfricaGIS 07, AARSE 08, etc).

Develop/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 post-graduate 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., 1 to 3 months)
- Explore/support distance learning
    - 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)

Improve access to regional and international RS communities

- Support participation in regional/international meetings (RCs and universities)
- Support participation/membership in professional organizations
- Involvement in CEOS (Committee on Earth Observation Satellites)?

Improve infrastructure for data access, analyses, and distribution – 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 capacity, support efforts for trunk line [i.e., Internet 2])
- Improve servers and storage capacity (e.g., purchase, maintenance, and systems and data administration capacity)

Strengthen regional coordination

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

Plan for future activities

- Implement monitoring and evaluation of RS programs/applications
- Conduct further evaluation on:
    - RS business models
    - Sustainability
    - Role of other regional institutions, associations, partnerships (e.g., CGIARs, UNEP, EIS-Africa, NEPAD, etc.)
- Develop an implementation plan with 5- to 10-year goals and milestones.

Acknowledgements

We would like to acknowledge a number of people (see Appendix 7) for their contributions to this document which include provision of content, data collection, editorial review, document preparation, and other support. Of particular 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.

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Appendix 1 - National 'geospatial entry points'

Country	"Points of entry"
Algeria	
Angola	
Benin	SIG Environnemental, L'Agence Beninoise pour l'Environnement
Botswana	National GIS Coordination Committee; Department of Surveys and Mapping, Ministry of Lands & Housing; Botswana Surveying and Mapping Association (BSMA) (future geomatics association)
Burkina Faso	Conseil National de Gestion de l'Infrastructure Nationale des Données Spatiales (INDS); Institut Géographique du Burkina (IGB); Association des Geometres et Topographes du Burkina
Burundi	
Cameroon	GIS Unit (Lab), Limbe Botanical and Zoological Gardens; IUCN-Global Forest Watch; OSFAC-Cameroon; Ordre National des Geometres du Cameroun; ADIE-PRGIE- Cameroon
Cape Verde	Environmental Information System Portal of Cape Verde
Central African Republic	
Chad	Centre National d'Appui à la Recherche; Direction Urbanisme du Cadastre et de la Cartographie, Ministère de l'Aménagement du Territoire, de l'Urbanisme et de l'Habitat; Lake Chad Basin Commission (LCBC)
Comoros	
Congo-Brazzaville	Centre de Recherche Géographique et de Production Cartographique (CERGEC)
Côte d'Ivoire	Centre de Cartographie et de Télédétection (CCT); Comité National de Télédétection et d'Informations Géographique (CNTIG)
Democratic Republic of Congo	ADIE-PRGIE-DRC
Djibouti	Laboratoire National de Cartographie du Centre d'Etudes et de Recherches de Djibouti (CERD)
Egypt	Ministry of Communications and Information Technology; Egyptian Geography Network (EGN); Egyptian Committee for Surveying and Mapping
Equatorial Guinea	
Eritrea	
Ethiopia	Ethiopian SDI Committee (dormant), Ethiopia Mapping Authority (EMA)
Gabon	ADIE-PRGIE-Gabon
Gambia	National Environmental Agency (NEA)
Ghana	Ghana Institution of Surveyors; Environmental Protection Agency (EPA); Center for Remote Sensing and GIS, University of Ghana (CERSGIS) (formerly the Remote Sensing Applications Unit)
Guinea	Institut Géographique National de Guinée
Guinea-Bissau	
Kenya	NSDI Secretariat, Survey of Kenya; Kenya Institute of Surveying and Mapping; NSDI in Kenya; Society for Conservation CGIS - Kenya
Lesotho	Committee on Environmental Data Management (CEDAMA); metadata workshop report
Liberia	Liberian Institute for Statistics and Geo-Information Services (LISGIS), Department of Statistics, Ministry of Planning and Economic Affairs; National Information Management Centre (NIMAC)
Libya	Advisory Committee to the Chairman of the General Authority for Information (LSDI committee in development)
Madagascar	Association du Réseau des Systèmes d'Information Environnementale

	(ARSIE); Foiben-Taosarintanin'i Madagasikara (FTM) (Institut Géographique et Hydrographique National)
Malawi	Malawi Geographic Information Council (MAGIC); National Spatial Data Centre
Mali	National Committee for Geographical Information (CNIG); Centre d'Information Géographique du Mali (CIGMa), l'Institut Géographique du Mali
Mauritania	
Mauritius	Cartographic Section, Ministry of Housing & Lands, (Mauritius Natural Resources Information System (MAURIS)
Morocco	Royal Centre for Remote Sensing (CRTS); Ordre National des Ingénieurs Géometres-Topographes
Mozambique	National Directorate of Lands (DINAT); Land Information Management System
Namibia	Inter-ministerial NSDI Committee (dormant)
Niger	Système d'Information Géographique du Niger (SIGNER); Système d'Information Environnementale National du Niger, Direction de l'Environnement; Département de photogrammétrie et télédétection, Institut Géographique National du Niger
Nigeria	National Geospatial Data Infrastructure Committee; National Space Research and Development Agency (NASRDA)
Rwanda	Centre for Geographic Information Systems and Remote Sensing
São Tomé and Príncipe	
Senegal	Groupe Interinstitutionnel de Concertation et de Coordination en Géomatique (GICC); Centre de Suivi Ecologique; Direction des Travaux Géographiques et Cartographiques (DTGC); Association Sénégalaise pour l'Information Géographique (ASIGEO)
Seychelles	GIS Centre, Ministry of Land Use and Habitat
Sierra Leone	Sierra Leone Information System (SLIS), Development Assistance Coordination Office (DACO); Encyclopedia
Somalia	FAO Somalia Water and Land Information Management System (FAO-SWALIM); UN Somalia Interagency Mapping and Coordination (SIMaC) Working Group
South Africa	Committee for Spatial Information; National Spatial Information Framework; National Working Group on Space Science and Technology; Geo-Information Society of South Africa (GISSA); South African Earth Observation Network
Sudan	UN Sudan Interagency Mapping
Swaziland	NSDI Committee, Surveyor's General Department; Swaziland Association of Geographic Information Systems
Tanzania	NSDI Committee (dormant), Survey and Mapping Division (SMD), Ministry of Lands; University College of Lands and Architectural Studies (UCLAS), Tanzania GIS Users Group (TZGISUG)
Togo	Direction Général de la Cartographie et du Cadastre
Tunisia	National Geomatics Program
Uganda	Geography Department, Makerere University; National Integrated Monitoring and Evaluation Strategy (NIMES)
Western Sahara	
Zambia	Zambia Forum for Environmental Information and Network Management Systems (EINMS); Zambia Association for Geographic Information Systems (ZAGIS) (dormant); Environmental Council of Zambia, Integrated Environmental Assessment & Reporting in Zambia)
Zimbabwe	Zimbabwe SDI Steering Committee (dormant); Surveyor General Department

Appendix 2 - Projects, initiatives, investments

Scope	Source	Primary application area	Description
Africa-wide	European Commission Joint Research Centre	Forestry	Forest Observatories in Africa (FORAF), http://ies.jrc.cec.eu.int/468.html A regional centre in Central Africa will be set up for the African Forests Observatory (FORAF) project in Kinshasa under the Congo Basin forest partnership. A 3-year service contract will cover supply of long-term (local and international) and short-term (local and international) experts tasked with collecting and structuring data on Africa's humid forests (exploitation, conservation), setting up data monitoring mechanisms, analyzing factors threatening these ecosystems and providing in-project training for users of this information. The experts will be called on frequently for assignments in Africa and Europe. Furthermore, the damage done to the forest mass will be measured by satellite remote sensing working from a sample from the 1980s and an analysis made of different factors causing this damage. Particular attention will be paid to protected areas. [Tender deadline was January 4, 2007]
	European Commission Joint Research Centre (7th Framework Programme)		ACP Observatory for Sustainable Development http://www-tem.jrc.it/African_Observatory/index.htm http://www-tem.jrc.it/images/pages/africa_pbservatory/290-AfricaObservatEN.pdf A key objective is to provide EC services with environmental information for the orientation, management and evaluation of the international cooperation activities. This activity relies on and consolidates pre-existing JRC activities, in particular in the field of food security, environmental mapping and monitoring, and crisis management.
Africa-wide	EU - estimated at 24 million euros from EU development co-operation resources, available for the project over four years.	Environment	AMESD (African Monitoring of Environment for Sustainable Development) Creation of an Observatory for Environment for Sustainable Development for Africa Project to help African countries introduce Earth Observation (EO) information to better manage their water and land resources has been endorsed by its African beneficiaries and the European Commission (EC). The cost has been estimated at 24 million euros from EU development co-operation resources available for the project over four years. An eighteen month-long feasibility study was funded by the EC, and was considered by African regional economic groups. Potential participants include: SADC (Southern African Development Community); CEMAC (Communauté Economique et Monétaire de l'Afrique Centrale); IOC (Indian Ocean Commission); ECOWAS (Economic Community of West African States); and IGAD (Intergovernmental Authority on Development). The study recommends five thematic areas of focus each led by a Centre of Excellence located in an economic group. The areas are: Water Resources Management; Crop and Range-Land Management; Land Degradation Mitigation and Natural Habitat Conservation; Marine and Coastal Management; and

			Epidemiological and Invasive Risk Management (i.e. for locust swarm invasions). AMESD will also provide resources to maintain and upgrade the PUMA satellite receiving station network. EUMETSAT's contribution to the AMESD project will include data from Meteosat satellites, which will be disseminated via the EUMETCast distribution system. Furthermore, training support and technical expertise for expanding the PUMA user base to non-meteorological users will be provided. AMESD will assist established regional institutions to develop the required regional information services based on available Earth Observation (EO) and other data sources. *Data Supply*: Activities envisaged include assisting the African organizations involved to support, maintain and upgrade the EUMETCast receiving stations installed by the MTAP project, including a) develop and implement continent-wide EO-data production and dissemination services b) negotiate better data access with EO providers to ensure sustainability of supply c) maintain and upgrade the existing EUMETCast stations and potentially expand the network with low-cost ones (activities to be carried out under a separate tender and contract) d) identify and inform the potential user community of the data and information services available and under development by AMESD. *Information Services*: Five Regional Thematic Actions (THEMA) will be established by the pre-selected regional institutions to develop information services appropriate to the already prioritized decision needs of the RECs in the fields of: (i) water resource management, (ii) crop and rangeland management, (iii) agricultural and environmental resource management (iv) mitigation of land degradation (including forest) and conservation of natural habitats, (v) marine and coastal management.
Africa-wide	10th European Development Fund (EDF)		http://www.eumetsat.int/Home/Main/Media/Press_Releases/028690?l=en Global Monitoring for Environment and Security (GMES) extended to Africa - "GMES Africa" GMES Africa would be a continuation of the African Monitoring of Environment for Sustainable Development (AMESD) project. The African component of this initiative would enable African regional and national decision-makers to benefit from the operational use of Earth Observation technologies and related methodologies in support to the implementation of their development policies. The initiative is expected to provide useful data and tools that will help accelerate sustainable development in the region by successfully managing the continent's environment and its natural resources. These would be based on the currently planned GMES services developed in Europe. The implementation of the "GMES Africa" initiative might be funded as part of the 10th European Development Fund (EDF).
Africa-wide	European Space Agency (ESA)	Water	TIGER - TIGER Executive Bureau, http://www.tiger.esa.int/ In the last few years TIGER has involved more than 150 African universities, water authorities and technical centres. TIGER supports African partners with access to space-borne data and products, by offering specific training on EO applications for water management, by funding North-South

			collaborative projects aimed at developing and demonstrating tailored EO-based information services and systems to support African water authorities, and by favoring operationalization and technology transfer of those demonstrated systems to African water authorities in order to attain the final goal: improving water governance and IWRM. In order to reinforce the African ownership of the TIGER initiative and to coordinate and support the execution of the initiative, in June 2005, the TIGER Steering Committee agreed to create a TIGER Executive Bureau to be set up in Africa for an initial period of 3 years. This Bureau will be responsible for coordinating, monitoring and supporting the execution of the TIGER Implementation Plan. http://www.tiger.esa.int/pdf/TIGER_Imp_Plan_06.pdf; http://www.tiger.esa.int/pdf/tiger_brochure.pdf
Selected countries, Africa-wide	ESA EO Data User Element (DUE)		GlobWetland, part of TIGER, funded by ESA's Data User Element (DUE), provides products for a wide range of terrain types to users across four continents: North and South America, Europe (including European Russia) and Africa, including Algeria, Egypt, Cameroon, Central African Republic, Chad, Niger, Kenya, Nigeria, Senegal and South Africa. http://www.globwetland.org/
Africa-wide	ESA EO Data User Element (DUE)		River and Lake project, part of TIGER. Envisat tracking Africa's rivers and lakes to help manage water resources, http://earth.esa.int/riverandlake/, http://www.esa.int/esaEO/SEMM7B5Y3EE_index_0.html
Africa-wide	USAID	Early Warning	FEWS-NET, http://www.fews.net
Central Africa	USAID	Forestry	Central African Regional Program for the Environment (CARPE), http://carpe.umd.edu/
	FAO	Land cover/land use	Africover, http://www.africover.org/
Africa-wide	UNEP / Norwegian government	Environment	Africa Environmental Information Network (AEIN) http://www.unep.org/dewa/africa/aeoprocess/aein/aein.asp
Southern Africa	UN OCHA	Humanitarian	SAHIMS, www.sahims.net
Africa-wide	(Completed, 2001-2005) 11 million euros from the European Development Fund (EDF)	Water	Preparation for the Use of MSG in Africa (PUMA) (precursor to AMESD project) http://www.eumetsat.int/Home/Main/What_We_Do/Cooperation/Development_Assistance/PUMA___AMESD/index.htm?l=enhttp://www.eumetsat.int/Home/Main/What_We_Do/Cooperation/Development_Assistance/PUMA___AMESD/index.htm?l=en The PUMA project came to a close in September 2005, after the installation of more than 50 satellite receiving stations. AMESD represents the envisaged follow-on project. The PUMA project, funded with 11 million euros from the European Development Fund (EDF), was designed to assist 53 African countries and four regional meteorological centers with computers, satellite receivers, training and application support for receiving meteorological data. By the end of April 2005, some 26 receiving stations had been installed and validated by the project management team. Training is ongoing, and pilot projects for the meteorological and non-meteorological use of the data are also moving forward.

			Once all 53 PUMA receiving stations are installed, the entire African continent will be outfitted with the same state-of-the-art technology for receiving meteorological data. This represents a “first” and will inevitably lead to regional and continental applications for the data. Such applications can help fight drought, desertification and improve the management of resources.
	EU		Meteorological Transition in Africa (MTA) Project Meteorological Transition in Africa (MTA) Project was a European Union funded project, through which 46 National Meteorological/Hydrological Services, as well as four regional centers, were provided with satellite ground receiving equipment for the Meteosat Second Generation (MSG) satellite.
	Under discussion	Disaster Management	SPIDER - United Nations Platform for Space-based Information for Disaster Management and Emergency Response, http://unstats.un.org/unsd/geoinfo/17thunrccapIP24.pdf http://www.un.org/News/Press/docs/2006/gaspd357.doc.htm http://www.un.org/News/Press/docs/2006/gaspd347.doc.htm http://www.un.org/News/Press/docs/2006/gaspd346.doc.htm A program within the United Nations to provide universal access to all countries and all relevant international and regional organizations to all types of space-based information and services to support the full disaster management cycle. “SPIDER”, would provide access and services mentioned above, by being a “gateway” to space information for disaster management support, serving as a bridge to connect the disaster management and space communities and being a facilitator of capacity-building and institutional strengthening, in particular for developing countries. If adopted by the Assembly, SPIDER would have an office in Beijing, China, and in Bonn, Germany. A liaison office in Geneva, Switzerland, could be considered. The program would be supported through voluntary contributions and through a rearrangement of priorities, within the framework of the United Nations reform process. Adoption of the draft would not result in an increase of the total regular budget of the Organization.
Global	UNITAR	Disaster / humanitarian	UNOSAT, http://www.unosat.org/ UNOSAT is a United Nations program created to provide the international community and developing countries with enhanced access to satellite imagery and Geographic Information System (GIS) services. These tools are used mainly in humanitarian relief, disaster prevention and post crisis reconstruction.
Eastern and Southern Africa		Geology	http://www.seamic.org/gisafrica/pmwiki.php?n=RegionalProjects.Geodesa GEOscience Data compilation in Eastern and Southern Africa (GEODESA) The project’s overall objective can be summarized as “Making southern and eastern Africa’s geoscience and exploration information more easily accessible”. Increased data accessibility is expected to contribute to creating an enabling environment with optimal investment conditions for the private sector. Furthermore, the strengthened Geological Survey institutions will also be better equipped to execute their own tasks in a better and more efficient manner, and regional institutions could start acting as “one-stop-shop” for services and information related to geoscience information. 13

			Geological Surveys have been involved in this project which focused on managing and upgrading their existing geoscientific data.
		Geology	AEGOS : ACP - European Georesource Observation System Initiative
Southern Africa		Water	Okavango Integrated River Basin Management Project
Southern Africa	USAID	Water	USAID-SADC partnership plans to improve river basins, protect biodiversity The Southern African Development Community (SADC) and the United States Agency for International Development (USAID) signed a grant agreement in April 2006 to improve the management of selected shared river basins and protect biodiversity in the Southern Africa region. The agreement is funded with a $2,160,000 grant and has a total estimated value of $6.5 million through 2008. SADC and USAID will assist river-basin institutions in providing more effective services for river-basin planning, biodiversity protection and conflict mitigation as well as helping selected communities to manage watershed resources. The long-term impacts of the assistance are expected to include more effective regional institutions, improved cooperation, and better information for planning and development decisions for shared river basins. The agreement also outlines how USAID and SADC will work in collaboration with other international cooperating partners to achieve mutual objectives through training, technical assistance and other support.
		Ocean	Regional Ocean Observing and Forecasting System for Integrated Management of Ocean and Coastal Environment and Natural Disasters in Africa (ROOFS-AFRICA) http://ioc.unesco.org/goos/Africa/ROOFS-AFRICAPRoject2003.doc
		Carbon	GLOBCARBON (ESA, Europe), http://geofront.vgt.vito.be/geosuccess/documents/PLUMMER-GLOBCARBON-USym.ppt
Global		Training materials	Virtual global faculty for remote sensing, http://www.bilko.org
Mozambique		Curriculum development	http://www.geog.psu.edu/geclab/miombo/Projects/GIS_RS_Training/UEM-UVA_GIS_Course/uem-uva_gis_course.html Curriculum Development n Use of GIS and Remote Sensing in Environmental Assessment and Modeling / Mainstreaming Use of GIS and Remote Sensing in Environmental Assessment and Sustainable Development
Greater Horn	USAID/OFDA February 2002 - June 2005	Climate	http://iri.columbia.edu/africa/whatisnew/IRI_USAID_GHA_final.pdf Regional Climate Prediction and Risk Reduction in the Greater Horn of Africa: Computing Infrastructure and Technical Support to the GHA Program http://iri.columbia.edu/africa/project/RiskReductionGHA/ Improved climate application skill. Tailored products for applications in the livestock sector. Applications to reduce vulnerability in the livestock, water, health and agricultural sectors.

Southern Africa	USAID/OFDA July 2003 - June 2005	Climate	Mitigating the Effects of Hydro Climate Extremes in Southern Africa http://iri.columbia.edu/africa/project/HydroExtremesSAfrica/ Scoping of tailored products the agricultural, water and health sectors and the media. Increased regional capacity through the southern African Regional Outlook Forum.
Global			http://geofront.vgt.vito.be/geosuccess/relay.do?dispatch=introduction Geosuccess - Global Earth Observation in Support of Climate Change and Environmental Security Studies. The objective of this Geosuccess website is to demonstrate a variety of operational products based on remote sensing data, which give timely information on the evolution of the vegetation cover and its related parameters. Some of these products are calculated in near real time, at the global or regional scale.
Sub-Saharan Africa	ESA under the joint ESA and European Commission -----European consortium (12 partners)		http://www.gmfs.info/ ; http://esamultimedia.esa.int/docs/GMES/GSECo-loc4GMFS.pdf (partnered with AGRHYMET, RCMRD, and RRSU) Global Monitoring for Food Security (GMFS): Understanding Africa's changing agro-environment. GMFS provides early warning, agricultural mapping and crop yield assessment services in support of food security monitoring activities in Africa. GMFS partners with key actors in the sector at the international (EC and UN), regional (Regional Economic Communities or key institutes) and national level (Ministries of Agriculture or national Food Security Monitoring groupings). At national level GMFS Activities focus on .Ethiopia, Sudan, Senegal, Zimbabwe and Malawi. GMFS is an activity started by the European Space Agency (ESA) under the joint ESA and European Commission (EC) Global Monitoring for Environment and Security (GMES) initiative. Through GMES, ESA and the EC have combined forces to unite the research, development and operational user communities across Europe in a coordinated effort to establish, by 2008, a European capacity for Global Monitoring for Environment and Security. -- one of 12 projects in GMES Service Element program of ESA -- one of the demonstrator projects of the ESA TIGER initiative for Africa
	European Commission		TREES-3 (2007 – 2013), http://ec.europa.eu/environment/climat/pdf/nairobi/4.pdf A project of the European Commission's Joint Research Centre Goal: To reduce uncertainties in global/regional estimates of forest area changes and related biosphere-atmosphere processes With focus on the Tropics and boreal Eurasia. Follows on from TREES-I / TREES-II fifteen years expertise in mapping and monitoring of the world's forests Methods: Extensive use of Earth observing satellite data. Collaborative partnership with FAO FRA 2010 Programme and national or regional agencies. TREES-3 main objective is to update and improve forest change estimates at global to regional scales for the periods: (mid 1975)-1990-2000-2005(-2010). Approach: Intensive use of Earth Observation data, a sample of 20-30m resolution satellite imagery. Fine spatial resolution data (10-30m)- frequency limited to once every 20 days
		Agriculture	JRC MARS Crop Monitoring and Food Security Project (produces bulletins) -- in the framework of the Global Monitoring for Environment and Security (GMES) initiative.

			http://dma.jrc.it/DecisionSupport/EarlyWarning.asp The Monitoring of Agriculture with Remote Sensing, MARS, project, started in 1988, was initially designed to apply emerging space technologies for providing independent and timely information on crop areas and yields. Since 1993, driven by user requirements, the team has contributed towards a more effective and efficient management of the Common Agricultural Policy through the provision of a broader range of technical support services to DG Agriculture and Member-State Administrations. Since 2000, the expertise in crop yields has been applied outside the EU. Services have been developed to support EU aid and assistance policies and provide building blocks for a European capability for global agricultural monitoring and food security assessment.
			FAO GIEWS and the locust early warning system http://www.vgt.vito.be/vgtapen/pages/fullpapers/Ceccato_full.pdf
			Malaria and Rift Valley fever projects
			Food Insecurity and Vulnerability Information and Mapping Systems (FIVIMS) are networks of national information systems that assemble, analyze and disseminate data on food insecurity and vulnerability
Africa-wide	Indian government	Tele-education, Tele-medicine (including resource mapping and meteorological services)	Pan-African e-Network Project, http://www.tcil-india.com/new/html/PAN%20Africa.html The network will primarily provide Tele-Education, Tele-Medicine, Internet, videoconferencing and VOIP services. It also supports e-Governance, e-Commerce, infotainment, resource mapping and meteorological services. As of February 2007, 20 African countries have so far signed agreements with the Telecommunications Consultants India Ltd. (TCIL), a government of India enterprise, to implement the Project: Benin, Burkina Faso, Burundi, Comoros, Republic of Congo, Cote d' Ivoire, Djibouti, Ethiopia, Gabon, Gambia, Ghana, Guinea, Mauritius, Nigeria, Tanzania, Senegal, Seychelles, Sudan, Uganda and Zimbabwe.
	AU & WFP		Alert Africa - An African Early Warning System
Greater Horn of Africa	IGAD 4,070,000 USD		Enhancing Hydroclimate Monitoring, Early Warning and Applications for the Reduction of Climate Related Risks in the Greater Horn of Africa IGAD Climate Prediction and Applications Centre (ICPAC). Objectives: Improvement of data base and Dissemination of early warning products Increased availability of tailored climate products to reduce vulnerability to climate extremes Improvement of regional climate modeling, prediction and early warning
			Enhancing Marine Multi-hazard Early Warning System in West African Countries for Improved Marine Safety
	250 KEUR		The Invitation To Tender (ITT) on the DUE, "DIVERSITY", Ref. AO5078 in the ESA Invitations to Tender, has been published today on EMITS with a closing date of 8 September 2006. The European Space Agency (ESA) hereby invites all interested companies from DUE participating countries to submit a tender for the DIVERSITY procurement. If companies are not yet registered as an ESA bidder, they are invited to obtain access to EMITS by completing a questionnaire, which can be found at the indicated URL below, section Registration Request.

			The DIVERSITY project shall cover the study, definition and development of information services to support the implementation of the United Nations Convention on Biodiversity (UNCBD). Services are related to the different areas where EO technology may contribute to support the conservation and monitoring activities of the different actors involved in the UNCBD: e.g., Geo-information for planning and managing habitat, protected areas and bio-corridors; Coral reef monitoring; Geo-information for supporting endangered species conservation; EO-derived biodiversity indicators; The DIVERSITY project precise objectives are to: Define the user base identifying the main national and international bodies involved in the implementation of the UNCBD; Identify their needs in terms information products and services that may be derived with the support of EO technology; Define in collaboration with key users a set of prototype service to be prototyped and demonstrated. Implement and integrate the services at various locations. Validate the services. Prepare the basis for a large project on biodiversity to be launched in 2008. http://dup.esrin.esa.it/news/pnews119.asp
Southern Africa			UNESCO Sustainable Integrated Management and Development of the Arid and Semi-Arid Region of Southern Africa (SIMDAS), http://www.harare.unesco.org/simdas/index.htm
	FAO, IFAD	Health	http://www.fao.org/ag/againfo/programmes/en/paat/home.html Programme Against African Trypanosomiasis (PAAT) PAAT-Information System is made up of several components: this Web site, the Geographical Information System (GIS), the Tsetse and Trypanosomiasis Information (TTI) Bulletin, the Technical and Scientific Series, the PAAT – Link and the Knowledge Base and Resource Inventory. The Geographical Information System (GIS) provides the capability for storage, display and analysis of layers of spatial data. http://www.fao.org/ag/againfo/programmes/en/paat/gis.html http://www.fao.org/ag/againfo/programmes/en/paat/maps.html With regard to tsetse-transmitted trypanosomiasis, area-wide knowledge of the different factors affecting the interactions between vectors, parasites and hosts is of paramount importance for a rational disease management. In this regard, GIS and RS are widely used to map in space and time the distribution of tsetse species, trypanosomes, cattle and several ecological variables which are susceptible to affect vectors, pathogens and parasites distribution. Spatial analysis has also proven very powerful in the identification and prioritization of intervention areas and in the investigation and prediction of environmental implications of different control measures. Furthermore, when socio-economic data are integrated in a geographical environment, a deeper insight into the impact of the

			disease can be given. Spatial layers on cattle breeds and density, husbandry systems, tsetse or disease distribution are put together to estimate the potential economic benefits of trypanosomiasis removal from a given area. Consequently, priority areas for intervention can be pinpointed with the ultimate goal of optimizing the cost/benefit ratio. http://www.galvmed.org/assets/news_0605/PAAT-IS-CTVM.pdf
			GEOLAND, carried out in the context of GMES, a joint initiative of European Commission (EC) and European Space Agency (ESA), which aims to build up a European capacity for Global Monitoring of Environment and Security. http://www.gmes-geoland.info/index.php
	European Commission (EC) 2005-2007 564 k€ [EC/FP6 (GMES)]		http://www.vgt4africa.org/ViewContent.do;jsessionid=8B1544EE6111CF6B6C829EFCEA3F9DBA?pageId=1 VGT4Africa - Distribution of Végétation data (environmental EO products) in Africa through EUMETCast every 10 days (timely, accurate and free added value). The general objective of VGT4Africa is to take benefit of the above-mentioned assets to ensure distribution, through the EUMETCast system and PUMA receiving stations, of advanced products beyond the standard Végétation catalogue to the user community in Africa, composed of the national meteorological services and regional centers. VGT4Africa is a 'fore-runner' to AMESD. Coordinator: VITO.
	ESA		GMES – Respond, www.respond-int.org Respond is an alliance of European and International organizations working with the humanitarian community to improve access to maps, satellite imagery and geographic information. Respond is part of the European Global Monitoring for Environment and Security (GMES) program. In February 2007, it was announced that GMES has received funding from ESA for three more years.
			http://ec.europa.eu/europeaid/projects/forests/projects_en.htm
			http://www.ignfi.fr/england/referenceafrique00.htm IGN France International
Botswana	UNDP	Environment	National Environmental Information System A consultancy, falling under the Government of Botswana - UNDP Environment Support Programme (ESP), intends to develop an Environmental Information System which will include the development of a core set of environmental indicators. The system will contain various data sets and environmental indicators that will inform environmental decision-making and will aid in the production of the next State of the Environment Report (SoER). [Tender deadline was August 31, 2006]
Liberia	UNDP	Information Management	National Information Management Centre (NIMAC) The National Information Management Centre (NIMAC) is a technical assistance and capacity building project developed jointly by the Liberian Institute for Statistics and Geo-Information Services (LISGIS) and UNDP to respond to the data and information needs of the government and broader development community in Liberia. http://www.nimacliberia.org/
Nile Basin		Water	The Nile Basin Initiative (NBI) is a partnership of the riparian states of the Nile: Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda. http://www.nilebasin.org

Somalia	FAO	Land/water	Somalia Land and Water Information Management Systems Project (SWALIM) http://www.faoswalim.org/
Madagascar	Care International		SIRCAT : (Système d'Information sur les Risques et place des Catastrophes) http://www.ngi.no/english/files/lezlie_moriniere_-_case_study_from_madagascar.pps
Madagascar	French Min. of Foreign Affairs (2000-2003), African Bank for Devel. (2005-2008).		Early warning on the Malagasy Migratory locust outbreaks http://www.cirad.fr/ur/index.php/acridologie_en/projets_recherche/lutte/alerte_precoce_lmc
Mauritania, Senegal			Early Warning Systems for Desert Locusts – A West Africa Pilot Project http://unisdr.unbonn.org/ewpp/project_viewer.php?project_id=33
Botswana			Consultancy services supplied to Botswana for establishment of remote sensing infrastructure in the Botswana Department of Surveys and Mapping Proposals were due by July 5, 2006. [Source: Government of Botswana tenders website]
Uganda	Nordic Development Fund (EUR 6.0 million)	Mining/Geology	Sustainable Management of Mineral Resources Project Mining cadastre and registry system, airborne-geophysical data processing and interpretation, complementary mapping and mineral resources assessment [Tender deadline: July 17, 2006]
Tanzania	World Bank	Mining/Geology	Sustainable Management of Mineral Resources (Tanzania) – Geological infrastructure component The geological infrastructure component of this World Bank supported project is meant to support the provision of basic and reliable geological information necessary to facilitate the promotion of private investments in explorations and mine development, to foster future small-scale and artisan mining, and to support adequate planning of the socio-economical development of the country. This includes: i) complete the regional airborne geophysical coverage of selected areas; ii) complete update and publication of the existing coverage of geological maps at 1:000.000 scale, for sub-areas selected on the basis of their mineral resources and environmental characteristics; iii) upgrade and computerize the existing Geological and Mineral Information System (MIS), to store, process and facilitate access to the information to a multi-sector base of users; and iv) restructure and strengthen the Geologic Survey of Tanzania and its central laboratory at Dodoma.
Uganda	Nordic Devel. Fund	Statistics	Second Economic and Financial Management Project (EFMP II) (NDF301) GIS Capacity Building for Uganda Bureau of Statistics U-Consult Sweden AB (March 1, 2004) SEK 625
Ethiopia	Nordic Devel. Fund	Transportation	Road Sector Development Programme Support Project (NDF 207) Ethiopian road network GIS and Database (PMMS) CarlBro AS (October 8, 2004) EUR 456 955,00 ETB 2 117 425,00
Ghana	Nordic Devel. Fund (EUR	Land Administration	Land Administration project - Orthophoto mapping, technical assistance for land use planning [Tender deadline: February 1, 2007]

	7.0 million)		
Ghana	World Bank		Ghana's Land Administration Project (LAP)
Seychelles	FAO, $235,001	Agriculture	FAO Technical Cooperation in the Seychelles - Establishment of an agricultural GIS The main objective of the assistance is to upgrade the capacity of the DNR of the Ministry of Environment and Natural Resources to develop and implement its land and natural resources management program for a more sustainable agricultural development. The project aims at: assisting the Government in its long-term and medium-term agricultural development plans; setting-up a GIS and database to facilitate land use planning and natural resources management; providing training to staff; installing specific equipment, software and datasets (including satellite imagery as required); preparing land cover/land use maps and management plans for a pilot area; and networking national institutions and expertise. [Duration: 2006-2007; Budget: $235,001]. Contact TCP@fao.org (Subject: TCP/SEY/3101 - Establishment of an agricultural GIS).
Namibia	World Bank	Biodiversity conservation	Coast Biodiversity Conservation and Management Project
Burkina Faso	World Bank	ecosystem management / land use planning	Burkina Faso - Sahel Integrated Lowland Ecosystem Management Project SILEM will support capacity building in integrated ecosystem management / land use planning capacity, including the construction of a GIS data base and piloting the use of GIS tools in its intervention sites.
Mozambique	Canadian Space Agency 2006-2007	drought and flood monitoring	http://www.iucn.org/places/canada/prog/Mozambique.htm http://www.iucn.org/places/canada/pdf/prog/ConsCommons/Mozambique_ExSummary.pdf Remote sensing & GIS applied to integrated water resource management with the Canadian Space Agency. The project will help put in place a Decision Support System relative to drought and flood monitoring and response in the Limpopo basin. RADARSAT imagery will represent a main source of information for improving existing hydrological models as well as increasing the effectiveness of the web-based DSS application.
Morocco	EU		Projet Système Maghrébin d'Alerte à la Sécheresse (SMAS) Dans le cadre du programme LIFE-Pays Tiers financé par l'Union Européenne, le Maroc participe à un projet régional, pour la mise en place d'un Système Maghrébin d'Alerte précoce de la Sécheresse (SMAS) dans trois pays de la rive sud de la Méditerranée dont la coordination est assurée par l'Observatoire du Sahara et du Sahel (OSS). Le projet SMAS, s'inscrit dans le cadre d'une approche intégrée pour la mise en place d'un observatoire de la dégradation de l'environnement causée par la sécheresse grâce à l'amélioration du diagnostic de crise et au développement de stratégies d'adaptation en vue de réduire son impact en utilisant un système d'alerte précoce permettant le suivi régulier des changements environnementaux en Tunisie, en Algérie et au Maroc. Ce projet sera élargi dans une deuxième phase aux deux autre pays du Maghreb la Lybie et la Mauritanie.
	2006 Flemish-		Boost for national earth observation through SA/Flanders collaboration Earth observation and remote sensing technologies skills will be strengthened nationally with the

	South Africa		signing of a memorandum of understanding (MOU) by South Africa and Flanders in March 2006. The Council for Scientific and Industrial Research (CSIR) and the Flemish VITO made a mutual commitment to cooperate across international boundaries in areas of common concern. [March 2006]
			EU RS Feasibility study in Burundi
	Japan		Geographical Survey Institute, 2004. Technical Cooperation in Surveying, Mapping and Charting by Japan. Bulletin of the Geographical Survey Institute 50: 27-32 (March, 2004). http://www.kkc.co.jp/english/ps/ http://www.gsi.go.jp/PCGIAP/kl/japan1.pdf Technical Cooperation in Surveying, Mapping and Charting by Japan Regional Environment Information Management Program (1998-2003, US$4.08 million)

Appendix 3 - Thematic networks

At the beginning several networks are included that specifically focus on geospatial networking and data/information management (across multiple domains).

Domain/orientation	Network
Geospatial	African Association for Remote Sensing of the environment (AARSE), http://www.itc.nl/aarse/
	CODI-GEO Executive Committee, http://geoinfo.uneca.org/
	EIS-Africa, http://www.eis-africa.org
	Open Source Geospatial Foundation (OSGEO)-Africa, https://africa.osgeo.org/
	Famine Early Warning Systems Network (FEWS NET)
	Fedération des Géomètres Francophones, http://www.fgf-geo.org/
	RSACCRS/Southern Africa Co-operative Centre for Remote Sensing
	Spatial Information Association for Southern Africa, http://www.gsdi.org/SDIA/docs2006/dec06links/SIASA.pdf
	Community Mapping Network – East, Central and Southern Africa (ERMIS), http://www.ermisafrica.org/
	AFRICA GEODEV, http://membres.lycos.fr/africageodev/Index.htm
	East Africa ESRI User Group; West African ESRI User Group; Southern Africa ESRI user group
Earth system science (cross cutting)	AFRICANESS (African Network of Earth System Science), http://www.igbp.net/page.php?pid=303
	Environmental Long-Term Observatories of southern Africa (ELTOSA), www.eltosa.org.za; http://www.ilternet.edu/networks/
Early warning / (Disasters, Water, Weather)	Famine Early Warning Systems Network (FEWS NET) http://www.fews.net, http://earlywarning.usgs.gov
	Sahara and Sahel Observatory (OSS), http://www.unesco.org/oss/
	University Network for Disaster Risk Reduction in Africa (UNEDRA), http://www.itc.nl/unu/dgim/unedra/default.asp
	Southern Africa Flood and Drought Network, http://www.sadc-hazards.net/
Climate	African Monsoon Multidisciplinary Analysis Network (AMMA-Africa), http://www.ird.ne/partenariat/ammanet/
Fire	Southern Africa Fire Network (SAFNet), http://safnet.firetab.net/
	Regional Subsahara Wildland Fire Network (Afrifirenet), http://www.fire.uni-freiburg.de/GlobalNetworks/Africa/Afrifirenet.html
Geology	SIGAfrique Network
Forests	African Forest Research Network, http://www.afornet.org/
	Global Forest Watch Cameroon
	MIOMBO Network
Soils	African Soil Science Society, http://www.asssonline.org
Water	African Network of Basin Organizations and the Network of International Commissions and Transboundary Basin Organizations, http://www.riob.org/pdf/inbo14_pages07_11.pdf
	Water resources engineering, http://www.wrem.udsm.ac.tz/regional_links.html
Agriculture	Regional Agricultural Information Network (RAIN), Association for Strengthening Agricultural Research in East and Central Africa (ASARECA), http://www.asareca.org/rain/
	Forum for Agricultural Research in Africa (FARA), http://www.fara-africa.org/
	Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD), http://www.acsad.org
	Association of Agricultural Research Institutions in the Near East and North Africa (AARINENA), http://www.aarinena.org/

Oceans	Ocean Data and Information Network for Africa (ODINAFRICA), http://odinafrica.org
	Western Indian Ocean Marine Science Association (WIOMSA), http://www.wiomsa.org/
Humanitarian	Southern Africa Humanitarian Information Network (SAHIMS), http://www.sahims.net
	Southern African Regional Poverty Network (SARPN), http://www.sarpn.org.za/
Health	HELINA - Health Informatics in Africa, http://www.helina.org/
Air pollution	Air Pollution Information Network Africa (APINA), http://www.york.ac.uk/inst/sei/rapidc2/apina/apina.html
Environment & Ecology	Association pour le Développement de l'Information Environnementale (ADIE), Programme Régional de Gestion de l'Information Environnementale (PRGIE) (active?)
	Network for Environment and Sustainable Development in Africa (NESDA/REDDA), http://www.nesda.kabissa.org/ (active?)
	Southern African Research and Documentation Centre, http://www.sardc.net/index.asp
	Africa Chapter of International Association of Landscape Ecology (Africa-IALE), http://snr.unl.edu/africa/index.htm, http://calmit.unl.edu/africa-iale/
Biodiversity	World Wildlife Fund Regional Program Offices (WWF-SARPO; EARPO, CARPO), http://www.panda.org/about_wwf/where_we_work/africa/index.cfm
	IUCN regional offices/network
	African Wildlife Foundation (AWF) network
	African Biodiversity Network
	BIOTA, www.biota-africa.org
	Society for Conservation Biology – Africa section http://www.conbio.org/Sections/Africa/?CFID=7519983&CFTOKEN=33230602
	African Conservation Foundation

Appendix 4 - Existing geospatial services

[See the Data/Tools section of the monthly SDI-Africa newsletters for information on other discovery, data, and decision-support services, http://www.gsdi.org/newsletters.asp. Due to time constraints, only a few services have been included in this appendix for illustrative purposes].

Agricultural Geo-referenced Information System (AGIS)

AGIS is a joint initiative in South Africa between the National Department of Agriculture, the nine Provincial Departments dealing with agriculture and the Agricultural Research Counsel. The strategic vision for AGIS is to facilitate access to structured, integrated, relevant, reliable and timely data, information and decision support systems for the agricultural sector of South Africa. This includes policy makers, researchers, extension officers and rural communities.

Egyptian Geography Network

Egyptian Geography Network is a national network of geographic information users and providers. It uses the infrastructure of the Internet to deliver organizations geographic content to user browsers and desktops. EGN is a collaborative, multi-participant system that provides the framework needed for publishing, sharing, and using geographic information on the Internet. Through the Egyptian Geography Network, GIS organizations can publish their own data via map & metadata services, and search for data available at other agencies as well. The Geography Network is available to private, public, and commercial users, data publishers, and service providers. The data services can be used over the Internet for those agencies and organizations that require authorized access to information.

Botswana NGIS Metadata Service

The Botswana NGIS Metadata Service was developed within the project *Establishment of a National GIS*. It is intended to document as much as possible of available the Geographic Information and Data in Botswana. The amount of metadata depends on how much the different organizations are able to provide. The idea behind the NSDI is to eliminate duplication of efforts as far as the Geographical Information is concerned. The Metadata Service enables users to search through the metadata records to identify data suitable for their their particular uses, and discover whether it is available and where, etc. The GIS Unit also is working on providing a Data Request Service. The ambition for the Data Request Service is to have a Data exchange, at least between the major GI

producers and stakeholders, and for this, the Scaleable Vector Graphics (SVG) application is going to be used.

SWALIM GeoNetwork Opensource

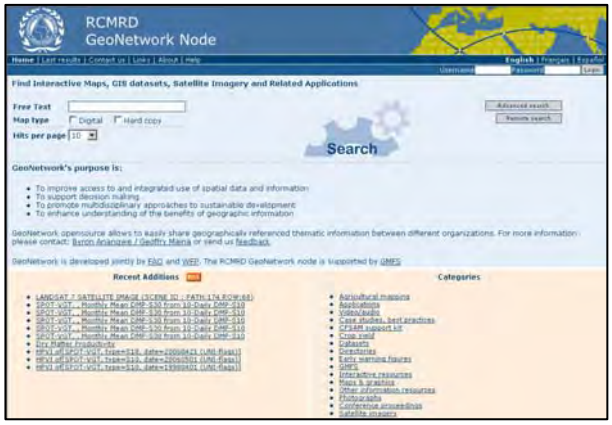
GeoNetwork opensource allows for the easy sharing of geographically referenced thematic information between different organizations. For more information please contact: geonetwork@faoswalim.org. SWALIM is still setting up an interactive map service for users to browse and preview datasets. The feature will be available in the coming months. Historical flood and inundation risk maps now are available. Under recent additions, click "Inundation Risk and Historical floods (Juba and Shabelle basins)" and then click on the link next to the "Data for Download" heading. Note these do not reflect the current flood situation, but can be used for future reference and planning.

The Network of Environmental Information Systems (ARSIE) base

ARSIE is composed of metadata, also called referential data. These metadata provide information about existing data concerning environment and rural development in Madagascar. Thus, metadata are data about data, e.g., publication titles, authors, date of publishing, access mode constitute metadata. ARSIE base contains 7756 metadata (Mar 07). Access to metadata is free of charge. This can be done on line or directly by writing to ARSIE.

[Source: Le dernier bulletin FEHY de l'Association du Réseau des Systèmes d'Information Environnementale (ARSIE), Quatrieme trimestre 2005 [FEHY Spécial N°12].

RCMRD metadata site (GeoNetwork node) for browsing data archives for Africa



GeoNetwork's purpose is: to improve access to and integrated use of spatial data and information; to support decision making; to promote multidisciplinary approaches to sustainable development; and to enhance understanding of the benefits of geographic information. GeoNetwork opensource enables sharing of geographically referenced thematic information between different organizations. For more information contact: Byron Anangwe / Geoffry Maina or send feedback. GeoNetwork is developed jointly by FAO and WFP. The RCMRD GeoNetwork node is supported by GMFS.

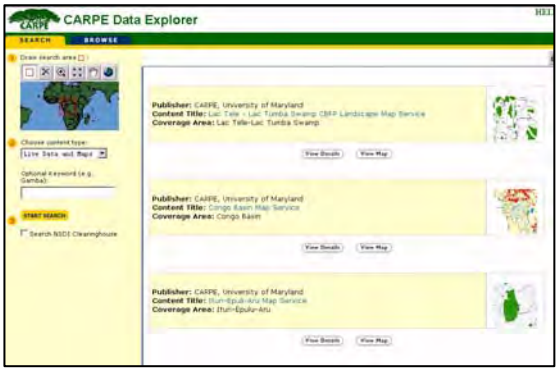
[SADC GeoNetwork]
This site is maintained by SADC RRSU of the Food, Agriculture and Natural Resources (FANR) Directorate. For more information please contact: rrsu@sadc.int. The Agricultural Information Management System also provides data at: http://www.sadc.int/fanr/aims/index.php

[GEOOSS map server of the Royal Centre for Remote Sensing (Morocco)]
This geographical metadata and data server enables a reply to the key question asked day after day by the staff responsible for the management of natural and agricultural areas : what geographical data is existing in the area A_i?, and to the corollary question : what is, on ground, the extension on ground of the data D_i?

Geographical or localized data presented in our server is dedicated to desertification and environmental monitoring and made with datasets including resources. Metadata describes both dataset and their resources. GEO-OSS is dedicated to :

- Dataset and resources retrieving, within the geocatalogue, according to their extension and main attributes (search page),
- Check the extension of datasets and their main features and display a preview of datasets (result page),
- Display the model resource of each dataset, if available in the geocatalogue (display page),
- To display the entire metadata of a dataset and to download its resources, if they are available in the geocatalogue and free of charge (metadata page).

[Central African Regional Program for the Environment (CARPE) Data Explorer]



Central African Regional Program for the Environment (CARPE) Data Explorer – online data and metadata for the Congo Basin. The CARPE Data Explorer offers GIS data, satellite derived products, live map services, static maps, posters and other documents related to the Congo Basin. The data explorer has been established to assist conservation efforts by providing a focal point for CARPE partners to share spatial information on both land use and conservation activities. CARPE data explorer allows users to perform keyword or map based searches and download CARPE related data with associated metadata. Contact carpe@umd.edu

[Regional marine remote sensing products freely available through the Web]

The remote sensing server for marine sciences is a public resource for marine remote sensing data and imagery for the southern African region. This trial server, which went

online the end of July 2006, is jointly funded by BCLME, ACEP, and BCRE, and is operated by the University of Cape Town, Marine and Coastal Management, NatMirc and BENEFIT. The server will make regional RS products freely available through the world wide web. It will provide near real-time products from NASA's Moderate Resolution Imaging Spectrometer (MODIS). Core products will be 1 km resolution chlorophyll a and sea surface temperature imagery and data, for seven regions: Angola; Namibia; South African west, south and east coasts; Delagoa Bight; and Madagascar. The server site will also provide archived data, a variety of mean and anomaly products, and free tools to visualize and analyze RS data. The project will run for a period of 18 months, and during this time will aim to expand the range of RS products available on the server, improve the ability of RS users to freely access and analyze satellite data, and validate available satellite products for regional use. Contact: saulquinbertrand@yahoo.fr.

SAHIMS GIS Data Server

The SAHIMS GIS Data Server, an effort of the Southern Africa Humanitarian Information Management Network, offers easily accessible standardised data provided by various United Nations, non-governmental organisations and government agencies. Datasets in this catalogue are downloadable without any charge. Metadata is available to help the user have a better understanding of data sources, applications and copyright. Recent additions to the data service include:

GIS & Database for Risk Mapping - Madagascar

SAHIMS in collaboration with UNDP facilitated GIS training in Madagascar in the first quarter of 2005. Madagascar's National Emergency Council (CNS) prepared various baseline datasets for this event and these datasets can now freely be downloaded from SAHIMS. Contact: simon.cnsmira@netclub.mg.

Cape Verde Environmental Information System on the Internet

The General Direction of the Environment (Direcção Geral do Ambiente) has managed with the support of the French cooperation the implementation of the Environmental Information System (EIS) in Cape Verde. The first phase of the project permitted on one hand the adoption of a law establishing the creation of the EIS and its jurisdiction, and on the other hand, the design a protocol agreement describing the functioning of the EIS. Twenty-eight national partners have signed this document. The second phase of the project has been devoted to the technical implementation of the EIS, with an online connection of metadata bases and the creation a web portal. On April 7, 2006, a meeting of the EIS partners will be held in Praia in order to present the achievement of this technical phase and to launch the EIS Internet portal. Contact: Pedro Ramos Carvalho, Direcção Geral do Ambiente, pcoramos@gmail.com.

GISCOE Web Services website, GISCOE Pretoria Demonstration Map Service

GISCOE offers web hosting services. Their servers currently host web services for: Southern District Municipalities interactive GIS site (South Africa)

The southern District Municipality GIS is dedicated for delivering accurate and reliable development information for the municipality at your fingertips by July 2007. This access is provided by the use of web and GIS technologies, to enable the sharing of information and improve business decisions.

The Municipalities GIS steering committee provides this site to you as a interactive tool to make customized maps, find information, and to explore the growing number of GIS data layers developed for the municipality.

The GIS system contains 8 sector plans for which GIS data are being developed and are contained by map services developed per Sector plan.

The aim of the interactive GIS site is to develop a GIS database for each sector plan. This will enable decision-makers to make more informed decisions using this interactive GIS database.

Appendix 5 –
QUESTIONNAIRE SUPPORTING REMOTE SENSING NEEDS IN AFRICA

1) Do you use remote sensing data in your work or research?

2) If you had access to remote sensing, would you use it in your work or research?

If NO to questions 1 and 2, there is no need to continue; thank you for your Participation.

3) Do you have access to
   a) Landsat image data? How?
   b) MODIS image data? How?
   c) ASTER image data? How?
   d) commercial high-resolution image data (e.g., Quickbird, IKONOS, etc)? How?
   e) other (e.g. AWiFS, etc)? How?

4) If the answer to (3) is "no", do you need, or desire, access to
   a) Landsat image data?
   b) MODIS image data?
   c) ASTER image data?
   d) commercial high-resolution image data (e.g., Quickbird, IKONOS, etc)?
   e) other (e.g. AWiFS, etc)?

5) Do you have problems accessing remote sensing data?
   a) would high-speed internet help access data

6) Are there other limitations to your use of remote sensing data?
   a) Cost of source data?
   b) Applications software?
   c) Lack of understanding or experience?
   d) Other

7) For what applications do you access remote sensing data, e.g.
   a) Biodiversity
   b) Environmental monitoring
   c) landuse / landcover change
   d) deforestation
   e) other

8) How could remote sensing **data access** be improved in Africa, or your region?

9) What is your affiliation / organization?

10) What is your background/experience in using remote sensing data?

11) Comments

Thank you for your participation.

Appendix 6 – Summary of feedback from RCMRD National Focal Points

1. Do you use RS data in your work or research?

Ethiopia	-	Yes
Lesotho	-	Yes
Malawi	-	Yes
Namibia	-	No
Swaziland	-	No
Tanzania	-	Yes
Uganda	-	Yes
Zambia	-	Yes

2. If you had access to RS, would you use it in your work or research?

Ethiopia	-	In both
Lesotho	-	Yes
Malawi	-	No response
Namibia	-	Yes
Swaziland	-	Yes
Tanzania	-	Yes
Uganda	-	Yes
Zambia	-	No response

3. Do you have access to:

a. Landsat image data? How?

Ethiopia	- Yes. From purchases and collections
Lesotho	- Yes. Purchase from SAC in South Africa
Malawi	- No
Namibia	- No
Swaziland	- Yes. Through RCMRD
Tanzania	- Not online but archives thru projects & RCMRD
Uganda	- Yes. Got a set from RCMRD
Zambia	- Yes. Donated from RCMRD

b. MODIS image data? How?

Ethiopia	- No
Lesotho	- No
Malawi	- No
Namibia	- No
Swaziland	- No
Tanzania	- No
Uganda	- No
Zambia	- No

c. Aster image data? How?

Ethiopia	- No

Lesotho - No
Malawi - No
Namibia - No
Swaziland - No
Tanzania - No
Uganda - No
Zambia - No

d. Commercial high resolution image data (e.g QuickBird, IKONOS, etc)? How?

Ethiopia - In some cases
Lesotho - No
Malawi - Yes. Through RCMRD
Namibia - No
Swaziland - No
Tanzania - Yes. By buying from sales agents (QuickBird)
Uganda - Yes. By buying from sales agents (QuickBird)
Zambia - Yes. Thru donations from persons/organizations

e. Other (e.g AWIFS, etc)? How

Ethiopia - Yes. SPOT
Lesotho - No
Malawi - No
Namibia - No
Swaziland - No
Tanzania - No
Uganda - No
Zambia - No

4. If the answer to (3) is no, do you need or desire access to:

a. Landsat image data

Yes to all countries except blanks for Namibia and Uganda

b. MODIS image data

Yes to all countries except blanks for Namibia and Uganda

c. ASTER image data

Yes to all countries except blanks for Namibia and Uganda

d. Commercial high res image data

Yes to all countries except blanks for Namibia and Uganda

e. Other

Yes to all countries except blanks for Namibia and Uganda

5. a) Do you have problems accessing RS data?

Ethiopia	- Yes
Lesotho	- Yes
Malawi	- Yes
Namibia	- Yes
Swaziland	- Yes
Tanzania	- Yes. It is not well marketed in the country/region
Uganda	- Yes. They are expensive
Zambia	- Yes. Due to limited financial resources

b) Would high speed Internet help access data?

Ethiopia	- Not yet
Lesotho	- Yes
Malawi	- Yes
Namibia	- Yes
Swaziland	- Yes
Tanzania	- Yes (but online purchases not yet possible)
Uganda	- Yes (but the data costs would still be a limitation)
Zambia	- Yes (if cost of high speed Internet is affordable)

6. Are there other limitations to your use of RS data

a) Cost of source data. How?

Ethiopia	- Yes. Expensive in many cases & time consuming
Lesotho	- Yes. Data is expensive
Malawi	- No response
Namibia	- Yes. Cost is too high
Swaziland	- Yes. Cost is very high
Tanzania	- No. Sat. data is less expensive than aerial photos
Uganda	- Yes. Data is expensive
Zambia	- Yes. Data is very expensive (the institution has limited financial resources to afford satellite data)

b) Application software. How?

Ethiopia	- Yes. Limited number of licenses
Lesotho	- Yes. Limited licenses and inability to upgrade
Malawi	- No response
Namibia	- Yes. License fees are too high
Swaziland	- Yes. Availability is related to cost
Tanzania	- Yes. Training of adequate utilization of software is essential for full utilization of satellite imagery
Uganda	- Not for now. We use Idrisi 32, Geovis and Arcinfo
Zambia	- Yes. Have no application software currently

c) Lack of understanding or experience? How

Ethiopia	- No response
Lesotho	- Yes. Have 1 GIS person & are hiring more staff. Training will be needed.
Malawi	- No response
Namibia	- Yes. Basic skills in the use of satellite images is required
Swaziland	- There is adequate understanding to develop experience if data availability and application related problems are resolved
Tanzania	- Training on adequate utilization of application software is essential for utilization of satellite data. Also should be made clear on limitations of satellite imagery in other applications, e.g., large scale mapping and DTM generation
Uganda	- Image processing techniques are required
Zambia	- No.

d) Other

Ethiopia	- High turnover of experts
Lesotho	- No response
Malawi	- No response
Namibia	- No response
Swaziland	- Not applicable
Tanzania	- No response
Uganda	- High speed computers to handle large images
Zambia	- No response

7. For what applications do you access RS data

Ethiopia	- Environmental monitoring, deforestation, (other), Hydrology, Watershed management, Geology, etc
Lesotho	- Land use / Land cover change
Malawi	- Land use / land cover change, (other) Map revision exercises
Namibia	- No response
Swaziland	- Biodiversity, Environmental monitoring, Deforestation
Tanzania	- Environmental monitoring, (other) Urban mapping
Uganda	- Environmental monitoring, (other) Updating topographic maps scales 1:50,000 and 1:2,500
Zambia	- Other (no mention of which ones)

8. How could RS data access be improved in Africa, or your region / country?

Ethiopia	- Capacity building in ICT area and reduction of costs of high resolution data
Lesotho	- Having remote sensing committees
Malawi	- Access to relevant software and training in application usage
Namibia	- Availability of local institutions that can distribute data
Swaziland	- Development of African based and operated acquisition systems
Tanzania	- RCMRD is becoming a distributor of remote sensing data and also offers training and conducts pilot projects which use remote sensing data as a resource.

Uganda	- Lower the cost of images
Zambia	- By making remote sensing data for applications free, by reducing the cost of acquiring remote sensing data, and by upgrading to high speed Internet access

9. What is your affiliation / organization

Ethiopia	- Government (Ethiopian Mapping Authority)
Lesotho	- Land use planning division
Malawi	- Department of Surveys and Mapping, Ministry of Lands, Housing and Surveys (Government)
Namibia	- National Surveying and Mapping Agency (Govt.)
Swaziland	- National Surveying and Mapping Agency
Tanzania	- Surveying and Mapping – the National Mapping Organization
Uganda	- Lands and Surveys Department
Zambia	- Mapping Organization

10. What is your background / experience in using RS data?

Ethiopia	- Remote sensing professional in training and experience
Lesotho	- We have not used RS data intensively as one would expect to use on a day-to-day basis as part of one's expectations as a GIS user
Malawi	- A few members of staff have some exposure to remote sensing, but there is need for in-depth training
Namibia	- No background but would like to use satellite data for planning cadastral surveys of farm holdings
Swaziland	- Development of Swaziland SPOT image map and Global map of Swaziland
Tanzania	- Land Surveyor by profession with higher training in photogrammetry. I have used aerial photography extensively in mapping. I am also familiar with QuickBird satellite imagery in thematic mapping of urban areas
Uganda	- I use this a lot
Zambia	- Map updating / feature extraction

11. Comments

Ethiopia	- None
Lesotho	- We really need the technical know-how and professionalism on how to extensively analyze RS data, and come up with meaningful information that will help decision makers
Malawi	- No response
Namibia	- No response
Swaziland	- There is need for high resolution images like QuickBird for updating small and large scale mapping. Such data is also required for developing land cover datasets and environmental studies.
Tanzania	- Our concern is to use satellite imagery extensively in map updating and monitoring of the environment. In urban areas we envisage to use high resolution satellite (1m or less) and 2.5 - 5m in rural areas. In the meantime, we are converting our paper maps

	into digital format to render them suitable for updating using satellite imagery.
Uganda	- We are looking forward to having access to these images quickly and cheaply.
Zambia	- No response

Appendix 7 – Acknowledgements

CSIR - Meraka Institute (Pretoria, SA)
Philip Frost
Andrew Terhorst
Dechlan Pillay

Agricultural Research Council – Inst. for Soil, Climate and Water (Pretoria, SA)
Talita Germishuyse
Dirk Craigie
Harold Weepener
Dawi van Zyl

EIS-Africa (Pretoria, SA)
Sives Govender

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

SADC 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)
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Basuti Mathangwane
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Botswana College of Agric., Ag Eng and Land Planning Dept. (Gaborone, Botswana)
Rejoice Tsheko
Mataba Tapela
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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 Tech at SAAO (Cape Town, SA)
Peter Martinez
Helena Bosman (collaborating from SunSpace)

Sunspace (Stellenbosch, SA)
Sia Mostert, Director
Helena Bosman