

Integrating Geo-spatial Information Infrastructure into Conservation and Management of Wetlands in Ghana

Owusu-Banahene W.
Computer Engineering Department
University of Ghana, Legon
Accra, Ghana
e-mail: banahene@ug.edu.gh

Nti I.K., Sallis P.J.
Geoinformatics Research Centre
Auckland University of Technology,
Auckland New Zealand,
e-mail :isaac.nti@aut.ac.nz; philip.sallis@aut.ac.nz

Abstract— Most data infrastructure tend to focus on data access and not particularly spatial aspects of data and services especially data relating to natural resource management. This project will conceptualise and implement a geospatial information infrastructure to facilitate conservation and management of wetlands in Ghana, where a scalable, accessible and robust solution is urgently needed. Critically, rather than relying on governmental agency as a sole means of continued and current data provision, the approach will link technical advances in mobile telephone services, global positioning systems and concepts of citizen science with advanced developments in semantics and interoperability to formalise a spatial infrastructure system capable of weighing assertion and achieving authority. This paper attempts to propose the use of the following technology in developing a Ghana Wetland Information System: remote sensed imagery plus scripting and database, e-Governance frameworks and Protégé OWL for the management of semantics.

Keywords-geospatial;informatics infrastructure;management of wetlands; management of semantics;data and services.

I. INTRODUCTION

Conservation and management of wetlands is a crucial component in natural resources management of a country. In the process of wetlands conservation and management, Information and Communications Technology (ICT) could play a key role. However, in Ghana as in many developing countries, the benefits of ICT have not been fully utilized in managing natural resources. The goal of this project is to explore the use of some ICT option such as, Web Geospatial Information System, Remote Sensing and Global Positioning Systems, in facilitating wetlands conservation and management in Ghana.

The first objective would be to create a national distributed geo-database for wetlands. The second objective is to integrate data, metadata and information available on wetlands in Ghana in a unified Online Geo-Information System (GIS) and to develop systems of updating the wetland database. The third objective is to implement Web based GIS for delivery of data, mapping capabilities and Geo-Information services. The fourth objective is to develop a Ghana Wetland Information

System (GWIS) as a platform for developing a National Natural Resources Information System.

The results will be an integrated Online Wetland GIS valuable over the World Wide Web to all stakeholders in the conservation and management of wetlands. The project is achievable within three years.

II. LITERATURE SURVEY

Wetlands in Ghana are unique ecosystems that provide valuable products and services to satisfy social, economic, and ecological needs at the local, national, and international levels. Ghana has been a signatory to the Ramsar Convention since 1988. A major obligation under the Convention is the implementation of the principle of 'wise use' of the wetlands resources, where "wise use" is understood to mean "their sustained utilisation for the benefit of humankind in a way compatible with the maintenance of the natural properties of the ecosystem" [7]. Wetlands are biologically diverse and productive systems that house a variety of unique plants and animals. They are rich in both natural and cultural heritage and have educational, aesthetic, recreational, economic, and intrinsic and conservation values. Wetlands are also particularly important in the maintenance of a number of basic ecological functions, such as nutrient cycles, energy flows and the breakdown of toxins. Wetlands have recreational, social, historic and aesthetic values. They have the potential to contribute significantly to regional and state economies.

In spite of these values, there are threats to wetlands in Ghana; the major ones include: water loss, loss of run-off control, wetlands conservation, regulation of water supply, saltwater intrusion/soil salinisation, soil degradation, pollution, over-exploitation, sediment and nutrient diversion, deforestation and disruption of stable climatic conditions. This research would be appropriate to support management and conservation of wetlands assets and threats by compiling data and information on wetlands resources in Ghana. This would contribute to the generation and dissemination of wetland resources and their use. It will also contribute to improving knowledge

for determining management priorities and evaluating land use practices by giving greater recognition to the importance of wetlands in land use and regional planning; improving the knowledge base of aquatic ecosystems and their management in Ghana.

Remote sensing is the technique or process of obtaining data or images from a distance, as from satellites or aircraft [6]. It has the advantage of covering a larger geographic area more frequently than field sampling. Integration of Remote Sensing and GIS is helpful for monitoring wetland changes at the landscape scale. GIS and remote sensing can form the basis for analysis and monitoring system for supporting the assessment of the changes in wetland diversity. This research would set a platform for support in wetland monitoring in Ghana where Remote Sensing and GIS techniques would be employed as assessment and monitoring tools. GIS is an ideal tool to use for the analysis and solution of multiple criteria problems[1].

Ultimately, the GIS functions as a spatial decision support tool whereby it permits future recommendations to be based on a thorough evaluation of the existing data. In this specific application in the research work it will assist management and other types of environmental control. Online GIS offers a cost-effective way to include mapping, GIS functionality, and geographic content in Web-enabled applications [2]. The tremendous growth in Internet use has resulted in an increased demand for the delivery of geographic data, maps, and applications over the Internet. Generally speaking, Online GIS focuses on disseminating and processing geographic information by means of Internet and the World Wide Web.

Protégé is a free, open-source platform that provides a growing user community with a suite of tools to construct domain models and knowledge-based applications with ontologies[8]. Protégé implements a rich set of knowledge-modeling structures and actions that support the creation, visualization, and manipulation of ontologies in various representation formats. The Protégé-OWL editor is an extension of Protégé that supports the Web Ontology Language (OWL). OWL is the most recent development in standard ontology languages, endorsed by the World Wide Web Consortium (W3C) to promote the *Semantic Web* vision[11]. Protégé OWL will provide a platform for the management of the semantics in this research.

III. PROPOSED METHODOLOGY

A. System Requirements

The basic system requirements in setting up the proposed *Ghana Wetland Information System* include:

1. Data and Metadata

The backbone of GIS is the geo-database which is simply data sets that represent geographic information in terms of a generic GIS data model (features, rasters, topologies, networks, and so forth). Metadata which is data about data would also be incorporated in the geo-database component of the system. Data and Metadata would be collected from institutions that have been involved with the management and conservation of wetlands in Ghana. Where there is the need to update, field data collection would be considered using GPS technology.

2. Software

The system requires different softwares to handle the geodatabase, geoprocessing, visualisation and server GIS application. Open source GIS softwares such as MAPSERVER UMN, PostgreSQL, PostGIS, UDig just to name a few could be used if there are no commercial softwares available. However, if there are commercial products available, an intelligent mixture of commercial and open source would be resorted to due to some limitations of open source softwares in terms of GIS functionalities intended for this specific application and the amount of work involved in setting them up. Protégé OWL will be used for the management of the semantics.

3. Platform and Accessibility

The proposed system could run on Linux or Windows environment since it would be much easier to integrate the GIS software in Linux or Windows. The system would require access to a server via Wired or Wireless communication network or intelligent combination of both. The choice of accessibility should be reliable and dependable. Internet/WWW access could be achieved via the existing university's internet set up.

B. Project Approach

With Remote Sensing, Global Positioning System (GPS) and Geographical Information System a variety of data sets will be integrated to generate an extensive geo-data base. As wetland dynamics result from a background of natural and anthropogenic factors, this study will encompass the use of data with geographical, geomorphical, geological, hydrological, demographical, environmental, and climatological attributes. The integration of these three geospatial technologies creates a synergy in which the GIS improves the ability to extract information from remotely sensed data and GPS data, and Remote Sensing and GPS in turn keeps the GIS up-to-date with actual geo-data and information. As a result, large amounts of spatial data can now be integrated, modelled, analysed, visualised and distributed.

One of the benefits that this research will produce is that it will provide a Ghana Wetland Information System

(GWIS) to support wetland conservation and management in the country. The GWIS will be a geospatial-temporal information system running on Windows (or an open sources platform) and other GIS software in an integrated, user-friendly manner that can be updated as required. It will also be designed to facilitate statistical analysis, report generation, modelling and predicting.

1. Database driven Web GIS Application

Online GIS offers a cost-effective way to include mapping, GIS functionality, and geographic content in Web-enabled applications [2]. The tremendous growth in Internet use has resulted in an increased demand for the delivery of geographic data, maps, and applications over the Internet. Generally speaking, Online GIS focuses on disseminating and processing geographic information by means of Internet and the World Wide Web. A centralized GIS database reduces the data redundancy and discrepancy. In case of updating the information, only one update on the central database is necessary, no needs for duplicated work. A flexible and user-oriented application can be developed to improve the utility of the GIS resource and this is the essential part of the Internet GIS. A database driven Web based wetland information system would serve the purpose of distributing data and information related to wetlands in Ghana to the public over the internet.

2. Semantic Mngement using Protégé OWL

According to [10] there are several features that distinguish Protégé from other knowledge base editing tools according to the following features:

- Intuitive and easy-to-use graphical user interface.
- Scalability: Protégé's database back-end loads frames only on demand and uses caching to free up memory when needed. There is virtually no deterioration in performance as you go from several hundred frames to several thousand frames.
- Extensible plug-in architecture: Protégé could be extended with plug-ins tailored for one's domain and task.

Protégé-OWL will be used for the management of the semantics.

IV. METHODOLOGY FOR DATA COLLECTION

A Geodatabase is a data model for representing geographic information using standard relational data base technology [3]. In this research, geodatabase technology will be employed to support the management of data and information related to wetlands in Ghana. One of the backbones of a GIS development is the database. This research aims at developing an extensive multipurpose database which would support several GIS applications such as monitoring, modelling, spatial decision support and server applications.

The conservation and management of wetlands resources involve a number of activities. In Ghana, they are carried out by a number of government and non-governmental institutions including: Wildlife Department, Ministry of Environment, Science and Technology (MEST), Environmental Protection Agency (EPA), District and Metropolitan Assemblies, Ministry of Food and Agriculture, Survey and Meteorological Services Department, Ministry of Lands and Forestry, Forestry Department, Universities, Council for Scientific and Industrial Research (CSIR) as well as NGOs. These institutions would be part of the sources of existing data. This data base will be incorporated into selected GIS based on a temporal/spatial basis. GPS and Remote sensing data would be interpreted in many ways to also provide input for the GIS. This research would lead to the development of a multi-user database on wetlands.

V. ANALYSIS AND EVALUATION

A. Geovisualisation

Geo-visualisation deals with the working of maps and other views of the geographic information, including 3-D scenes, interactive maps, summary charts and tables, time based views etc. A GIS is a set of information transformation tools that derives new geographic data sets from existing data sets. These geo-processing functions take information from existing data sets, apply analytic functions, and write results into new derived data sets. Visual display of the data and data analyses for interrelationships and changes will be conducted using Remote Sensing and GIS. GIS provides a powerful tool for mapping, data analysis and temporal/spatial presentation of data.

B. Geo-statistical Analysis

A GIS can be linked to a database in order to spatially relate, analyze and compare information. The ArcGIS Geo-statistical Analyst is an example of GIS statistical tools for analysing and mapping continuous data and for surface generation. Based on these visual results, standard multivariate statistical analysis would be applied to test the likely relationships between the geomorphic variables. Following the statistical analysis, the GIS becomes a powerful tool for creating spatial models that can evaluate the trends identified as being significant by the statistical analysis.

C. GIS and Modelling

GIS can be used as a preprocessor and postprocessor of spatial data for modelling. GIS can play a role in developing prediction models based on the trends in a historical data. As with any type of analysis, the results produced by the model are only as reliable as the initial quality of the data. *The more reliable the data, the more*

reliable the spatial modeling. However, the GIS will be used to evaluate various “what if” scenarios in different spatial and temporal dimensions.

D. Remote Sensing, GIS as Monitoring Tools

Remote sensing is the technique or process of obtaining data or images from a distance, as from satellites or aircraft [6]. It has the advantage of covering a larger geographic area more frequently than field sampling. Integration of Remote Sensing and GIS is helpful for monitoring wetland changes at the landscape scale. GIS and remote sensing can form the basis for analysis and monitoring system for supporting the assessment of the changes in wetland diversity. This research would set a platform for support in wetland monitoring in Ghana where Remote Sensing and GIS techniques would be employed as assessment and monitoring tools.

E. Spatial Decision Support System

GIS is an ideal tool to use for the analysis and solution of multiple criteria problems [1]. Ultimately, the GIS functions as a spatial decision support tool whereby it permits future recommendations to be based on a thorough evaluation of the existing data. In this specific application in the research work it will assist management and other types of environmental control.

VI. EXPECTED OUTCOME

The proposed project when completed would provide the means for managing large GIS datasets in a distributed computing system. GIS software would be centralised in application servers to deliver GIS capabilities to a large number of users over networks. The system would be accessible via internet or WWW. Intuitive GUI would be incorporated to provide user friendly interaction within the system. The system is expected to:

- Provide a national distributed geo-database for wetlands
- Integrate data, metadata and information available on wetlands in Ghana in a unified Online Geo-Information System (GIS) and to provide systems of updating the wetland database.
- Be a Web based GIS for delivery of data, mapping capabilities and Geo-Information and data delivery services.
- Host a Ghana Wetland Information System (GWIS) as a platform for developing a National Natural Resources Information System.

VII. CONCLUSION AND FUTURE WORKS

This work would contribute to research by providing information and knowledge on wetlands as well as contribute to ecological and mapping inventory in Ghana. It would provide an information base for wetlands assessment in terms of socio-economic and environmental aspects. It would also support wetland monitoring and modelling. The development of an internet based wetland information system would promote generation and dissemination of information on wetland resources and their use to the public as a means of raising awareness and achieving sound management of these resources. This research will contribute to improving knowledge for determining management priorities and evaluating land use practices by giving greater recognition to wetland conservation. The wetland information system would serve as a Spatial Decision Support System for wetland conservation and management in Ghana.

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