

# Geographic Information for Sustainable Development



Geographic Information for  
Sustainable Development  
Working Group Draft Proposed  
Plan of Action





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This working paper was prepared for the Geographic Information for Sustainable Development Working Group. Views or conclusions contained herein should not be interpreted as representing the official opinion or policy of the U.S. government.



## Executive summary.

The World Summit on Sustainable Development (WSSD) will be held September 2002 in Johannesburg, South Africa. It will be a forum for world leaders to address progress made on the “Agenda 21” issues raised at the previous summit in Rio de Janeiro in 1992. In addition, leaders must chart a course for the next decade by supporting practical, results-oriented programs to alleviate poverty, environmental degradation, food insufficiency, and natural resource mismanagement. While many of the problems covered by Agenda 21 remain severe, the past decade has seen a significant improvement in earth observation data and information management systems that can help address those issues at global, national, regional, and local levels. A key challenge for the international community during the next decade is to make geographic information more accessible and useful to decision makers working on sustainable development problems, especially in poor regions such as Africa.

Over the past decade, the public and private sectors have successfully collaborated in

- The collection of earth observation data (from Landsat to IKONOS)
- The technologies that allow such data to be accurately georeferenced (global positioning system [GPS]), organized, and displayed (geographic information system [GIS])
- The telecommunications media that allow such data to be broadly and quickly disseminated locally and internationally (Internet)

Scientists around the world have undertaken pioneering work in applying these data sets and technologies to a wide range of pressing natural resource management problems—from forest fire prevention to soil conservation. The United States is committed to working with the United Nations (UN), other governments, nongovernmental organizations (NGOs), and the private sector on developing the decision making tools and earth science-based information needed by local and national resource managers to make environmentally and economically sound decisions. A priority is sustainable agricultural production to feed a growing world population.

This proposed Geographic Information for Sustainable Development (GISD) plan of action outlines a U.S.-led international effort to apply a new generation of earth observation data, state-of-the-art GIS-linked technologies, and field-tested geographic knowledge to ongoing sustainable development projects in four diverse areas within Africa. The aim is to assist local, national, and international agencies working in Africa to better address long-term challenges such as disaster mitigation, natural resource management, and poverty alleviation. The results will demonstrate the value of international collaboration in using geographic information for a broad range of sustainable development challenges over the next decade.





## Chapter one. Introduction and project proposal.

### **The proposal.**

The Geographic Information for Sustainable Development project will develop an international public–private collaboration to demonstrate the value of remotely sensed data and other geographic information for sustainable development decision makers, especially those working in Africa. The results will be presented at the WSSD in Johannesburg, September 2002.

On March 30, 2001, the Acting Assistant Secretary of the State Department’s Bureau of Oceans and International Environmental and Scientific Affairs convened an interagency meeting to discuss how the United States might effectively present valuable geographic information to those working on sustainable development issues.

Participating agencies included the following:

- National Aeronautics and Space Administration (NASA)
- National Imagery and Mapping Agency (NIMA)
- National Oceanic and Atmospheric Administration (NOAA)
- National Research Council (NRC)
- U.S. Agency for International Development (USAID)
- U.S. Environmental Protection Agency (EPA)
- U.S. Geological Survey (USGS)

Over several meetings, representatives from these agencies discussed scientific data and technological opportunities as well as constraints. For example, while new satellite data is offering exciting possibilities, funding and time limits dictate the use of data sets already collected and either readily available or with a strong likelihood of being available in the near future. Similarly, any program presented at the next WSSD must itself be sustainable for the foreseeable future, with a firm commitment by participants to make earth observation data available to areas of the world not yet well served by the Internet and other information technologies.

In tandem with the formation of this interagency working group was the organization of a study to be carried

out by the NRC on the use of GIS and remote sensing technologies to promote, plan, and monitor sustainable development projects. The results of this study will be presented alongside case studies. A parallel effort, led by the Open GIS Consortium (OGC), will demonstrate data sharing capabilities including a data access and integration pilot project in Africa.

### **Geographic information for sustainable development.**

The GISD project aims to take advantage of geographic information science and technology to better inform local decision makers working on life-threatening dilemmas in selected project areas. It takes advantage of a substantial U.S. investment already made in collecting earth observation data for real-world demands. It also underscores a commitment to apply relevant information to address Africa’s pressing development problems—not by “dumping” data across the digital divide but by working with institutions in the continent that are committed to making a difference. Active engagement by local practitioners is critical for “ground truthing” remotely sensed earth observation data and to enable lasting institutional collaborations. An effective information management package requires an outreach strategy that encompasses funding, public diplomacy, education, and public–private partnerships. Private companies that sell remotely sensed data, GIS/GPS software, and/or data integration services may wish to support such an initiative. Academic and nonprofit organizations that promote earth science research and education may also wish to play an active role.

The NRC, for example, will pull together leading earth scientists and development practitioners to look at lessons learned and appropriate applications for remote sensing and GIS tools, while OGC will work with public and private sector partners in demonstrating the value of sharing geographic information for improved decision making. The State Department will engage with the UN and overseas missions to obtain international support for the project.

### **Earth observation data—production and access.**

Several U.S. government agencies are committed to using remotely sensed data to address national and interna-

tional environment and development concerns. Several types of earth observation data that were unavailable or were of little use in 1992 now have significant relevance to Agenda 21 concerns.

- The georeferenced imagery record taken by successive Landsat satellites can be used to document rapid land use changes since 1970;
- Advanced Very High Resolution Radiometer (AVHRR) and other high-temporal imagery from NOAA and NASA research missions now provide timely earth observations for weather forecasting; crop yield predictions; and fire, flood, and desertification monitoring;
- Digital elevation data derived from the NASA/NIMA Shuttle Radar Topography Mission (SRTM) will improve our knowledge of much of the earth's topography. Population estimates and proxy population data from the University of California at Santa Barbara (Global Demography Project), Center for International Earth Science Information Network (CIESIN) at Columbia University (Gridded Population of the World), Department of Energy Oak Ridge National Laboratory (LandScan), and NOAA National Geophysical Data Center (Nighttime Lights of the World) improve our understanding of regional and global demographic patterns/vulnerabilities; and
- As part of the USAID-funded Famine Early Warning System Network (FEWS NET), NOAA's Climate Prediction Center has developed a program for rainfall estimation over the African continent. This system is based on several different data sources: the European geostationary meteorological satellite's (METEOSAT) infrared imagery, microwave data from the Advanced Microwave Sounding Unit flown on NOAA Polar-Orbiting Operational Environmental Satellite (POES), the U.S. Defense Meteorological Satellite Program's Special Sensor Microwave Imager, and rain gauge data retrieved via the World Meteorological Organization (WMO) Global Telecommunication System. The information is processed and made available daily and in summaries made over 10-day, monthly, and seasonal periods.



An abundance of earth observation data is of little value if it cannot be provided to those who need it most. Perhaps the most relevant data management tool for remote sensing imagery is GIS, which can integrate georeferenced imagery as data layers that can be linked directly to other data sets over a given area. Commercial GIS tools, especially when connected to GPS-enhanced field data, share a location-based methodology that is having a profound impact on resource management. The Internet and new kinds of data management and transmission capabilities, such as data compression programs that permit access to large imagery files and new Internet Map Server applications, offer a world of data—if they can be accessed. Many poor countries still lack adequate Internet access, and even those with access still need assistance in tapping into the full utility of the Internet. Organizations such as NASA, NOAA, and USGS have done pioneering work in collecting, analyzing, and disseminating earth observation data.

#### **Sustainable development applications.**

Even accessible data is of little value if there is no institutional capability to apply this data to specific natural resource management problems. To be effective in using earth observation data and related technologies, an institution must have a vigorous program of working with communities directly in the affected area. It must have staying power so that data collected from the field and from satellites can be used to monitor changes over time. It must have a strong connection to international research organizations so that new scientific findings,

standards, and techniques can be applied. Moreover, it must have a training program to include resource practitioners who are trying to deal with the immediate resource needs of impoverished communities and the long-term goals of ensuring a sustainable economic basis for future generations.

USAID has extensive experience with development organizations in Africa and will work with the selected African institutions in tackling their sustainable development concerns, especially those involved in improving agricultural production. These multidisciplinary and international efforts will not by themselves resolve the region's sustainable development crises, but they do point the way toward a model of information support for resource management that will be increasingly important in the decades ahead.

Africa is a diverse continent with unique ecosystems and genetic wealth; a rapidly growing, economically impoverished yet intellectually and culturally rich human population; and an economy highly dependent on primary materials production. All these are stressed by environmental, demographic, and economic factors that could be better understood and at least partly alleviated with better access to improved geographic information by national and local decision makers. Though such demographic, environmental, and economic challenges exist worldwide, the WSSD venue and compelling regional needs justify a special focus on sharing earth observation data with organizations already coping with specific sustainable development issues in Africa. Local institutions will be supported to demonstrate how geographic information can assist decision makers in four regions including

- Limpopo/Zambezi River Basin in southern Africa
- Upper Niger Basin in northwest Africa
- Tanzania/Kenya coastal zone of East Africa including the Mt. Kilimanjaro region
- African Great Lakes region

While ecologically unique, each area faces escalating pressures that threaten both struggling societies and their environments.

- Devastating floods have hit the transboundary Limpopo/Zambezi river system over the past two years, killing thousands and leaving hundreds of thousands homeless.
- Desertification has struck the Upper Niger River Basin and the vast Sahelo–Sudanian region, crippling food production.
- Traditional land management practices based on wild-land fire are now overused due to expansions in rural populations, permanently damaging land and water resources.
- The Tanzania/Kenya coast is experiencing rapid development, threatening coral reefs and fish-breeding areas critical to the livelihoods of fishing villages.
- Lake Victoria has been devastated by invasive species (water hyacinth) and contamination caused by upstream expansion of agriculture in the East African highlands, destroying one of the world's most biodiverse freshwater bodies.

For each area, organizations have been identified that are already established locally, have a solid track record with international scientists, and are willing and able to work with new earth observation data sets. While each is unique, the selected project areas in Africa face food insufficiency and natural resource management problems that would be better addressed with timely, accurate, and relevant earth observation data.

The GISD project will use these four regional case studies to demonstrate how appropriately applied geographic information can make a difference in how life-threatening problems are addressed.



## Chapter two.

### Geographic information science and technology for sustainable development.

The next decade presents an opportunity to realize the value of a substantial investment already made in collecting earth observation data for tackling real-world demands and pressing environmental demands such as biodiversity issues. The challenge is making geographic information more accessible and applicable to sustainable development problems including integrating data across multiple scales and sectors. While there have been remarkable improvements in “connectivity” around the world, the “digital and knowledge divide” is still very real, particularly for vulnerable peoples living in rural areas.

Producing an effective geographic information “package” requires an outreach strategy that includes an examination of lessons learned by organizations with experience in Africa, and appropriate design, testing, and deployment of applications for remote sensing, GIS, and decision support systems that address real problems, not abstract models. By bringing together leading earth scientists and development practitioners, the NRC will provide an intellectual basis for promoting these applications worldwide.

#### Overall goals of NRC involvement.

The NRC will provide an evaluation of the potential of geographical information science and technology to assess, monitor, and mitigate a range of sustainable development issues and problems. The study committee will draw on the experience of organizations working in Africa that are willing to share their knowledge with other groups.

The NRC study will contribute to our understanding of how geospatial data and decision support tools can be effective in addressing issues of Agenda 21. These issues fall into five broad categories defining needs for

- Substantial gains in food resource productivity while reducing or limiting land degradation and the impact of fertilizers, irrigation, pesticides, and waste management practices on ecosystems;
- Generation of more energy with less impact on local, regional, and global health and environment from emissions and energy generation activities;

- Generation of goods and services including transportation with lower materials and energy intensities;
- More efficient and sustainable use of water resources, including coastal zone management, in ways that preserve important services performed by ecosystems including the contribution of wild caught fisheries to food security; and
- Better methods of addressing evolving trends including urbanization and human health issues in the contexts of food security, energy, infrastructure development, and integrated water resource management.



#### Statement of task.

As a component of the State Department’s contribution to the WSSD, the NRC study will examine the geographic foundation for natural resource management and development issues in Africa. Specific examples will be drawn from case study regions where USAID and other agencies have broad experience. Centered on a place-based, integrative framework, the study will draw on experiences of U.S. government agencies, international groups, and experts to examine

- Existing remote sensing and GIS efforts in case study regions and lessons learned from those efforts
- Existing levels of local expertise and technology and ongoing efforts in geospatial capacity building
- A range of questions relating to the practical application of new and existing spatial data (e.g., required resolution, challenges of integrating layers of envi-

ronmental and social data, and baseline data against which future change can be measured)

- The role of decision support systems in the application of this data
- Options for making these efforts sustainable

An ad hoc committee of approximately 10 members representative of the range of expertise required will conduct the study. Committee members will be drawn from academia, industry, and NGOs including representation from African institutions. The latter representation would be selected through the NRC's network of international academic contacts.

The NRC-led study will last 12 months, with a final consensus report due by August 1, 2002, for dissemination at the WSSD. The study will require five meetings. Following an initial planning meeting, the committee will hear testimony on data availability and existing efforts in the case study regions. The third meeting, involving a subset of the committee, would coordinate with the "AFRICA GIS" meeting in November 2001 in Nairobi, Kenya, to learn firsthand from those involved in GIS projects in Africa. The fourth meeting would focus on capacity-building efforts and future prospects for data, partnerships, and technology transfers. A final writing session would complete the schedule of meetings.

#### **Data interoperability for information management.**

Sustainable development decision makers are highly dependent on the availability of and access to geospatial information. Relevant sources of geographic information often exist at local and national levels, in the private sector, academia, and NGOs. To help make this information more available and usable, data and metadata standards are being developed and agreed to at the national and international levels, with their use reinforced by governments and the UN through efforts such as the Global Spatial Data Infrastructure (GSDI) initiative (see [www.gsdi.org](http://www.gsdi.org)). Furthermore, the Internet is helping to provide a communications medium to discover, access, and apply this information.

Geographic information tools and techniques help visualize, model, and analyze sustainable development issues of many types. They are crucial to linking small landholders to the global market and trading systems that increasingly require certification and verification of compliance with global standards. The variety of GIS software today is increasingly based on open standards for interoperability (the ability of software to operate with other software and data on any computing system, network, or vendor brand). Future geographic information technologies will be "plug and play," require less maintenance, allow for growth of new capabilities, and encourage wider consumer use.

Open standards and interfaces then become a mechanism to discover, share, and apply geographic information in a real-world setting. They promote private sector investment and "buy-in" that will mean entrepreneurship is maximized, and sustainability is more likely to occur. The use of common information and technology standards, therefore, must be an essential element of any sustainable development strategy.

#### **A public-private partnership to advance geographic information.**

The OGC, a not-for-profit international organization, will create, in conjunction with its member organizations, a public-private partnership to promote understanding and application of interoperability standards and improve the ability of GIS-linked technologies to discover, share, and apply geographic information. This partnership will allow an open and direct dialog with more than 210 OGC international members from industry, government, and academia and GIS practitioners in Africa and elsewhere around the globe.

OGC will host a Special Interest Group (SIG) for the sustainable development community that will be a mechanism for addressing interoperability requirements for GIS needs in Africa. OGC also proposes development of a "pilot project" to illustrate how consistent use of industry and international data and technology standards can improve the ability of the sustainable development community to share and apply critical geographic information. It would be tailored to address the specific

application needs of one or more of the selected operational areas for the GISD initiative. This test bed process would be demand driven by decision makers who would help with problem set definition and evaluation of technological effectiveness and efficient implementation given realities in Africa.

OGC's SIG will provide guidance to encourage usage of internationally accepted standards in geospatial data and technology procurements and programs. The SIG will also provide a forum for discussion of geospatial data standards issues within the industry.

By managing, disseminating, and applying spatial data to GIS products that employ open interfaces (from a Web browser to a traditional GIS package), sustainable development practitioners will be able to access, integrate, and use this information more efficiently and effectively. Using OGC interfaces, they can manage their data in any popular proprietary data format and rely on Web servers to provide a variety of geospatial information to any client. Where feasible, the Web services approach offers users more freedom of choice, encourages lower life cycle costs, and simplifies capacity building.

In sum, the OGC-led initiative will

- a) Create a Sustainable Development SIG to facilitate discussion and focus on interoperability requirements needed by the sustainable development community (October–December 2001).
- b) Establish and maintain a Web-based communications capability to exchange information on project plans, define “use cases,” monitor progress, and give feedback to designers and implementers. The Web site will include an online discussion forum, e-mail reflectors, documentation management, and scheduling capabilities (October–December 2001).
- c) Identify GISD requirements, funding, and sponsorship sources for an interoperability pilot project to support the selected African project sites and requirements and prepare a detailed plan to identify interoperability requirements for sustainable development (October 2001–January 2002).

- d) Identify geospatial requirements, target architecture for interoperable technologies, and issue a call for industry participation in a pilot project for implementation in Africa by summer 2002 (October 2001–January 2002).

- e) Initiate a GSDI interoperability pilot project (pending sufficient funding) to deliver a limited framework of OGC interoperable technologies to demonstrate distributed data access, data integration, and application needs for one or more local programs (February–June 2002).

- f) Develop guidelines/recommendations for use by the sustainable development community to optimize interoperable data management and spatial applications. Guidelines are to be developed in collaboration with the GSDI initiative and other appropriate international standards bodies (June 2002).



# 3

## Chapter three. Earth observation data and access.

Earth observation data from satellites is an important information resource for sustainable development decision making. Satellite platforms can include very large areas in a single image or data set; acquire data from anywhere on the surface of the earth in a matter of hours or days; and repeat coverage of a given area daily, seasonally, or annually.

Satellite systems that acquire earth observations have different ground and spectral resolution characteristics affording a variety of different applications at different spatial scales. Civil and commercial earth observations are used for basic and applied science including studies of fundamental global processes and the impact of such processes on climate and life. Applications of earth observation data are often focused on changes to both land cover and land usage. Observations of the earth's terrestrial surface from space have been acquired by the United States since the 1960s, but the utility of most early observation programs for sustainable development is limited.

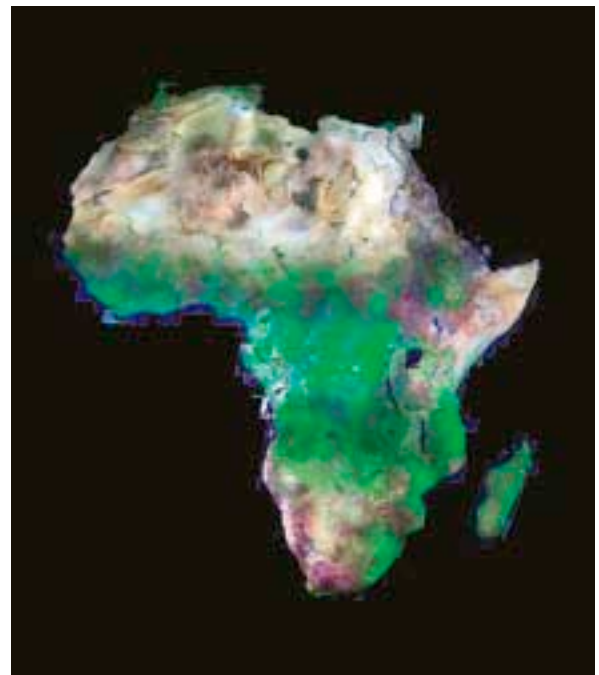
Several U.S. government-owned earth observation systems can provide data to support the GISD project. Data from these instruments is useful for studies at regional, continental, and global scales. NASA, NOAA, and other partners will provide data from Landsat, AVHRR, and SRTM. Additional data will also be provided from other systems as needed.

### **Landsat.**

<http://landsat7.usgs.gov>

The Landsat system is the oldest system for civilian land remote sensing. It has moderately high spatial resolution and low temporal resolution that makes its earth observations from space suitable for resource management. The first Landsat was launched in 1972. The most recent, Landsat 7, was launched in 1999. Landsat 5 and Landsat 7 remain operational. Both systems acquire 30-meter data resolution in six spectral bands in the visible, near-infrared, and mid-infrared wavelengths. Landsat 7 also includes a 15-meter panchromatic band for image sharpening. Each Landsat satellite can acquire repeat coverage of an area on the earth's surface every 16 days. Data from Landsat 5 was used to generate the first systematic, global data set of all land images from

an earth observation system with 30-meter resolution. A similar data set will be generated from Landsat 7 data acquired in 2000. The archive of Landsat imagery is an objective documentation of land cover and land use changes for the past three decades. If used effectively, it can provide a baseline for monitoring future surface changes and for managing scarce natural resources.



### **AVHRR.**

<http://www.ngdc.noaa.gov/seg/globsys/avhrr.shtml>

The AVHRR sensor flown onboard NOAA's operational polar-orbiting satellites makes 14 polar orbits daily. AVHRR is the current version of the longest running series of earth environmental observation systems, descended from the Television Infrared Observation Satellite (TIROS) systems of 1960. AVHRR is a system with lower moderate spatial resolution (1.1 km IFOV) but high temporal resolution with global daily coverage from each AVHRR sensor. Currently there are two satellites in orbit (morning and afternoon equatorial crossing) that provide daily global coverage of the earth. While this sensor was originally designed for global weather monitoring applications, NOAA provides complete access to the data,

allowing the data and images to be used on a daily basis for a variety of land, ocean, and atmospheric applications. Data from the POES series supports a broad range of environmental monitoring applications including weather analysis and forecasting, climate research and prediction, global sea surface temperature measurements, atmospheric soundings of temperature and humidity, ocean dynamics research, volcanic eruption monitoring, forest fire detection, global vegetation analysis, search and rescue, and many other applications. NOAA and NASA are collaborating on the successor of AVHRR, the Visible/Infrared Imager/Radiometer Suite (VIIRS). VIIRS will provide 400-meter gridding and possesses many more spectral channels in the visible, near, and thermal infrared bands that will optimize the ability to continue with existing data time series while supporting improved environmental monitoring.

One of the most noteworthy applications has been the use of AVHRR data for the FEWS NET. The USAID-funded FEWS NET uses AVHRR data to assess the yearly onset of greenness across Africa. By comparing current year patterns with the historical record of AVHRR data, agricultural ministries and others involved in famine prediction can model and predict drought patterns and trends.

#### **SRTM.**

<http://www.jpl.nasa.gov/srtm/>

Maps of the earth's topography are currently inaccurate and even nonexistent for large parts of the world—including many mountain chains, deserts, and tropical rain forests—because of the difficulty in getting to these remote locations. Even where topographic maps exist, their usefulness is often limited because neighboring countries may generate topographic data using entirely different methods. The resulting lack of standardization hinders the scope of regional or global studies where precise topography is important. The SRTM is an international project consisting of a specially modified radar system that flew onboard the space shuttle in February 2000. It will result in the most accurate and complete topographic map of the earth's surface ever assembled. SRTM uses two radar images taken from slightly different locations to calculate surface elevation.

Virtually any project that requires accurate knowledge of the shape and height of the land can benefit from this data. Some examples include flood control, soil conservation, reforestation, volcano monitoring, earthquake research, and glacier movement monitoring. The SRTM covered about 80 percent of the earth's landmass. The SRTM level one data set will be publicly available and will represent a vast improvement in the quality of topographic data used by sustainable development researchers and practitioners. The value of SRTM data will be previewed in a special early release for the specific areas identified under the GISD project.

#### **Other earth observation data.**

Polar-orbiting weather satellites under the U.S. Air Force Defense Meteorological Satellite Program (DMSP) (<http://dmsp.ngdc.noaa.gov/dmsp.html>) provide importance data for civil applications. Two of the most widely used sensors, Operational Linescan System (OLS) and Special Sensor Microwave/Imager (SSM/I), provide global data that is important in supporting sustainable development. The SSM/I provides important data on rainfall and soil moisture, an indicator of the ability of land to support robust agricultural production. The OLS sensor has a unique capability to observe human activity on the earth's surface through low light imaging of the earth at night. Lights from cities and towns, gas flares, and fires are apparent in DMSPOLS images. The data and processing algorithms are available in near real time from NOAA's National Geophysical Data Center (NGDC). The digital archive of DMSPOLS data held by NGDC extends back to 1992. In Africa, DMSPOLS data could be used to analyze the growth of cities and the expansion of electrification from 1992 to the present, temporal trends in fires, and the waste of fuel associated with gas flaring. These data sets from U.S. military weather satellites are now available for civilian applications, and similar sensors will be flown aboard future NOAA operational satellites. Similar DMSP sensors will be migrated to future NOAA operational polar satellites scheduled for launch in 2008 ([www.ipa.noaa.gov](http://www.ipa.noaa.gov)). Data will be fully available to the global user community.

The Moderate Resolution Imaging Spectroradiometer (MODIS) is one of five instruments aboard the Terra

satellite. MODIS views the entire earth's surface every one to two days with a maximum spatial resolution of 250 meters per pixel. These data sets will improve understanding of global dynamics and processes occurring on the land, in the oceans, and in the lower atmosphere. MODIS is playing a vital role in the development of validated, global, interactive earth system models able to predict environmental changes.

The SeaStar spacecraft carries the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) that is designed to detect changes in ocean color, hence productivity, based on changes in concentrations of chlorophyll and other plant pigments in the water. SeaWiFS views every square kilometer of cloud-free ocean every 48 hours. SeaWiFS can also sense the terrestrial surface of the earth and track values associated with terrestrial vegetation. These NASA research sensors are precursor instruments that will be migrated to future NOAA operational polar satellites scheduled for launch in 2008 ([www.ipa.noaa.gov](http://www.ipa.noaa.gov)). Data will be fully available to the global user community.

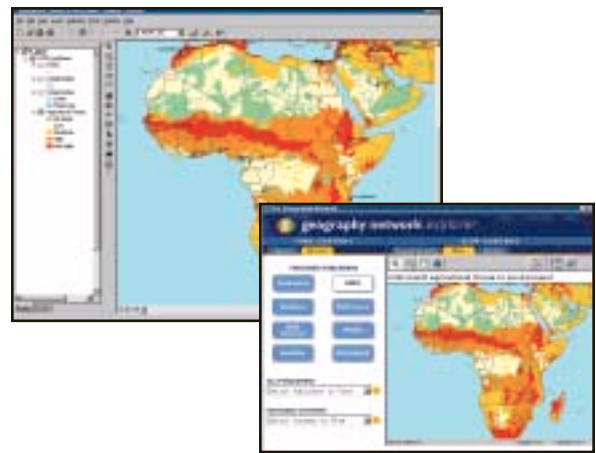
The large area coverage of MODIS and SeaWiFS makes them suitable for studies at regional or smaller scales. Their data sets are available at relatively low cost and can be integrated into a GIS, thereby increasing their use for monitoring regional ecosystems.

#### Digital atlas.

The last decade has been one of increasing cooperation between scientists, policy makers, and stakeholders at all levels in the sustainable development decision making process. Such decisions must be supported by an integrated and comprehensive set of equally accessible GIS tools that make data at global, regional, and local scales easily accessible so they can be utilized with project-specific data sets. The maps also provide a better understanding of the consequences of policies and management decisions by resource managers and a broader understanding of study areas.

Internet-based networks are increasingly utilized to access GIS-linked data. The GISD project will publish an interactive digital atlas of Africa and will provide GIS map services (in both ArcIMS® and OGC-compli-

ant WMS format and metadata) for all data sets on the Geography Network™ ([www.geographynetwork.com](http://www.geographynetwork.com)). The goal of this unprecedented data access is to provide a spatial data context for analysis of the sustainable development issues in the region.



The digital atlas of Africa will consist of basemap layers and project data sets. GTOPO30 is a global digital elevation model (DEM) with elevations regularly spaced at 30-arc seconds and will provide one-kilometer DEM data and shaded relief for the continent. GTOPO30 was developed to meet the needs of the geospatial data user community for regional- and continental-scale topographic data. HYDRO1k provides a suite of georeferenced data sets that allows users to utilize hydrologic information on a continental scale and consists of topographically derived data sets including streams, drainage basins, and ancillary layers. The EarthSat Orthorectified Landsat Thematic Mapper scenes for the late 70s, early 90s, and 2000 provide a three-decade record of land use change. Mosaics suitable for GIS will be created for the regional project areas as well as LandScan 2000 and Digital Chart of the World data. Project-specific data sets will be included for each of the focus areas as provided by partner organizations. This online atlas will allow users to view a variety of data themes at different scales over an area of interest. Users will be able to pan and zoom, identify features, and link from areas



of interest to Web pages that document projects in that area. Since all of the data sets viewable in this digital atlas will also be freely available from the Geography Network and UNEP.NET, users can preview data sets before incorporating them into their work. To maximize access and distribution of this GIS data throughout Africa, the data will also be published on CDs.

The digital atlas and the map services published on the Geography Network will be served by the USGS EROS Data Center in Sioux Falls, South Dakota. A Web interface will be created for viewing the digital atlas and will allow adequate access even in regions with slow-speed Internet connectivity.

Through an existing agreement with ESRI, the USGS will gain the technical assistance required to complete the GISD work. Specifically, ESRI will assist the USGS in developing the online atlas capability by providing ArcSDE™ and ArcIMS software and training. In return, USGS will publish map services and data download services on the Geography Network.

The digital atlas will be interoperable with other data services offered by participating organizations. For example, CIESIN is developing an interactive Ramsar Wetlands Data Gateway in cooperation with the Ramsar Secretariat on Wetlands of International Importance and Wetlands International. This Gateway incorporates spatial data on wetlands, population, land cover, and other important features relevant to wetlands managers at local, national, and international levels. CIESIN also offers online access to the population distribution data sets and other relevant global data sets such as the Environmental Sustainability Index.

# Chapter four.

## Sustainable development applications.

Reliable geographic information is critical to the development of adaptive and responsive natural resource management. Earth observation data can be used to analyze the status and trends of natural resource use and relate resource degradation to human causes and consequences. While such remotely sensed data sets are unique in their ability to detect patterns and trends in earth surface changes, they must be complemented by on-the-ground observations if they are to be fully validated for sustainable development decision making. New geographic information technologies are extensions of capacities, tools, and methods that have been field-tested in Africa. Such technologies can build on past experience to do things better and faster and be of use to more people, particularly those on the other side of the “knowledge divide.”

USAID, in partnership with others, will demonstrate the usefulness and applicability of geographic information to ongoing sustainable development projects in Africa. The GISD project effectively supports the “Four Pillars” strategic framework, recently enunciated by the new administrator of USAID and the Secretary of State, namely conflict prevention, health and population, agriculture and economic growth, and a new collaborative framework, the Global Development Alliance. The latter puts a high priority on the use of information technology and public-private alliances to help solve sustainable development problems.

While each of the four target regions exhibits a different set of challenges, in all cases key institutional partners have been identified that are well established locally, have solid track records with international and African scientists, and have expressed a strong interest in working with new earth observation data sets and tools. These local GISD partners are ready to expand their current usage of such tools in ways that can serve as innovation catalysts for others within and outside Africa.

### Resource management.

Natural resource management is a challenge that will affect virtually all of humanity over the next decade. The selected sites highlight a number of different land and water management applications, for example, that would

benefit from timely, accurate, and relevant earth observation data. They illustrate the complex linkages between water resource management issues and agricultural intensification, market reform, energy use, global health, conflict prevention, and economic growth. The sites were also selected because they represent innovative field applications of geographic information that lend themselves to replication elsewhere.



### Benchmark data.

The project provides a set of benchmark earth observation data that can be used to compare changes in land uses since 1992. In addition, some sites will receive additional specialized data sets for each area such as SeaWiFS for the Tanzania/Kenya coastal area and the African Great Lakes region; DMSP, MODIS, and AVHRR for the Upper Niger Basin; and SRTM for the African Great Lakes, Mt. Kilimanjaro, and Limpopo/Zambezi regions. Table one outlines the benchmark data sets that will be the main focus of efforts of initial satellite data collection activities.

### Project descriptions.

The proposed project sites, the issues to be highlighted, and the key partners for implementation of the GISD project are representative of Africa’s rich diversity, its sustainable development challenges, and the types of organizations committed to improving living conditions for all Africans.



Niger Basin



African Great Lakes region



Limpopo/Zambezi Basin



Tanzania/Kenya coastal zone

**Table one.**  
**Benchmark data needs—target WSSD case study sites.**

Region	Landsat '90s	Landsat 2000	GeoCover	AVHRR (1 km)	SeaWiFS	SRTM	DMSP Nighttime Lights	LandScan	MODIS	DMSP SSYMI
Niger Basin	•	•	•	•			• <sup>2</sup>	• <sup>2</sup>	•	•
African Great Lakes region	•	•	•	•	• <sup>6</sup>	• <sup>4</sup>			•	•
Limpopo/Zambezi Basin	•	•	•	•		• <sup>7</sup>	• <sup>3</sup>	• <sup>3</sup>	•	•
Tanzania/Kenya coastal zone <sup>1</sup>	•	•	•	•	•	• <sup>5</sup>			•	

Notes:

- <sup>1</sup> This region includes the entire watershed that starts on Mt. Kilimanjaro and in the Shimba Hills and (along the Tsavo River) that terminates on the Kenya coast at Malindi. This will present a test site for “ridge-to-reef” prototype activities. Therefore, the entire Tanzania/Kenya coastal zone target region needs to indent sufficiently along the Tanzania/Kenya border to include all of Mt. Kilimanjaro and its surrounding lowlands (see polygon outlined on attached map).
- <sup>2</sup> This region, if possible, will include the urban region around Bamako, Mali (within the Upper Niger Basin), as a demo site of LandScan and DMSP Nighttime lights imagery as a method for study of population–environment interactions (e.g., density, transportation, energy intensity) (see polygon outlined on attached map).
- <sup>3</sup> This region, if possible, will include the urban region around Pretoria, South Africa (within the Limpopo Basin), as a demo site of LandScan and DMSP Nighttime lights imagery as a method for study of population–environment interactions (e.g., density, transportation, energy intensity) (see polygon outlined on attached map).
- <sup>4</sup> SRTM-2 test site demo is only for the southwest Uganda and north-west Rwanda subregion (see polygon outlined on attached map).
- <sup>5</sup> SRTM-2 test site demo is only for the Mt. Kilimanjaro/Shimba Hills/Malindi subregion (see polygon outlined on attached map).
- <sup>6</sup> This provides SeaWiFS data (the terrestrial portion) for Lake Victoria and the Coastal Tanzania/Kenya region.
- <sup>7</sup> SRTM-2 data will be particularly important for the Limpopo Basin, where modeling of flood hazards in a much more precise manner will be possible with the new digital terrain topographic data it provides. This can build on an already significant investment by USAID and USGS toward enhancing the region’s capacity to model flood hazards and utilize more effectively the dams along the Limpopo River.

#### **A. The Limpopo/Zambezi River Basin.**

This river basin has seen devastating floods over the past two years and faces basinwide natural resources management problems. It also includes South Africa, host of the WSSD and a key country for providing capacity-building support to the region. This region offers an opportunity to highlight settlement changes and their impacts on agricultural and environmental conditions as well as potential conflict over land and water resources. It could be particularly helpful in demonstrating geographic information approaches focused on river-basin management, flood control, community-based and transboundary natural resource management, interactions between land uses and economic development, and infectious disease transmission.



Limpopo/Zambezi Basin

#### **Key partners.**

Environmental Information Systems (EIS)-Africa; USAID/South Africa; Regional Center for Southern Africa (RCSA), Gaborone, Botswana; Office of Foreign Disaster Assistance USAID (OFDA); Miombo.net; Harare Regional GIS Unit; NASA; NOAA; USGS; Southern African Development Community (SADC) Water Council; International Water Management Institute (IWMI), Durban, South Africa; International Center for Living Aquatic Resources Management (ICLARM); Mud Springs Geographers, Inc.; Broadening Access and Strengthening Input-market Systems (BASIS) Collaborative Research Support Program (CRSP) (various universities in Malawi, Mozambique, Zimbabwe, and South Africa); CIESIN; and Tracker

#### **Issues highlighted.**

Flood control, basin/watershed management, transboundary resource management issues, and conflict prevention

## B. The Upper Niger Basin.

The Upper Niger River Basin encompasses parts of the Sahel and Sudan ecological zones, where desertification and drought have rendered the population chronically vulnerable to food insecurity. But there are successes occurring in this region in agricultural intensification, productivity enhancement, and the rehabilitation of degraded lands. Case studies from Mali, Niger, and Burkina Faso highlight settlement changes and their impacts on agricultural/environmental trends, as well as socioeconomic dynamics that are pointing the way toward better disaster preparedness and poverty reduction.

### Key partners.

FEWS-NET; Office de la Haute Vallée du Niger, Mali (OHVN); USAID/Mali; Sustainable Agriculture and Natural Resource Management (SANREM)/CRSP; L'Institut du Sahel (INSAH); Permanent Interstate Committee to Combat Drought in the Sahel (CILSS); AGRHYMET; USGS; International Consortium for Agricultural Systems Applications (ICASA); International Crop Research Institute for the Semi-arid Tropics (ICRISAT)/Institut d'économie rurale, Mali (IER); Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH/French, Dutch, British, U.S. and other Yatenga researchers; CIESIN; Mud Springs Geographers, Inc.; Development Ecology Information Service (DEVECOL); NASA; NOAA; Stone Environmental, Inc.; U.S. Department of Agriculture (USDA)/Natural Resources Conservation Service (NRCS) World Soils Resources Office; Tracker; and the World Bank

### Issues highlighted.

Drought, land degradation, and agricultural intensification



Niger Basin

### C. The Tanzania/Kenya coastal zone.

This coastal region is experiencing rapid development, intensification of agriculture and mariculture, and expanding population growth, which threaten economic growth and important coral reefs and fish-breeding grounds. Two projects in this region—the national-level integrated coastal management activity ongoing in Tanzania and a “ridge-to-reef” project that is just being launched in the Shimba Hills of Kenya—will serve as the foci for capacity building and training.

A partnership involving the Tanzanian Environmental Management Council (TEMC), the University of Rhode Island, and USAID was established in 1997 to improve national coastal planning, policy, and management and to coordinate local and national coastal resource management. The Tanzania Coastal Management Partnership (TCMP) works with the existing network of integrated coastal management (ICM) programs and practitioners to promote a participatory, transparent process to unite government and community, science and management, and private and public interests to wisely conserve and develop coastal ecosystems and resources. The processing of satellite data and construction of GIS maps will help analyze rates of change over time in resource and land use patterns and identify priority locations for coastal action planning and conservation, aquaculture and tourism development planning, and land use zoning. The project will provide a major boost to a long-term, sustained effort in the use of science for coastal management.

The “ridge-to-reef” project will work in collaboration with an exciting effort recently launched by the United Nations Environment Programme (UNEP) to use high-resolution data sets of the Mt. Kilimanjaro region to better monitor global change. This mountain is at the headwaters of the Shimba Hills watershed that empties into the ocean via the Tsavo River near Malindi, Kenya. Inclusion of the entire Tsavo watershed provides a unique opportunity to demonstrate the “ridge-to-reef” approach to coastal and watershed management. It also provides another opportunity to address transboundary resource management issues, tourism and ecosystem management, and even such important global issues



Tanzania/Kenya coastal zone

as monitoring glacier ice changes on Mt. Kilimanjaro that may be an indicator of climate change.

#### Key partners.

Tanzania Coastal Management Partnership and its Science and Technical Working Group; Laboratory for Terrestrial Remote Sensing and the Coastal Resources Center, University of Rhode Island (CRC); USAID/Global Center for the Environment (G/ENV); USAID/Tanzania and Kenya; Regional Economic Development Services Office (REDSO) for east and southern Africa; United Nations Environment Programme (UNEP)/Nairobi; NASA; NOAA; USGS; IWMI; ICLARM; Tracker; and U.S. Forest Service Eastern Arcs Information Service.

#### Issues highlighted.

Coastal development, watershed management (ridge-to-reef), poor land use practices from intensive agriculture and mariculture, mountain development and climate change, and coastal and mountain tourism management



Satellite image courtesy of Space Imaging

#### D. The African Great Lakes region.

The African Great Lakes region is one of world's most biodiverse aquatic, wetland, and highland (montane) lake regions in the world and includes parts of at least six countries: Uganda, Ethiopia, Rwanda, Kenya, Burundi, and Tanzania. Several of the region's most important lakes, including Lake Victoria, are succumbing to invasive species (such as water hyacinth, which is causing Nile perch loss) and water and soil contamination with disastrous environmental and economic consequences for the littoral and downstream users and states, as well as increasing pressure on rare wetlands and montane forests.

Most of these negative land and water impacts result from accelerating soil erosion upslope in the densely settled East African Highlands (this region has some of the highest rural densities on the continent). Related problems stem from herder/farmer and ethnic conflicts. Associated with these land use/land cover, socioeconomic, and settlement conditions are severe public health problems (e.g., expansion of more virulent forms of malaria and Rift Valley fever as well as HIV/AIDS).

Human and animal health problems, such as schistosomiasis, Rift Valley fever, and malaria, are often closely linked to irrigation, land use change, and water resource use. Furthermore, many of these diseases are becoming more virulent, and drug resistance is increasing. Several ongoing USAID projects in the region offer test beds for capacity building, data enhancement, and sharing of lessons learned on the use of geospatial tools in disease prevention and management. For example, the Global Livestock CRSP's Livestock Early Warning System (LEWS) project focuses on animal health issues; the Agroforestry Research Network for East and Central Africa (AFRENA)/Africare project, which is also linked to the African Highlands Initiative (AHI), has focused on hillside erosion and other agricultural land use changes; and a collaborative project between Louisiana State University, the Centers for Disease Control and Prevention (CDC), the World Health Organization (WHO), and Mud Springs Geographers, Inc., is using GIS tools for studying health-related issues, such as schistosomiasis, Rift Valley fever, and malaria, to improve decision making, management, and prevention.



African Great Lakes region

#### Key partners.

Agroforestry Research Networks for Africa (AFRENA); Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA); African Highlands Initiative (AHI) and Associated Consultative Group on International Agricultural Research (CGIAR) Centers (e.g., International Center for Research in Agroforestry (ICRAF)/International Potato Center (CIP)/International Center for Tropical Agriculture [CIAT]); USAID/Uganda and Kenya; Pond Dynamics/Aquaculture Collaborative Research Support Program (CRSP); IWMI; USGS; World Health Organization (WHO)/CDC/National Institutes of Health (NIH)/Louisiana State University (LSU) Global Health Network; Central African Regional Program for the Environment (CARPE); CIESIN; USAID/G/ENV (Nile Basin Initiative); USAID Center for Population, Health and Nutrition (G/PHN); USAID Africa Integrated Malaria Initiative (AIMI-Africare); REDSO/Greater Horn of Africa Initiative (GHAI); Mud Springs Geographers, Inc.; Global Livestock CRSP (LEWS project); NASA; NOAA; Tracker; and USGS

#### Issues highlighted.

Steep lands erosion and downstream impacts, human and animal health/disease relationships with land use/land cover change, and population–environment interactions with agroecosystems

### Key role of selected Africa-wide partners in capacity building.

Besides specific on-the-ground USAID projects and partners involved in these four areas, other potential partners, including UN agencies (such as those participating in the interagency “Data Exchange Platform for the Horn of Africa”) and other bilateral donors and NGOs that work across the continent, will be included in this GISD effort. They will be important to give this project continuity beyond the WSSD and will become part of long-term capacity building. One example of this is the incipient efforts by USAID to create a “GIS Backbone” or Agricultural and Environmental Geospatial Information System (AEGIS) network that integrates efforts of many partners with which USAID works. These partners can help develop, test, and distribute tools that enhance analysis and problem solving, manage data, build capacity, and establish data sharing networks and training opportunities. Some GISD partners that could be included are the following:

- ICASA; Consortium for Spatial Information (CSI); and related CGIAR partners such as ICRAF, ICRI-SAT, CIP, CIAT, and the International Water Management Institute (IWMI) out of its new Durban, South Africa, office
- CIESIN and DEVECOL, which specialize in knowledge information system development
- Millennium Ecosystem Assessment (MEA) and participating multilateral donors and research groups such as the World Bank, United Nations Development Programme (UNDP), and Food and Agriculture Organization (FAO)
- The National Spatial Information Network of South Africa and EIS-Africa/GIS
- Mud Springs Geographers, Inc., which produces the Atlas Characterization Tool (ACT), now used by many of the collaborating partners in the region
- The Heron Group of Pennsylvania State University, which has developed and tested decision support tools
- University of Maryland’s Global Land Cover Facility, which contains an archive of earth observing satellite data

- Private sector partners such as EarthSat, ESRI, Oracle, Intergraph, and Hewlett–Packard, which are on the technology cutting edge for computer-based data management
- WHO/CDC/NIH/LSU (Global Health Network)
- UNEP/Nairobi

In addition, NOAA’s Climate Prediction Center has established an Africa Desk ([http://www.cpc.ncep.noaa.gov/products/african\\_desk/index.html](http://www.cpc.ncep.noaa.gov/products/african_desk/index.html)) that is involved in the seasonal forecasts over the African continent utilizing statistical pattern information based on global sea surface temperatures. These forecasts are included within the International Climate Forums in which a general consensus is developed for socioeconomic impacts from seasonal to interannual climate variations.

### Conclusion.

In summary, the test bed sites within the four regions and continentwide capacity-building activities afford a unique mechanism for making the GISD project truly demand-driven and focused on demonstrating new techniques and methodologies to address difficult sustainable development problems in Africa and elsewhere on planet earth. The GISD project’s application of new earth observation data, powerful geographic information technologies, and science-based problem solving capabilities to local and regional crises in Africa will show how sustainable development can be measured, monitored, and integrated into decision making by users themselves—from local to national and even global scales. If successful, it will provide invaluable insights for other world regions in the decade ahead.



**Initial GISD project timetable.**

**October 2001**

Specific data sets/availability/integration issues identified and commitments made for deliverables  
Funding obtained for project implementation  
Imagery needs for local applications defined and local agencies contacted  
Technical aspects of data dissemination agreed on  
Presentation of project to senior U.S. policy makers

**November 2001**

Presentation of GISD project at Africa GIS conference in Nairobi  
Delivery of remote sensing and geospatial data to partner agencies  
Draft lessons learned and applications for sustainable development  
Work initiated on Web site

**March 2002**

Progress report on applications  
Project workshop with local project partners to review data access and applications

**June 2002**

Demonstration of Web site and field results  
“Lessons learned” workshop by project participants

**September 2002**

Presentation at the World Summit on Sustainable Development



Key partner (in alphabetical order)	Description/Mission
AFRENA (Agroforestry Research Networks for Africa)	Consortium of East African nations working with ICRAF.
AGRHYMET - Regional AGRHYMET Center in Niamey, Niger	Part of a global initiative led by the CGIAR focused on “highlands/steep lands” agriculture. One of the focal areas is East Africa via the AHI. See <a href="http://www.icraf.cgiar.org/sys_wide/ahi/index.html">http://www.icraf.cgiar.org/sys_wide/ahi/index.html</a> and <a href="http://www.icraf.cgiar.org/inform/CorpReport/AHI.pdf">http://www.icraf.cgiar.org/inform/CorpReport/AHI.pdf</a> .
AHI (African Highlands Initiative) and associated CGIAR (Consultative Group on International Agricultural Research) Centers (e.g., ICRAF [International Center for Research in Agroforestry]), CIP (International Potato Center), CIAT (International Center for Tropical Agriculture)	Technical center focusing on agrometeorology and hydrology for the CILSS states.
ASARECA (Association for Strengthening Agricultural Research in Eastern and Central Africa)	See <a href="http://www.asareca.org/">http://www.asareca.org/</a> .
BASIS CRSP (Broadening Access and Strengthening Input-market Systems; Collaborative Research Support Program)	Various partners working on policy-relevant research focused on market-based land reform and water resource management. See <a href="http://www.wisc.edu/lc/basis.html">http://www.wisc.edu/lc/basis.html</a> .
CARPE (Central African Regional Program for the Environment)	USAID project on Congo Basin deforestation and biodiversity loss. See <a href="http://carpe.umd.edu">http://carpe.umd.edu</a> .
CIESIN (Center for International Earth Science Information Network, Columbia University)	See <a href="http://www.ciesin.org">www.ciesin.org</a> .
CILSS (Permanent Interstate Committee to Combat Drought in the Sahel)	Organization focused on combating desertification in the Sahel. Currently includes nine states in the Sahel Region of western and northern Africa. See <a href="http://www.cilss.org/">http://www.cilss.org/</a> .
CRC (Coastal Resources Center—University of Rhode Island)	Works to improve the governance of coastal ecosystems worldwide. See <a href="http://www.crc.uri.edu/">http://www.crc.uri.edu/</a> , East Africa project: <a href="http://www.crc.uri.edu/field/esa/index.html">http://www.crc.uri.edu/field/esa/index.html</a> .
CSI (Consortium for Spatial Information)	A global network of research laboratories, using GIS technologies for land use management and poverty alleviation. See <a href="http://www.spatial-info.org/shtml/init_csi.shtml">http://www.spatial-info.org/shtml/init_csi.shtml</a> .
DEVECOL (Development Ecology Information Service)	An information management system and resource designed for sustainable development field-workers who want to learn from site-specific experiences in comparable environments anywhere in the world. See <a href="http://209.135.244.135/DEVECOLsite/intro/Welcome.htm">http://209.135.244.135/DEVECOLsite/intro/Welcome.htm</a> .
EarthSat (Earth Satellite Corporation)	EarthSat is creating a global data set of orthorectified Landsat data for the 70s, 90s, and 2000. Landcover is also being derived. See <a href="http://www.earthsat.com">www.earthsat.com</a> .
Eastern Arc Mountains Information Service	See <a href="http://www.easternarc.org">www.easternarc.org</a> .
EIS-Africa GIS 2001 Conference	See <a href="http://www.icipe.org/africagis2001">http://www.icipe.org/africagis2001</a> .
EIS-SSA (Environmental Information Systems in Sub-Saharan Africa) and EIS-Africa	The EIS-SSA program aims to develop African capacity for management of environmental information as an integral component of the sustainable development process. See <a href="http://www.grida.no/eis-ssa/eisnews/2-00/index.htm">http://www.grida.no/eis-ssa/eisnews/2-00/index.htm</a> . EIS-AFRICA is a nonprofit pan-African organization of geoinformation practitioners and institutions. See <a href="http://www.grida.no/eis-ssa/eisnews/2-00/04.htm">http://www.grida.no/eis-ssa/eisnews/2-00/04.htm</a> .
ESRI (Environmental Systems Research Institute, Inc.)	ESRI’s GIS solutions are utilized in many types of business and government services. See <a href="http://www.esri.com">www.esri.com</a> .
FEWS NET (Famine Early Warning System Network)	USAID-funded program strengthening African food security organizations in 17 countries, implemented by NASA, NOAA, USDA, USGS, and a USAID contractor. Three Web sites: monthly food security reports at <a href="http://www.fews.net">http://www.fews.net</a> ; weather information at <a href="http://www.cpc.ncep.noaa.gov/products/fews">http://www.cpc.ncep.noaa.gov/products/fews</a> ; vegetation and other geospatial information at <a href="http://edcintl.cr.usgs.gov/adds">http://edcintl.cr.usgs.gov/adds</a> .
FGDC (Federal Geographic Data Committee)	U.S. government committee that coordinates the National Spatial Data Infrastructure. See <a href="http://www.fgdc.gov">www.fgdc.gov</a> .
Global Livestock CRSP Livestock Early Warning System (LEWS) Project	See <a href="http://glcrsp.ucdavis.edu/index.html">http://glcrsp.ucdavis.edu/index.html</a> and the LEWS project in East Africa— <a href="http://glcrsp.ucdavis.edu/project_subpages/LEWS_folder/LEWS.html">http://glcrsp.ucdavis.edu/project_subpages/LEWS_folder/LEWS.html</a> .

Key partner (in alphabetical order)	Description/Mission
GTZ/French, Dutch, British, U.S., and other Yatenga researchers	See FRAME Tracker documents on Burkina Faso <a href="http://www.nrmtracker.org/fr/Initiative_In_French_Search_Result2.cfm">http://www.nrmtracker.org/fr/Initiative_In_French_Search_Result2.cfm</a> .
Harare Regional GIS Unit	See <a href="http://www.sadc-fanr.org.zw/intro.htm">http://www.sadc-fanr.org.zw/intro.htm</a> , and Harare, Zimbabwe Regional Remote Sensing Unit <a href="http://www.sadc-fanr.org.zw/address.htm#RRSU">http://www.sadc-fanr.org.zw/address.htm#RRSU</a> .
The Heron Group LLC—Pennsylvania State University	Consultants in planning, organization, and management. See <a href="http://www.herongroupllc.com/">http://www.herongroupllc.com/</a> .
ICASA (International Consortium for Agricultural Systems Applications)	See <a href="http://www.icasanet.org/">http://www.icasanet.org/</a> .
ICRAF (International Center for Research in Agroforestry)	See <a href="http://www.icraf.cgiar.org">www.icraf.cgiar.org</a> .
ICRISAT (International Crop Research Institute for the Semi-Arid Tropics) and the IER (Institut d'économie rurale) in Mali	See <a href="http://www.icrisat.org/text/satrends/current/1.htm#Space-Age Partnership">http://www.icrisat.org/text/satrends/current/1.htm#Space-Age Partnership</a> . See also <a href="http://www.ier.ml/programmes/volaille/">http://www.ier.ml/programmes/volaille/</a> ; on the scientific side, the objective of the ICRISAT program in Mali is to bridge the scale gap between spatial monitoring/early warning at the regional level and agricultural/environmental research at the local/field level using GIS tools, remote sensing, and systems modeling.
IMWI (International Water Management Institute_Durban, South Africa)	A nonprofit research organization specializing in water use in agriculture and integrated management of water and land resources. See <a href="http://www.cgiar.org/iwmi/index.htm">http://www.cgiar.org/iwmi/index.htm</a> , South Africa site <a href="http://www.cgiar.org/iwmi/safrica/safrica.htm">http://www.cgiar.org/iwmi/safrica/safrica.htm</a> .
INSAH (L' Institut du Sahel)	A body of the CILSS that coordinates and promotes research in the Sahel region. See <a href="http://www.insah.org/index.html">http://www.insah.org/index.html</a> or <a href="http://www.insah.org/start_insah.htm">http://www.insah.org/start_insah.htm</a> .
Laboratory for Terrestrial Remote Sensing	At University of Rhode Island. See <a href="http://www.ltrs.uri.edu/index.html">www.ltrs.uri.edu/index.html</a> and <a href="http://www.edc.uri.edu/nrs">www.edc.uri.edu/nrs</a> .
Millennium Ecosystem Assessment (MA) and Participating Multilateral Donors and Research Groups	\$21 million, four-year effort will examine the processes that support life on earth. See <a href="http://www.ma-secretariat.org/en/index.htm">http://www.ma-secretariat.org/en/index.htm</a> .
Miombo.net (The Miombo Network)	Formed to create a regional network for global change research on the dominant biome of Southern Africa: the Miombo Woodlands. See <a href="http://miombo.gecp.virginia.edu/">http://miombo.gecp.virginia.edu/</a> .
Mud Springs Geographers, Inc.	Agricultural and natural resource management software firm. See <a href="http://www.mudsprings.com">www.mudsprings.com</a> .
NASA Goddard Space Flight Center	See <a href="http://www.gsfc.nasa.gov/">http://www.gsfc.nasa.gov/</a> .
NIMA (National Imagery and Mapping Agency)	U.S. government agency. See <a href="http://164.214.2.59/nimahome.html">http://164.214.2.59/nimahome.html</a> .
National Spatial Information Network (South Africa)	Program on environmental information systems in sub-Saharan Africa. See <a href="http://www.nsisf.org.za/eisdraftprog.html">http://www.nsisf.org.za/eisdraftprog.html</a> .
NOAA (National Oceanic and Atmospheric Administration) <ul style="list-style-type: none"> <li>• Climate Prediction Center</li> <li>• Satellites, Data, and Information</li> <li>• Office of Global Programs</li> <li>• Office of Global Programs—RANET Program in Africa</li> <li>• National Weather Service International Programs</li> </ul>	See <a href="http://www.noaa.gov/">http://www.noaa.gov/</a> and <a href="http://www.strategic.noaa.gov/">http://www.strategic.noaa.gov/</a> . <ul style="list-style-type: none"> <li>• NOAA/NWS Climate Prediction Center: Forecasts impacts of short-term climate variability emphasizing enhanced risks of weather-related extreme events for use in mitigating losses. See <a href="http://www.cpc.ncep.noaa.gov/">http://www.cpc.ncep.noaa.gov/</a>.</li> <li>• NOAA Satellites, Data, and Information—<a href="http://www.nesdis.noaa.gov">www.nesdis.noaa.gov</a>. Satellite Active Archive—<a href="http://www.saa.noaa.gov">www.saa.noaa.gov</a>. Future NOAA satellite systems—<a href="http://www.ipo.noaa.gov">www.ipo.noaa.gov</a>.</li> <li>• NOAA Office of Global Programs <a href="http://www.ogp.noaa.gov/mpe/csi/appdev/africa/index.htm">http://www.ogp.noaa.gov/mpe/csi/appdev/africa/index.htm</a> and <a href="http://iri.columbia.edu/">http://iri.columbia.edu/</a>.</li> <li>• NOAA Office of Global Programs—RANET Program in Africa <a href="http://www.oar.noaa.gov/spotlite/archive/spot_ranet.html">http://www.oar.noaa.gov/spotlite/archive/spot_ranet.html</a>.</li> <li>• NOAA National Weather Service International Programs—<a href="http://205.156.54.206/ia/home.htm">http://205.156.54.206/ia/home.htm</a>.</li> </ul>
The NRC/NAS (National Research Council/National Academy of Sciences) and its network of science partners in Africa	Private body created by Congress to advise the U.S. government on scientific/technical matters. See <a href="http://www.nas.edu/nrc/">http://www.nas.edu/nrc/</a> and <a href="http://www4.nationalacademies.org/nas/nashome.nsf">http://www4.nationalacademies.org/nas/nashome.nsf</a> .
OFDA (Office of Foreign Disaster Assistance, USAID)	See <a href="http://www.usaid.gov/hum_response/ofda/">http://www.usaid.gov/hum_response/ofda/</a> .

Key partner (in alphabetical order)	Description/Mission
OHVN (Office de la Haute Vallée du Niger, Mali)	Regional initiative focused on agricultural intensification and combating of desertification/land degradation. See FRAME/Tracker document: <a href="http://www.nrmtracker.org/fr/initiative_Search_Detail2.cfm?InitiativeID=20010226-111042">http://www.nrmtracker.org/fr/initiative_Search_Detail2.cfm?InitiativeID=20010226-111042</a> .
Open GIS Consortium and related FGDC (see entry above) partners in the U.S. Government (NASA, USGS, NIMA, NOAA, etc.) and private sector (ESRI, Oracle, Intergraph, H–P, etc.)	A not-for-profit membership organization that addresses the lack of interoperability among systems that process georeferenced data. See <a href="http://www.opengis.org/">http://www.opengis.org/</a> .
Pond Dynamics/Aquaculture CRSP (Collaborative Research Support Program)	An international, multidisciplinary effort to improve human nutrition through pond aquaculture research. See <a href="http://www.orst.edu/dept/crsp/homepage.html">http://www.orst.edu/dept/crsp/homepage.html</a> .
SADC (Southern African Development Community) Water Council	See <a href="http://www.sadcwscu.org.ls/default.htm">http://www.sadcwscu.org.ls/default.htm</a> .
SANREM (Sustainable Agriculture and Natural Resource Management)/CRSP (Collaborative Research Support Program)	SANREM-WA (West Africa) supports natural resource decision makers with appropriate data, tools, and methods. See final draft NASA proposal submitted December 2000. Carbon from Communities: A Satellite View. See <a href="http://www.sanrem.uga.edu/">http://www.sanrem.uga.edu/</a> ; West Africa project: <a href="http://www.oird.vt.edu/sanremcrsp/index.html">http://www.oird.vt.edu/sanremcrsp/index.html</a> .
Stone Environmental, Inc.	Private firm providing environmental science and geographic information systems services, wastewater management, municipal and natural resource planning. See <a href="http://www.stone-env.com">www.stone-env.com</a> .
TCMP (Tanzania Coastal Management Partnership) and its Science and Technical Working Group. See CRC (Coastal Resources Center) University of Rhode Island.	A cooperative initiative between the government of Tanzania, USAID, and the CRC to facilitate a participatory, transparent process to wisely conserve and develop coastal ecosystems and resources. See <a href="http://www.crc.uri.edu/field/esa/tanzania.html">http://www.crc.uri.edu/field/esa/tanzania.html</a> . See also Secretariat for Eastern African Coastal Area Management <a href="http://www.seacam.mz/home.htm">http://www.seacam.mz/home.htm</a> .
TRACKER	A tool for real-time learning from local resource management initiatives in Africa (a database for information exchange). See <a href="http://www.nrmtracker.org/">www.nrmtracker.org/</a> . Database also available on CD-ROM by e-mailing <a href="mailto:kpape@irglted.org">kpape@irglted.org</a> .
UNEP (U.N. Environment Programme)	Note specifically UNEP.Net, which delivers authoritative environmental information from a broad range of information and data providers committed to making their information freely available. See <a href="http://www.unep.net/">http://www.unep.net/</a> . See also <a href="http://www.unep.org/">http://www.unep.org/</a> .
U.S. Department of State	See <a href="http://www.state.gov">www.state.gov</a> .
USAID (U.S. Agency for International Development), including <ul style="list-style-type: none"> <li>• FEWS NET: Famine Early Warning System Network</li> <li>• G/ENV: Global Center for the Environment</li> <li>• G/PHN: the Center for Population, Health and Nutrition, AIMI-Africare: Africa Integrated Malaria Initiative</li> <li>• RCSA: Regional Center for Southern Africa, Gabarone</li> <li>• REDSO/GHAI: Regional Economic Development Services Office for East and Southern Africa/Greater Horn of Africa Initiative</li> <li>• G/EGAD/AFS: Global Center for Economic Growth and Agricultural Development, Office of Agriculture and Food Security</li> </ul>	See <a href="http://www.usaid.gov">www.usaid.gov</a> . <ul style="list-style-type: none"> <li>• USAID/Africa. See Africa Bureau programs at <a href="http://www.usaid.gov/regions/afr">www.usaid.gov/regions/afr</a> including information on RCSA and on REDSO/GHAI, which addresses the recurring cycle of crisis, instability, and famine in the region by improving food security and through formation of a system for conflict early warning, prevention, and response.</li> <li>• FEWS NET: To help establish more effective, sustainable, African-led food security and response planning networks that reduce vulnerability of at-risk groups. See <a href="http://www.fews.net">www.fews.net</a>.</li> <li>• G/ENV. See <a href="http://www.usaid.gov/environment">www.usaid.gov/environment</a>.</li> <li>• G/ENV (Nile Basin Initiative): program run by the G/ENV Center in collaboration with countries in the Nile Basin.</li> <li>• G/EGAD/AFS. See <a href="http://www.usaid.gov/economic_growth/">http://www.usaid.gov/economic_growth/</a>.</li> <li>• G/PHN (AIMI-Africare: Africa Integrated Malaria Initiative program). See <a href="http://www.usaid.gov/pop_health/cs/csmalaria.htm">www.usaid.gov/pop_health/cs/csmalaria.htm</a>.</li> </ul>
U.S. EPA (Environmental Protection Agency)	See <a href="http://www.epa.gov">www.epa.gov</a> .
USDA (U.S. Department of Agriculture)/NRCS (Natural Resources Conservation Service), World Soils Resources Office	See <a href="http://www.nrcs.usda.gov">www.nrcs.usda.gov</a> and <a href="http://www.nhq.nrcs.usda.gov/WSR">www.nhq.nrcs.usda.gov/WSR</a> .
USGS (United States Geological Survey)	See <a href="http://www.usgs.gov">www.usgs.gov</a> . USGS EROS (Earth Resources Observations Systems) Data Center International Program. See <a href="http://edcsnw3.cr.usgs.gov">http://edcsnw3.cr.usgs.gov</a> and <a href="http://edc.usgs.gov">http://edc.usgs.gov</a> .



