

Bioinformatics for the Albertine Rift: A roadmap and infrastructure for a virtual regional research centre for applied biodiversity in Rwanda, Africa which integrates biological and geographical information including soils

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Abstract

In 2008 Maxine Levin, Soil Scientist, USDA-Natural Resources Conservation Service participated in a US Embassy Science Fellowship in Kigali Rwanda. She was hosted by the Rwandan government and the US Embassy to work in the Ministry in the Office of the President (His Excellency Paul Kagame) in charge of Science and Technology under Minister Roman Murenzi. At the request of the Ministry, an extensive review of facilities, resources and databases was conducted to give advice and support to the planning of a regional research center for biodiversity. Analysis of Rwanda's present infrastructure showed a need for a regional data sharing policy as well as a focus on integration of all geographical (soils, geology, topography and land use) and biological (vegetation and wildlife) databases.

Key Words

Bioinformatics, Rwanda, data integration, geographic information systems, biodiversity

Introduction

Rwanda, a small, highland agriculturally-based country in Central Africa has undergone an environmental revolution since its devastating civil war and genocide in 1994. During the First International Research Conference on Biodiversity Conservation and Sustainable Natural Resource Management in Kigali Rwanda, July 2007, His Excellency Paul Kagame, President of the Republic of Rwanda, made a commitment to achieve socioeconomic development while preserving Rwanda's ecological integrity. The message "environmental protection is everybody's business" was expressed directly as part of the national development vision. He encouraged the leadership at the conference to shift into a new mode of thinking—a new business model—in which the protection of biodiversity will be viewed as a viable business opportunity for new products both in mainstream enterprises and small business prospects. Proposed Rwandan land policies that will ensure conservation, protection and economic viability were deemed equally important to the future of Rwanda. Recommendations of the Rwandan executive government acknowledged that Rwanda needed to adequately map and inventory the biodiversity of the Albertine Rift, acknowledge this important internationally designated "Biological Hotspot" (designated by Conservation International in 2006) and conserve, protect and manage Rwanda's national assets. The Government of Rwanda identified a need to improve its institutional capacity to do continuously monitor species and do scientifically innovative research in the field of applied biodiversity. At the conference His Excellency Paul Kagame wanted the participants to explore the idea of a regional approach to the establishment of a research center for biodiversity and natural resource management that pools the human resources of the entire region. He encouraged the long term commitment to this international partnership initiative to improve biodiversity and natural resources management in Rwanda and entire region.

Rwanda is known as the "Land of One Thousand Hills. In Rwanda, agriculture is mainly subsistence and occurs on small plots, often on extremely steep slopes. Naturally fertile soils in western Rwanda are prevalent with influences of volcanic ash downwind from the greater Virunga volcanic range. In eastern Rwanda, the climate is drier, the soils are less fertile, shallow, granitic bedrock-based. The gravelly soils are on flatter slopes but in many cases because of removed surface biomass, more sensitive to erosion. Since the late 1990's many refugees have moved into these areas to farm as well as graze increased cattle herds. Some statistics show decreased agricultural production throughout the region despite an influx of farmer and agriculture development support. In East Africa, the Great Rift Valley divides into two, the Western Rift Valley and the Eastern Rift Valley. The Western Rift, also called the Albertine Rift, is edged by some of the highest mountains in Africa, including the Virunga Mountains, Mitumba Mountains, and Ruwenzori Range. The Albertine Rift spans the national boundaries of 6 East and Central African countries, Uganda, Democratic Republic of the Congo, Rwanda, Burundi, Tanzania, and Zambia. Rwanda, (though a small part

of the Albertine Rift), lies mid-range in the region and is centrally located for access. The Albertine Rift has been identified as a “Biological Hotspot” by Conservation International for its wide range of endemic species and its susceptibility to degradation and change due to human socio-economic and population pressures.

Public funded biodiversity information provides an unbiased level playing field for integrated decision making for the best use of land, economic development and conservation of Rwandan and the Transboundary Albertine Rift’s natural resources. What makes economic sense for the regional development and conservation of the Albertine Rift needs to be a balance of public good, service-oriented infrastructure, sound governance, sound science, and regional human resource capacity. The demand for integrated land and biodiversity information is growing and requests for specific data and analysis are constantly evolving and continually changing. Demand is driven by change in agricultural program policy, land use changes, and evolving land-use law, regulation, policy and environmental concerns in the developing economy and well being of Rwandan national land base and population. Inventory and monitoring require continual improvement in order to assure an accurate and complete database that can satisfy evolving needs for data and analysis. In addition, potential climate change and the ensuing adaptation strategies are pushing East and Central African Nations towards more cooperation and the need for a regional approach to strategies as a mode of survival. Based on its focus of improving the lives of its people and those of the entire region with innovative uses of science and technology, Rwanda is at a point in its political and socio-economic recovery and development to support a service-based integrated database infrastructure for the region

Status of Integrated Databases in Rwanda

Since the early 1970s various biological scientists from many countries have inventoried general biological information on the Albertine Rift and monitored specific species for prevalence and resilience. The data is scattered through a variety of sources, some published and open to public and ministries through purchase of scientific journals and books. Most of the data has been monitoring data from protected areas that is proprietary by the collector or institution that conducted the field work. The raw data is available only in a limited sense to protect the investment scientifically and monetarily of the original investor of the work. In many cases the information is not in an electronic format and cannot be integrated without restructuring the data and inputting into a database.

Rwanda has made great strides in providing data infrastructure with a pilot within the National University of Rwanda (NUR) Center for Geographical Information Systems (CGIS)—the Geo Data Portal. The CGIS is a learning and research center created about 9 years ago. First supported by the NGO Dian Fossey Gorilla Research Fund to push forward spatial analysis of biological monitoring data, the Center’s primary focus has been to build capacity in GIS in Rwanda through education and pilot projects. The pilot projects demonstrated the intrinsic usefulness of integrated spatial analysis of biological, agricultural, market-based, community planning and human resource problems and best use management planning. Soil Survey data, a primary source for land based GIS analysis, was collected in the 1970’s and 80’s in Rwanda. It is digitized but not readily available to the science and agricultural community or to this Center.

At this point the basic framework of the Geo Data Portal is functioning. Its purpose is to funnel geographic land data from the different Rwandan Ministries to a controlled accessible site for intranet users. Control of the databases and certification of the data still lies with the Ministry or Investigator of origin. Integration of information spatially can start to take place between Ministries. At this time, CGIS is ready to hand off the maintenance and day-to-day functioning of the Portal to an appropriate neutral party and continue its education and demonstration project activities. Many of the applicable land-related databases already reside or will reside with the Rwandan government National Land Center. The Rwandan Information Technology Agency however has the expertise to provide neutral server and maintenance functions for the Portal and may be the best host at this time.

Technical Advantages to Bioinformatics Open Platform and Integrated Data Analysis with Geospatial land information

Integrated data analysis (on applied biodiversity questions) is best done as a team. With 3 to 5 virtual technical specialists as a team, it allows some to specialize in certain areas such as geospatial technologies (GPS, GIS and remote sensing) for landscape analysis (topography, vegetation, climate,

geology, and hydrology), biological and soil data comparison, microbiological and chemical data analysis and population, biological taxonomy and classification, etc. This leads to improved team performance, job satisfaction, and improved quality of the database, monitoring and inventory. Use of Ecological Site Descriptions with state and transition models have an excellent potential to portray and integrate biological and land based geographical data in a format easily understood by many of the disciplines. For building human capacity there is a trove of information about ecological landscapes, animal-plant-habitat interactions and synergies, animal behavior, etc. that can not be gained except through on the job training with seasoned scientists experienced in an area. Thus the field work needs to be place-based with teams working closely together in the locations where the data is to be collected. The documentation, analysis, archiving and distribution should be centralized virtually for maximum efficiency.

Organization Functions, Structure and Staffing

There are 4 major Divisions for the proposed virtual regional research center: “Inventory and monitoring”, “GIS/Information Technology Services”, “Laboratory Services”, and “Education”. The primary objective of the New Organization Structure Plan and Staffing recommendations is an efficient and effective organization to produce and maintain a consistent, seamless, digital inventory of the Transboundary Region of the Albertine Rift. A secondary objective of the new organization structure would be to assure that all lands and lake areas within the region will be inventoried and updates (through monitoring protocols) will be done on a continuous basis. The focus of the organization is on providing virtual service infrastructure to all active stakeholders in the region of the Albertine Rift. The emphasis on investment in virtual infrastructure would be to enhance present capacity for Rwanda and Rwanda’s neighboring countries’ institutions, committed international researchers and universities and active non-governmental organizations (NGOs) through service in providing tools for integration and standardization of data. Institutions already in place and working effectively should not be undermined by rather enhanced by the service of the virtual regional research facilities.

Establishing a service-oriented Virtual Regional Research Center for Applied Biodiversity with integration of land and biologically related data by 2010

With the consolidation of both monitoring and reference data and integration of land related data through a Geo-data Portal, a Virtual Regional Research Center for Applied Biodiversity is possible by December 2010 and is moving forward with support by the Rwandan government. This process can be enhanced by:

1. Focusing public service and contracted staff from some monitoring activities to data input and consolidation from published information, meta-data attached data identifying source.
2. Clarifying science policy of data sharing, public information for the public good, proprietary restrictions of data collected with public funds or on public lands.
3. Establishment of public service laboratories for production soil lab testing, genomics, biological and botanical taxonomy and microbial analysis and identification, preferably in a centralized location with appropriate transport and infrastructure capacity
4. Establishing and electronic virtual reference library of pertinent biological, meteorological, atmospheric and land data for the Albertine Rift that is public in nature for use by educators, public service land managers and scientists.
5. Working with NGO partners and already established Technical Networks-- Wildlife Conservation Society, Dian Fossey Gorilla Fund International, Conservation International, Great Apes Fund of Iowa, CARPE, ARCOS, Transboundary Secretariat for the Albertine Rift, GRASP
6. Supporting Satellite Centers such as Karisoke Research Center, ORTPN Interpretation Facilities in the National Parks and Protected Areas
7. Focusing funding to endowment strategies to provide consistent funding for permanent staff, maintenance and replacement of supplies and equipment on a 2-4 year cycle
8. Focusing project research funding on product development and production problems with integrated teams of biological, environmental chemistry and mechanical engineering research scientists
9. Supporting central laboratories and satellite research facilities with information technology technical support hardware and software maintenance either through NUR and KIST IT staff or Ministerial partnership

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