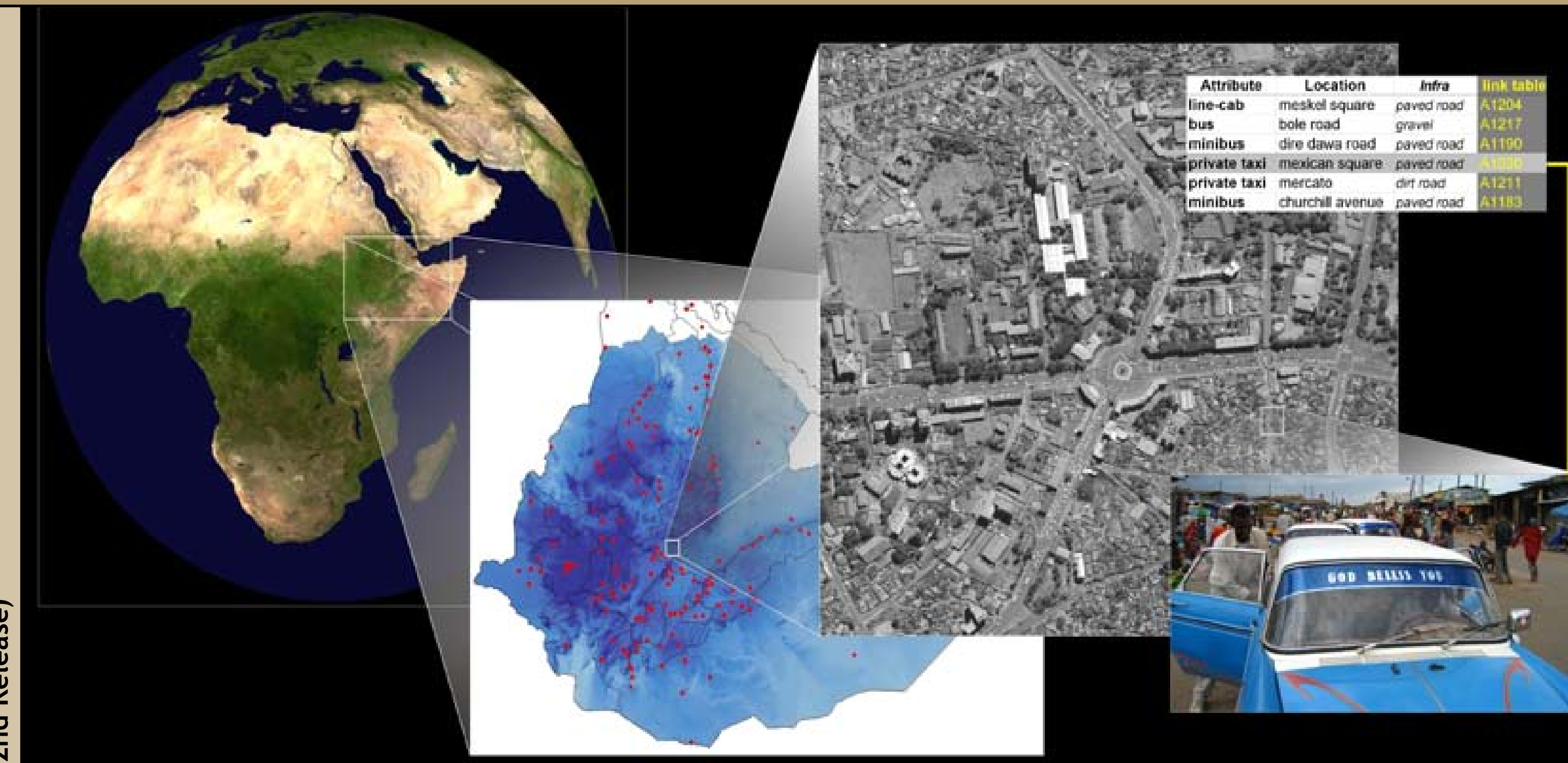
Top: Group photograph at ILRI

Bottom: Pre-workshop tour and capacity development at NMA, presentations on main workshop day at ILRI

Consultation Workshop on National Spatial Data Infrastructure and Ethio-GIS (2nd Release)



Consultation Workshop on National Spatial Data Infrastructure and Ethio-GIS (2nd Release)

Workshop Proceedings

Addis Abeba, November 28, 2007

Editors:
Gete Zeleke, Betre Alemu, Christian Hergarten and Juerg Krauer

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Gete Zeleke, Betre Alemu, Christian Hergarten and Juerg Krauer
(Editors)

Eastern and Southern Africa Partnership Programme (ESAPP)

Global Mountain Program (GMP)

Center for Development and Environment (CDE), University of Bern and

GIS Society of Ethiopia (GISSE)

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1 Welcome and Introductory Remark

Gete Zeleke, Co-ordinator, Rural-Urban Linkage Thematic Research Area for Africa , Global Mountain Program (GMP), P.O.Box 5689, Addis Ababa e-mail g.zeleke@cgiar.org

On behalf of the Global Mountain Program (GMP) and the EthioGIS group from the University of Bern, Switzerland, I welcome you all to this timely and crucial workshop that will deal with NSDI for Ethiopia and EthioGIS (2nd release). The GMP is pleased to organize the workshop as we believe that there are gaps and duplication of efforts in spatial data acquisition, compilation and dissemination. High-level GIS experts and institutions are participating in this consultation workshop and will share their experience in handling spatial data.

The GMP is a system-wide program of the Consultative group on International Agricultural Research (CGIAR). It was created by the CGIAR to respond to Agenda 21 to address key issues identified in Chapter 13 on sustainable management of fragile mountain environments, especially as related to issues in Chapter 14 on agriculture. Since the Earth Summit in Johannesburg in 2002, commitments to achieving the Millennium Development Goals (MDGs) have given the programme additional relevance.

Our meeting is very informal. We do not have guests of honour (except all of you) and opening speeches, as our workshop consists of technical consultation rather than official debate. Hence, we will go directly to the technical issues in order to make things simple and efficient.

I would like to mention two other things before we proceed to the workshop:

1) I wish to offer my apologies for the short notice.

2) I would like to express my greatest appreciation and heartfelt thanks for your positive responses and the turnout. It has not previously been possible to get such highly qualified professionals with nine short presentations on such short notice. Thank you once again.

Before we go into the details let me say a few words just to set the stage and cite the reasons for us to come together:

1.2 Ethio-GIS

- This was released in 1999 as the 1st of its kind, with well-organised spatial data released for users (academia and development groups)
- Many people have benefited from this database, including myself
- The Group led by Jureg Krauer has never stopped updating the system since then. Now they are almost ready to release the second edition of Ethio-GIS that will have many more state-of-the-art components than the previous version and is relevant for research and development.
- The question was then:
  - How can this fits with NSDI?
  - What more should the group add and what do stakeholders here in Ethiopia need to have in Ethio-GIS 2nd Release?

1.2 Spatial data-related challenges in the country

It should be noted that in the last decade many organizations have been working to collect geospatial data or have developed GIS labs and personnel. There has been considerable progress in the field and in the culture of utilising Geospatial data and capacity. However, the following issues are day-to-day challenges:

- Data sharing, including a data sharing protocol
- Data quality and standards: Woody biomass
- Data updating: some of the resource spatial data are 25 to 30 years old and at smaller scale, eg. Soil – EHRS-1984
  - Within country
  - Outside country
- Capacity – I wonder how many of us are using the huge potential of GIS tool
  - For modeling
  - Data management
  - For prediction or simulation
  - Interpolation, Developing interactive models such as decision support tools
  - Etc.

Looking at all these challenges, one would opt for a solution. The first step would be to start a dialogue among ourselves: So the above are some of the major reasons for us to organise this one-day consultative workshop.

After the end of this workshop we expect to achieve the following:

We hope we all get some information on the second release of EthioGIS 2nd and its other attributes, such as web-based modelling and application, etc. We will also be able to suggest what should be added and how it should be done. So the country will ultimately benefit from this product.

I am also hoping that this consultation workshop will speed up the NSDI initiative and or add value to what has already been started. So we might reach agreement on solutions to the key challenges mentioned above.

Last but not least let me extend my thanks to:

- Juerg Krauer and Chris Hergarten of the University of Bern (for their work on EthioGIS and follow-up services)
- The Centre for Development and Environment of the University of Bern, for financial support through ESSAPP
- NCCR-JACK-HOA for administrative support
- Ato Betre Alemu for identifying and trying to bring you all here, and all his other efforts to make this workshop a success.

2 Geospatial Information for Natural Resources Management - EthioGIS: Supporting NSDI in Ethiopia

Presentation made during the Consultative Workshop on National Spatial Data Infrastructure NSDI Ethiopia – Addis Abeba, 28.11.2007

Juerg Krauer, Centre for Development and Environment, University of Berne, Switzerland

2.1 Introduction

Socio-economic and geo-ecological conditions in Ethiopia have a pronounced effect on agriculture, the nation‘s most important production sector. Most food production is at the subsistence level. Because it needs a comparatively large cultivation area for food production, the country is heavily dependent on the interaction between landscape, vegetation, soil and climate. If agriculture is to be intensified in order to fight hunger and malnutrition, decisive measures will have to be taken to change agricultural policy. The Geospatial Information System Ethiopia, known by its working title ‘EthioGIS’, developed at the Centre for Development and Environment (CDE), University of Bern brings into focus all relevant spatial data such as terrain, soil, land cover and use, climate, drainage, infrastructure, population and agriculture in a Geographic Information System (GIS) as a basis for decision making and planning of national resource management strategies.

The potential EthioGIS project output, in its final release, will consist of map models based on actual population pressure and different management scenarios, a framework for watershed-based analysis, and finally thematic and interactive mapping for publications on the web, on DVDs and on paper. As a function of the individual modules developed to gain access to the EthioGIS database, the target scale ranges between 1:100k-1:500k for interactive mapping (desktop maps in A4 and A3 paper format) with either DVD or the web as a source, non-authorised topographic large format paper maps at 1:250k (30 map sheets), 1:500k (8 map sheets) and, finally, three thematic overview maps 1:1 Mio (optional 1 map sheet 1:2 Mio.).

The Centre for Development and Environment is a department of the Institute of Geography at the University of Bern. The Centre’s mission is to contribute to sustainable development in countries of the North, South, and East, through research partnerships, education and training, development of concepts and tools, sensitisation, and policy advice. CDE has a strong focus on management of natural resources, integrated regional development, and interventions that mitigate syndromes of global change. Within these contexts, applications of geographic information technologies GIT play a vital role and touch upon many aspects in development strategies.

2.2 Background

The beginning of Ethiopia’s national geospatial data compilation at CDE dates back to the early 1990s when spatial data modeling concepts in the Soil Conservation Research Project (SCRP) demanded a regional extrapolation base for knowledge obtained from six research sites in the Ethiopian Highlands.

Alarmed by the seriousness of land degradation in Ethiopia and encouraged by efforts undertaken by the Ethiopian government to conserve soils and water for agricultural purposes, scientists and development specialists created the SCRP in 1981. Their aim was to contribute to the technical, ecological, economic and social improvement of governmental efforts. The SCRP was carried out with the support of the Swiss Agency for Development and Cooperation (SDC) in a series of programme phases that lasted from 1981 to 1998. Since 1998, regional SCRP offices have continued their own research at the original SCRP sites and research in the framework of EthioGIS has been supported by SDC's Eastern and Southern Africa Partnership Programme (ESAPP).

Apart from a huge database covering natural resources, agricultural use and socio-economic conditions in six research stations, SCRP has produced a number of outputs: Over 45 research reports, regular process reports, immediate recommendations at least once every year, as well as training manuals, training courses, school books, maps, GIS analyses and training. And, with the compilation of digital terrain models as well as land use and soil maps for local watersheds, extrapolations of the results to wider areas have been made. These outputs can be obtained from the Natural Resources Development and Regulatory Department in Addis Abeba or from the Bureaux of Agriculture in the Oromia, Amhara, and Southern Peoples' Region, as well as from CDE at the University of Berne.

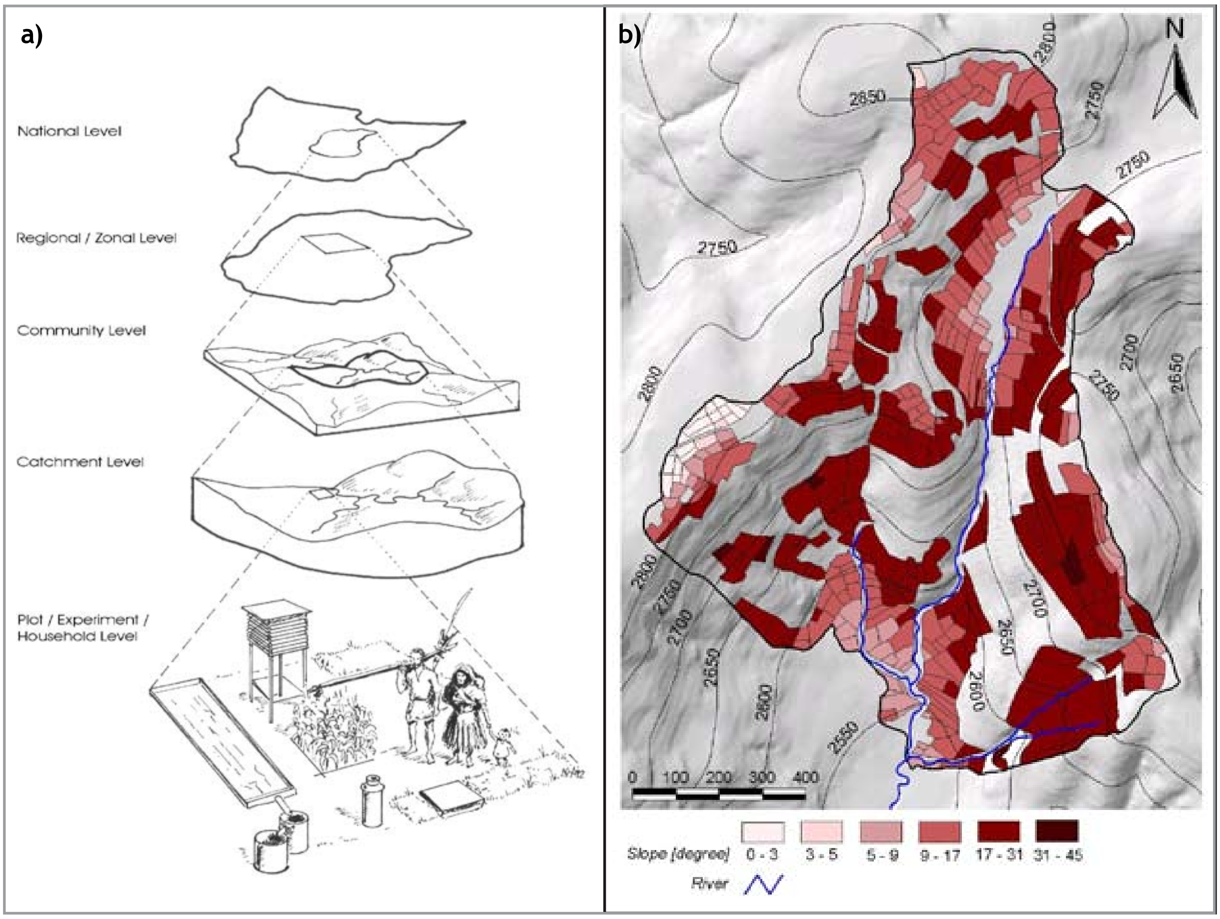

Figure 2.1: *a) Up-scaling within SCRP's research levels (Herweg & Hurni, 1993; b) Spatial distribution of slope classes within research catchment*

With the founding base of SCRP's geoinformation system for each of the six research catchments, the need to link research results to local or regional units (watershed or administration units) was the driving force for creating a national spatial data framework to support conservation strategies on a smaller scale. In an early evaluation of GIS and Environmental Information System (EIS) in Ethiopia, consulted by Joy Hecht (1992) for the UN Sudano-Sahelian Office, only a few spatial information systems were operational within the Ethiopian Government. One of the main actors was the Ministry of Mines and Energy with its Woody Biomass Inventory and Strategic Planning Project WBISPP project. Other key players apart from the UN agencies were found in watershed planning and forestry, the Land Use Planning and Regulatory Department (LUPRD), the Ethiopian Valleys Development Studies Authority (EVDSA), the Ethiopian Mapping Authority (EMA), the Central Statistical Authority (CSA) and the National Meteorological Authority (NMA).

In the early 1990s none of the authorities was in a position to provide national digital data sets at a working scale of 1:500k. Based on Landsat 5 imagery (total 55 scenes) provided by the UN through the Digital Exchange Platform of the Horn of Africa (DEPHA), and vector scans derived from the three map sheets 'Ethiopia Agroecological Belts 1:1 Mio', a first national digital terrain model was developed in 1991 with ESRI's Software ArcInfo (Environmental Systems Research Institute). In the late 1990s the national geospatial product was developed in its first release to a comprehensive national geographic reference system and distributed among all Ethiopian ministries. At the invitation of the Natural Resources Management and Regulatory Department (NRMRD) in September 1999, methods, a spatial information base, and the potential of geographic information systems were presented in a data transfer workshop to 30 participants from the Ministry of Agriculture, the Ministry of Water Resources, EMA, NMA, the Ethiopian Agricultural Research Organisation (EARO) and to regional authorities from Oromia, Bahir Dar, and Amhara National Regional State.

Data Transfer workshop at Natural Resources Management and Regulatory Department (NRMRD), September 1999. (Photo by Juerg Krauer)

At that time NARIC, the Natural Resources Information Centre of the MoA, was dedicated to making environmental information more readily and systematically accessible. Besides acquiring and disseminating integrated, spatially-referenced environmental data, NARIC has provided decision-support services to agronomists and environmentalists, governmental organizations, and NGOs. Due to the lack of free available spatially referenced data, the standard layers of EthioGIS became a widely used source for a national, spatially referenced information base.

2.3 Geographic Information Science (GIS)

In natural resource management, geographic information technologies - a set of specialized information and communication tools such as GIS, Global Positioning Systems (GPS), Earth Observation (EO) and web-applications - are mainly used for monitoring and analysis of spatial information. Geographic Information Systems can be defined either by their components, their functional requirements or by their mathematical definitions (see Figure 2.2). In a more generic sense, GIS is a tool that allows users to create interactive queries, analyses spatial information, edits data, and presents the result of all these operations in maps, models or statistics.

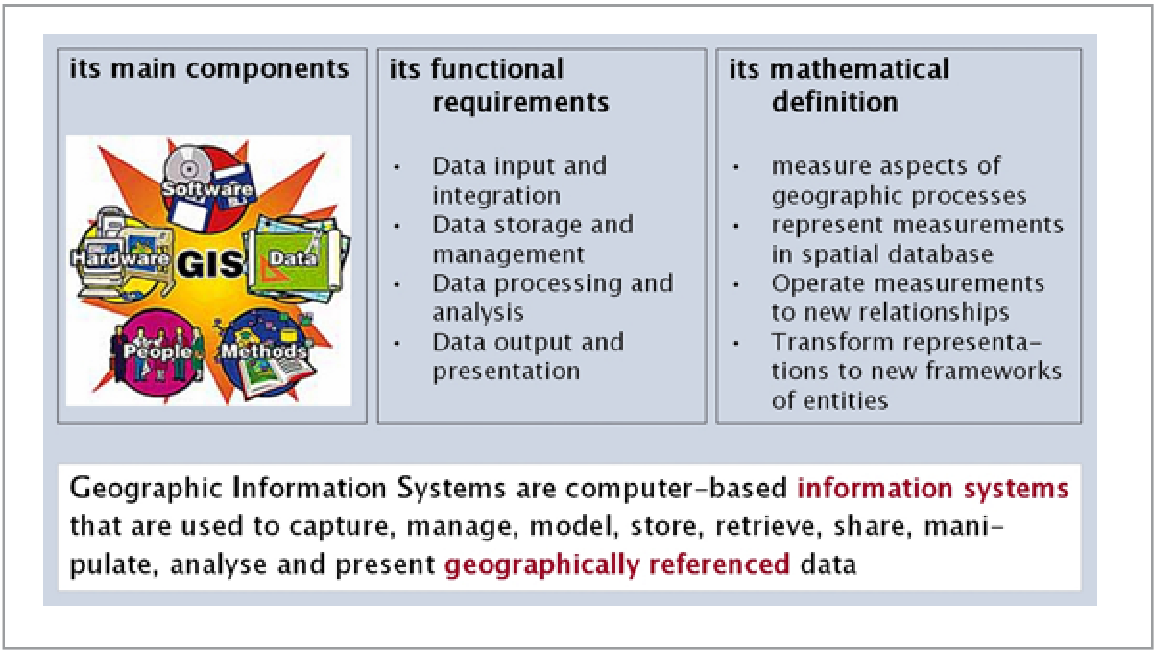

Figure 2.2: *Terms and definitions of Geographic Information Systems (GIS)*

The five elements in any GIS - the geographic media the spatial data are transferred from, the geospatial datasets, the processes and workflows used to compile the data, the models use to derive the parameters, and finally the data documentations - are listed below (Figure 2.3).

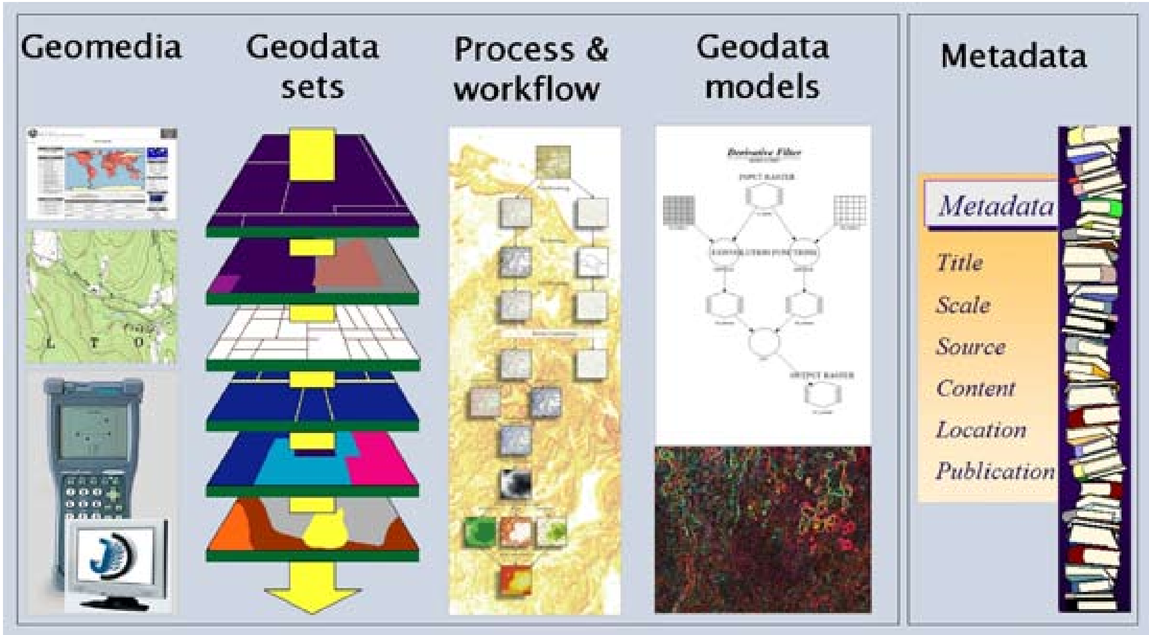

Figure 2.3: *The five elements of geographic information*

Geographic information science is the science underlying geographic concepts, applications and systems. Its main hallmarks are spatial analysis, geostatistics, place-based research, extrapolations, data integration, and decision support. The capability to visualize and present spatial information is an important feature for communication, dissemination and knowledge sharing among the NRM community.

Geoinformation science with a focus on NRM has emerged as an exciting multi-disciplinary research field, spanning such areas as environmental, economic and social geography, cartography, earth observation, image processing and communication technologies!

Areas where GIS-applications are used in natural resources management:

- **Impact on natural resources:** inventories, assessment of degradation and desertification
- **Land resources:** agricult. production and agro-forestry
- **Mitigation conflicts:** security, demining, peace building
- **Crises management:** rehabilitation, reconstruction, infrastructure planning
- **Urban environments:** population dynamics, migrations into cities
- **Watershed management:** irrigation, water resources use

The goal of any GIS application is to obtain a thorough basis of information for answering questions in decision making!

2.4 Geospatial Information for Natural Resources Management in Ethiopia

With the first release of EthioGIS in 1999, an initial step towards a national concept of spatial data infrastructure typical of the management of natural resources was initiated. The data compilation in the first release covered the most important national spatial data on a single CD-ROM, namely:

- Boundaries for three levels of administrative units (national, regional, *Weredas*)
- Monthly and annual average rainfall distribution (incl. rainfall erosivity model and rainfall and wind pattern regions)
- Towns and villages (with names and population figures)
- Infrastructure (railways, all weather roads, dirt roads, tracks)
- Topography (digital terrain model with slope, aspect, and elevation)
- Hydrography (streams, main rivers, perennial rivers, seasonal rivers, lakes and swamps)

The focus in release 1 was on principal geospatial layers for the scientific community in the field of natural resources management (i.e population density based on 1994 census data, see Figure 2.4). Metadata and procedures in data compilation were kept quite simple and dissemination was restricted to interested ministries of the Ethiopian Government.

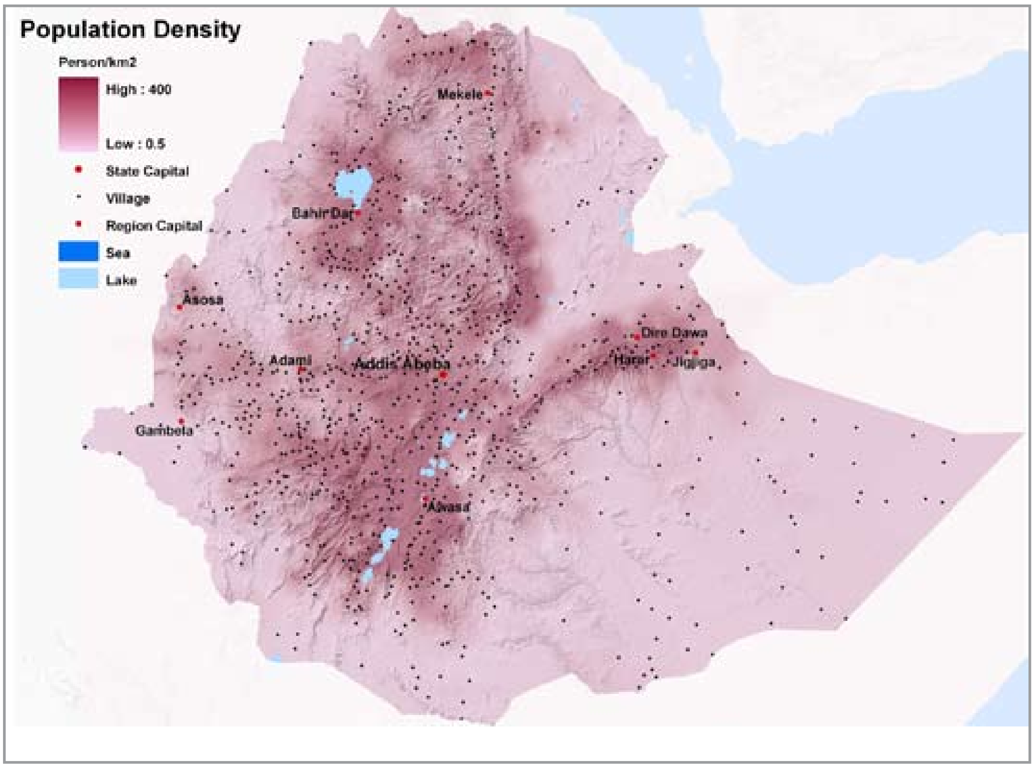

Figure 2.4: *Ethiopia: Population Density 1994 (EthioGIS, 1999)*

From 2000 onwards informatics and the use of geospatial data within the ministries has increasingly been used so that for the next release all related documents, metadata descriptions and geodata standards have to be enhanced and the contributing community has to be extended. But not only does the particular field of the geospatial information, - the Infoware – have to be updated; the other three dimensions of Geographic Information Systems also need to have a careful upgrade within the framework of release II of EthioGIS.

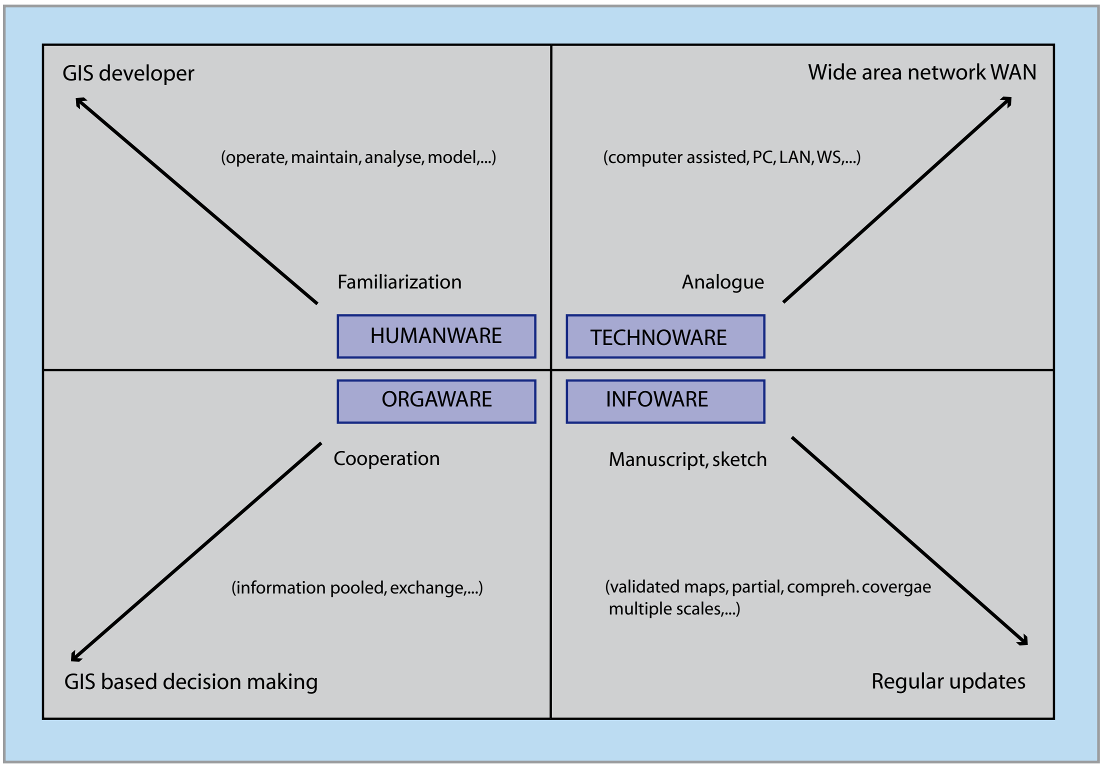

Figure 2.5: *The 4 dimensions of GIS in Ethiopia's Natural Resources Management*

While the technology or technoware is given by the soft- and hardware components of a geographic information system, and the degree of intra- and inter-institutional cooperation is determined by the set-up of the organizational workflows, the humanware is the most important dimension with a view to successful implementation of a GIS enterprise within the government of Ethiopia. Figure 2.5 illustrates that the provision of geospatial information needs to be accompanied by serious development of governmental structures and the building of enough capacity in the management of geospatial information. Since geographic information is widely used as a reference layer for any kind of location-based information, the need for spatially literate and trained staff is extremely high throughout all departments. A well-trained GIS analyst is in a position to create data processing workflows and to prepare geospatial statistics and knowledge, as a sound basis for monitoring, understanding and decision support within the government.

With respect to the wider prospective use of geospatial information within the government of Ethiopia, and with the great amount of feedback in recent years, release II of EthioGIS will give special attention

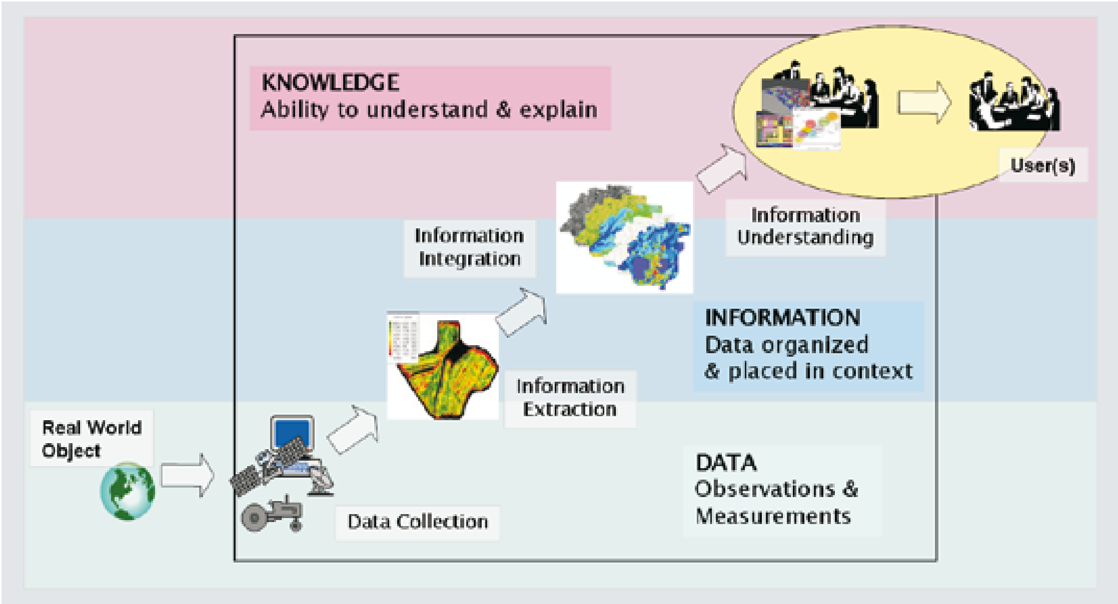

Figure 2.6: *Spatial information chain for decision support*

to the following two dimensions:

- Humanware: Handover and data dissemination will be conducted by a thorough introduction into geodata and modeling concepts for the national databank
- Infoware: All layers of release I will be improved (settlements, topography, hydrography, etc.), updated (i.e. administration, settlements, etc.) and upgraded (i.e. topology, hydrology, soil resources, land cover and land use types, etc.). Many more layers will be added to the standard layers of release I, namely nationwide and multi-temporal earth observation layers (i.e. radar rainfall, temperature, albedo, NDVI, etc.) and derivates from SRTM (Shuttle Radar Topography Mission) (i.e. watersheds, stream lines, flow accumulation, etc.). Meta-data and a detailed description of the source of information will also be part of the new release.

2.5 Developments of tools and geospatial data for Release II

In the framework of the ‘EthioGIS’ research project, a series of tools and models have been developed: In a first step, templates for large format map services have been programmed covering three map series between 1:1 Mio. and 1:250k. In a second step the script language program of ArcGIS (MXD) was enhanced by a module for the production of field maps with a variable geographic centre location (X/Y-coordinates in UTM) and a specified range of map scales, Any topic or theme can be chosen as principal map content; depending on their use, map features can be selected or deselected.

With a third module watershed-based interactive desktop mapping and reporting (pdf) was developed based on ESRI’s ArcServer technology (see figure 2.7). This tool was requested by institutions working in the field of watershed planning, and makes it possible to provide spatial statistics in report form for any selected poor point on a stream. The state-of-the-art application also has some disadvantages: The costs for the software to run the application interactively are extremely high and internet connectivity (bandwidth) is still very poor in Ethiopia. For release II, a stand-alone version is planned and, to reduce the costs, open source software will be explored to cover the needs of desktop mapping and analysis based on interactive watershed delineation.

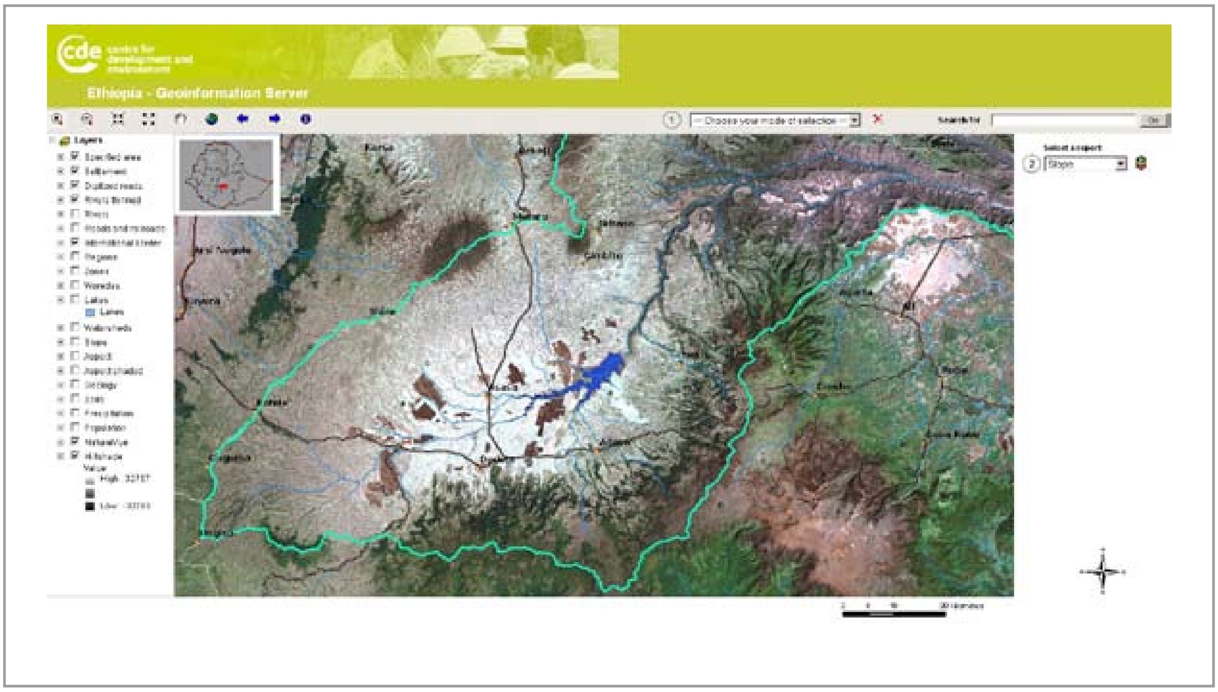

Figure 2.7: *Web-mapping and watershed planning based on interactive watershed delineation (Hösli, 2006).*

Based on the nation-wide 90 m digital terrain model (SRTM), watersheds of almost any size (< 10 km2) and corresponding geostatistics on any theme of EthioGIS can be calculated, presented as reports, and visualized with ESRI's ArcGIS software.

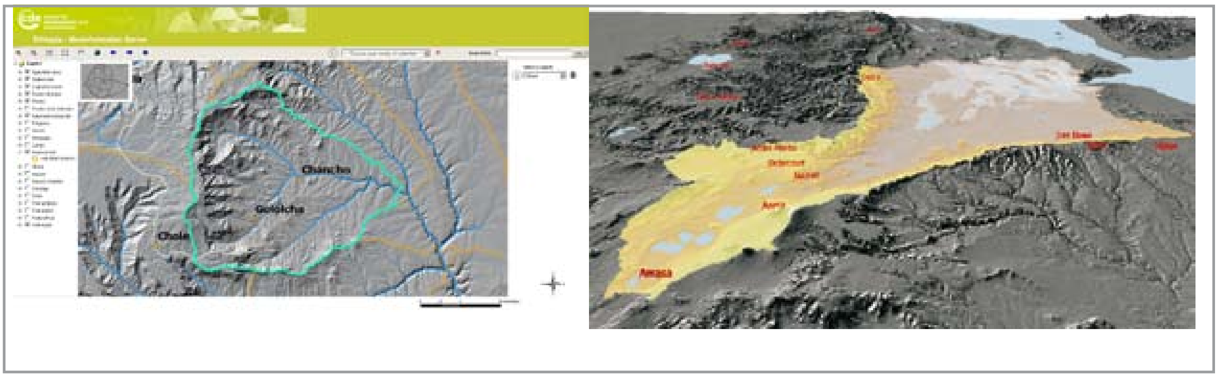

Figure 2.8: *Watershed boundaries as a result of interactive location of river outflow and 3D visualization in ESRI's ArcScene (Hösli, 2006)*

One of the most advanced developments within EthioGIS II is the Digital Drainage Model Ethiopia (DDM). Based on the principle of vector/raster modeling (surface flow direction for each pixel) a hydrological information system for water resources management was developed. In a first step a drainage direction matrix with a mesh of flow directions was created. The flow direction of each pixel was determined by the steepest descent direction among the neighboring 8 directions provided by the digital elevation model (DEM). Followed this rule, together with the accumulated amount of pixels, river lines were created in a hierarchical downstream order. Except for sinks, concave or completely flat areas, the drainage model derived from the DEM bore up against the satellite imagery (see Figure 2.9).

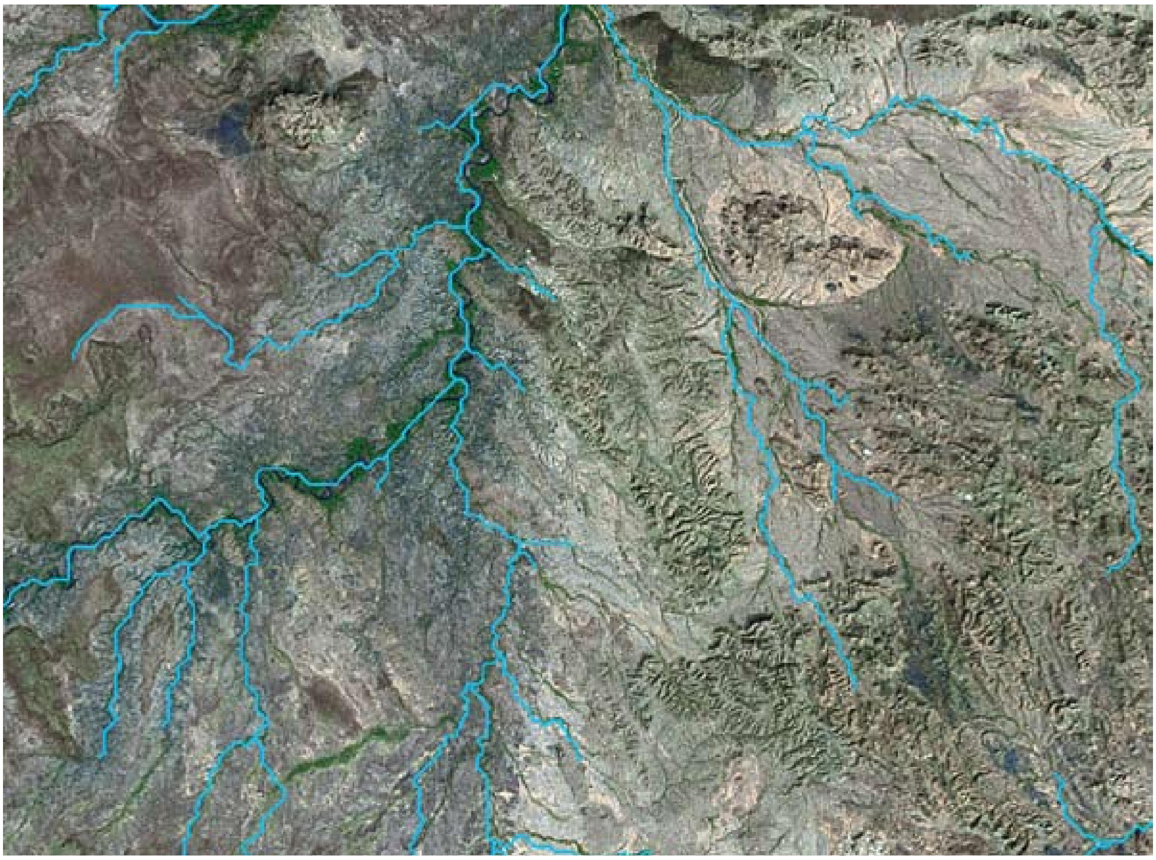

Figure 2.9: *Visual drainage model validation on top of EarthSat 15m psm imageries.*

Finally, release II will incorporate a series of multi-temporal imagery and models derived from Terra MODIS (Moderate Resolution Imaging Spectroradiometer), launched in December 1999 and Envisat MERIS (Medium-spectral Resolution Imaging Spectrometer), launched in March 2002. Terra and Envisat satellites view the entire Earth's surface every 1 to 2 days, acquiring data in 36, respectively 15 spectral bands. The range of the georeferenced themes covers radar rainfall estimations, various vegetation indices, surface reflectance, land surface temperature, and atmospheric water vapor. The image resolution of the multi-temporal data varies between 4 km and 250 m.

As a common geospatial reference for all imagery products and drainage derivates (stream lines, stream order, flow accumulation, watershed boundaries, etc.), the corrected and calibrated digital elevation model compiled from the Space Shuttle Radar Topography Mission (SRTM) data is used. As a sample, one of the products derived from the SRTM DEM is shown in Figure 2.10. Albedo or reflectivity is defined as the ratio of upwelling to downwelling radiative flux at the surface. The figure below presents the albedo over Ethiopia at local solar noon. The figure shows a marked difference between the reflections in areas of highest vegetation (bright, i.e. Bale area) and lowest vegetation cover in large river valleys and the lowland (dark, i.e. Danakil area).

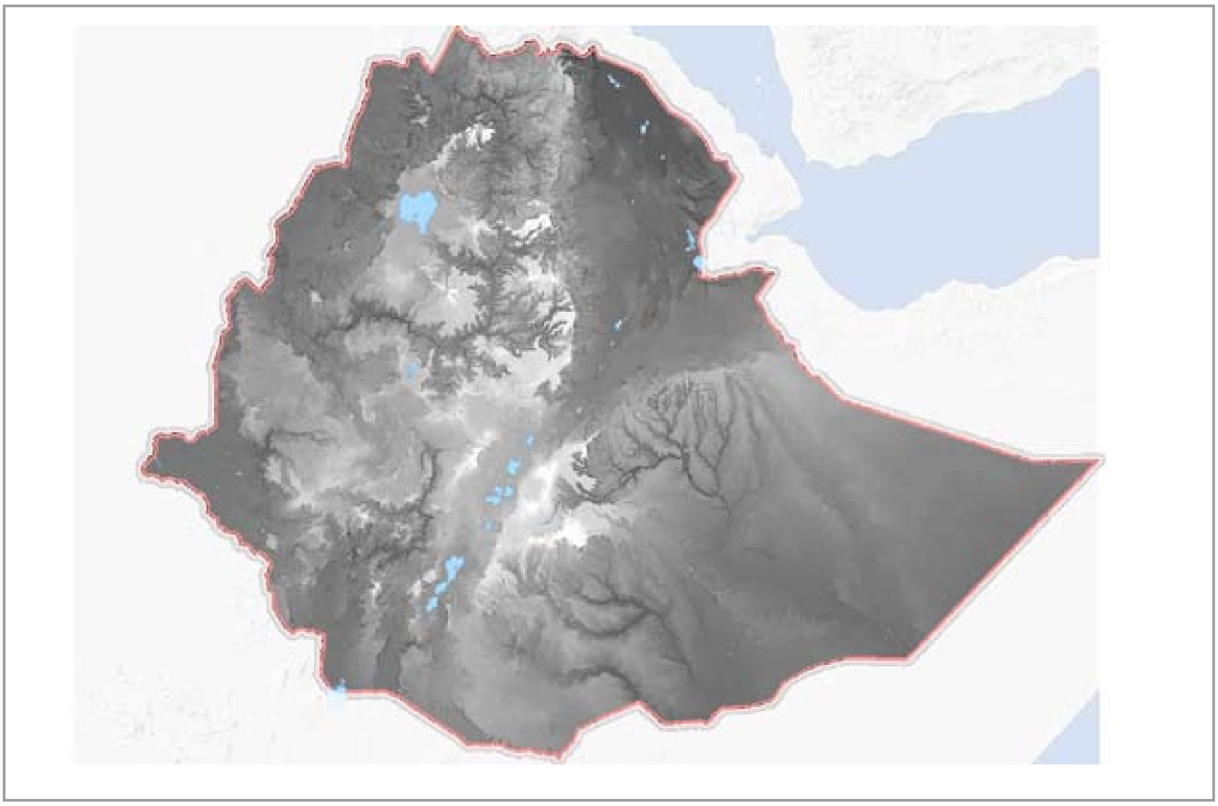

Figure 2.10: *16-day average reflectivity (Hergarten, 2007)*

2.6 EthioGIS a substantial contribution to the National Spatial Data Infrastructure (NSDI) in Ethiopia

National Spatial Data Infrastructure constitutes a set of policies, technologies and standards that interconnect a community of spatial information users, and related support activities for production, dissemination and management of geographic information.

The goal of the national initiative is to reduce duplication of effort among agencies and institutions, to improve quality and reduce costs related to all kinds of geographic information, to make them more accessible to the community, to increase the benefits of using available data, and to establish key partnerships with authorities, academia, the regions, the international community, and the private sector in Ethiopia.

Right from the project start, EthioGIS' contribution to a national geodata infrastructure was meant to avoid redundant efforts in digitizing of spatial data with a focus in natural resources management, to share resources, to consolidate information, and to disseminate all related products to interested local institutions.

In the early 1990s, standards in geoinformation projects were not quite common. Due to the general lack of information at that time, the EthioGIS project mainly followed the principles and formats provided by software resellers. With the first release, standards provided by the 'Digital Platform Horn of Africa' (DEPHA) and by UNITAR were applied. Meta-data were provided to both organisations in 1995 for cataloguing. Dissemination of EthioGIS release I was secured by presentations at Africa GIS in 1995, in Abidjan and 2000 in Nairobi.

In view of the forthcoming release II data format, standards and reference systems will be adapted to the latest developments in the filed of spatial data infrastructure. The dissemination will be arranged with leading institutions in Ethiopia and local specifications will be adapted beforehand. As far as possible, common NSDI efforts and standards used in Ethiopia will be applied. As long as local adaptations are missing, standards communicated by the Economic Commission for Africa (ECA) the Global Spatial Data infrastructure Association (GSDI) and EIS-Africa, with the collaboration of the International Institute for Geoinformation Science and Earth Observation (ITC), will be used. Together with the dissemination of the data, assistance will be provided to integrate the datasets into local GIS and to improve the management of their geospatial data resources in a way that effectively supports decision-making by the requesting institutions and governmental agencies.

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3 Potentials and Limitations of Internet-based Geo-processing Tools for Watershed Management

Chris Hergarten (University of Berne, Switzerland), e-mail christian.Hergarten@cde.unibe.ch

3.1 Background

The maintenance of a sustainable equilibrium between the use of natural resources (i.e. land and water) and the preservation of a healthy natural environment in rural and peri-urban areas is one of the challenges many countries are facing. Activities aiming at sustainable resource management are often focusing on watersheds being the relevant spatial unit for hydrologic, geomorphologic and socio-economic processes. Due to the complex nature of many natural and anthropogenic systems, the ability to comprehend and predict future conditions based on watershed approach has increasingly chosen a geographic dimension. So Geographic Information Science has played a decisive role in many aspects of sustainable watershed management, from visualizing impacts of alternative management scenarios to the assessment of catchment conditions by modeling impacts of anthropogenic activities on water quality.

The field of Geographic Information Science has evolved from a technology in selected disciplines to become a major player in the domain of the omnipresent information technology. Enhancements in computer software and hardware, the standardisation of formats and the finally the sophistication of geo-processing functions have dramatically increased the usability and also demands for GIS technology, especially since the use of internet based real-time analysis and mapping has become an option. In sustainable watershed management GIS deployment has changed from operational support to an analytical modeling tool and even a strategic decision support system. In short, Geographical Information Systems are among the most comprehensive and sophisticated tools available for sustainable watershed management. Thereby the deployment of GIS will not only help to reduce time costs for information analysis, but can as well ensure a more efficient and sustainable use of resources.

3.2 Concepts of watershed management

The watershed approach is an ecologically meaningful way for analyzing and dividing space as opposed to many arbitrarily delineated administrative boundaries. From a functional perspective, a watershed is the area of land where all of the water that drains off of it flows into the same place, the outlet point.

J. W. Powell’s more holistic definition:

> *“…that area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course and where, as humans settled, simple logic demanded that they become part of a community.“*

As a consequence, watershed management is dealing with spatially relevant activities, harmonizing downstream with upstream residents. It is crucial to understand a watershed's structure and natural processes to grasp how anthropogenic activities can degrade or improve the condition of a watershed, including water quality, its fish and wildlife, its vegetation, and the quality of community life for people who live there. Knowing the watershed structural and functional characteristics and how people can affect them is a crucial prerequisite for any effective watershed management. Furthermore, it is important to bear in mind that watershed management can take place at different levels in a hierarchical structure.

To reveal some ways in which GIS can be deployed for sustainable watershed management a few exemplary applications are listed below.

Baseline characterization and assessment of watersheds

For assessment and characterization studies requiring a watershed-based approach the deployment of GIS has a long tradition. Using available digital terrain models (DTM) basic physical characteristics of catchments can be derived, such as drainage networks, channel hierarchy and flow paths. In conjunction with additional data such as water quality or precipitation watershed action plans can be developed and existing as well as potential pollution issues within a watershed can be identified. Data collected from remote sensing systems and from GPS surveys can be combined within a GIS for an integrated characterization and assessment of watershed conditions and functions.

Watershed management planning

Planning becomes very important when facing challenges involving water quantity and quality due to natural or human-induced hazards (e.g., droughts, urbanization, floods), in mitigating impacts and ensuring optimal utilization of available resources. Outputs received from assessment studies, mainly in form of maps and charts, should be combined with ancillary data to optimize the assessment of complex correlation between natural and anthropogenic systems relating to resource and land use within a watershed. Eventually GIS provides a very useful framework for most data received from a variety of sources required for watershed management. The important spatial dimension inherent to biophysical and human linked processes makes GIS a powerful tool to grasp these processes and for managing impacts of human-induced activities.

Combined with the intensive growth of the Internet, the visualization and modeling capabilities of state-of-the-art GIS offer fundamentally new and efficient instruments to better comprehend the processes and its dynamics shaping the biological, physical and chemical environment of a watershed. The increasingly significant linkages between the Internet, GIS and environmental spatial databases is very helpful for planning studies and cases when information exchange and real-time feedback is crucial and more so when several different institutions and stakeholders are involved.

Watershed rehabilitation

GIS provides a perfect environment to handle watershed rehabilitation studies efficiently and accurately that usually involve the evaluation of diverse alternatives. GIS is being successfully applied for restoration studies varying from small rural watersheds to large urbanized landscapes. Using hydrological and spatially explicit water quality modeling, GIS can assist in water assessment projects. Due to its integrating capabilities a GIS can provide an interface to transfer and emulate the complexity of real world systems within the confines of a digital environment accurately and efficiently. As a consequence, GIS provides a platform for collaboration among watershed stakeholders, researchers and policy makers. Such common ground tends to significantly improve consensus building and offers the opportunity for collaboration on questions concerning interdisciplinary environmental policy.

Watershed decision support and policy analysis

The field of watershed planning and watershed science in general is experiencing fundamental changes having important impacts on the use of computer-based simulation modeling in resource planning and management. The dramatically increased availability of low-cost and open-source, easy-to-apply GIS software tools, and more extensive spatially referenced data, are definitely turning GIS into an essential tool for sustainable watershed management tasks. However, the rapid advancement in applying GIS has brought the affects of mainstreaming leading finally to an increased realization that GIS alone cannot satisfy all the needs expressed by planners sustainably managing watersheds. As a consequence, watershed manager’s interest has grown in the development of a decision support system combining not only GIS, spatial and non-spatial data, but also computer-based biophysical and socio-economic models, knowledge-based expert systems, and sophisticated visualization methods into encompassing integrated systems enhancing planning and supporting policy analysis tasks. Coupled with spatial decision support systems, GIS provides most powerful visualization instruments for displaying and manipulation, allowing immediate intuitive evaluation being done to that a wide range of non-technical managers and decision makers can relate to.

3.3 GIS for watershed management in Ethiopia

Given its unique and strategic location in East Africa, Ethiopia is controlling the headwaters of important rivers such as the Blue Nile. As a consequence, sustainable watershed management is an issue of utmost importance, not only for Ethiopians, but even more for its neighboring countries prone to droughts and water scarcity. Accordingly, resource planners, researchers and policy makers in Ethiopia are increasingly realizing the power of GIS and its unique ability to support and enhance sustainable watershed management. Anyway the exploitation of the potentials of GIS is still poor, especially in institutions outside the capital Addis Ababa. Although the amount of data collected by Ethiopian institutions is rapidly increasing, the applied manner of storing, processing and disseminating data only partly meets the demand for a comprehensive foundation for watershed based decision making. Without appropriate methodologies and applications for terrain based analysis it will be difficult to aggregate the required geospatial data on a meaningful watershed level.

This situation clearly highlights the needs for an integrated approach targeting the empowerment of governmental institutions in terms of technical capacity, strengthening of inter-institutional cooperation and policy dialog. An ESAPP[1] funded project[2] launched in autumn 2005 was aiming to investigate solutions for the technical, and to some lesser extend also for the institutional problems. According to the inceptive assessment the major challenges in terms of sustainable watershed management include:

- Weak inter-institutional cooperation
- Poor dissemination of technical capacities in terms of GIS application
- Difficult hardware setup
- Very heterogeneous software setup

To counteract at least some of these issues the mentioned project tried to sound the options for the implementation of a distributed GIS server application, providing access to powerful geo-processing functions like customized watershed delineation and reporting through a common web browser interface. The proposed setup is based on a centralized repository holding all spatial data and a centralized GIS server application running all processing requests send by potential users dispersed all over the country. The requesting users only need a common computer connected to the internet instead of a high performance workstation running expensive GIS software. Using the internet, the processing request is send to the GIS server which is processing the request and upon completion sends the results back to the client computer.

The functions provided by the GIS server application are highly customizable; for the discussed project the server delineates the watershed for any point and calculates area statistics based on a digital terrain model.

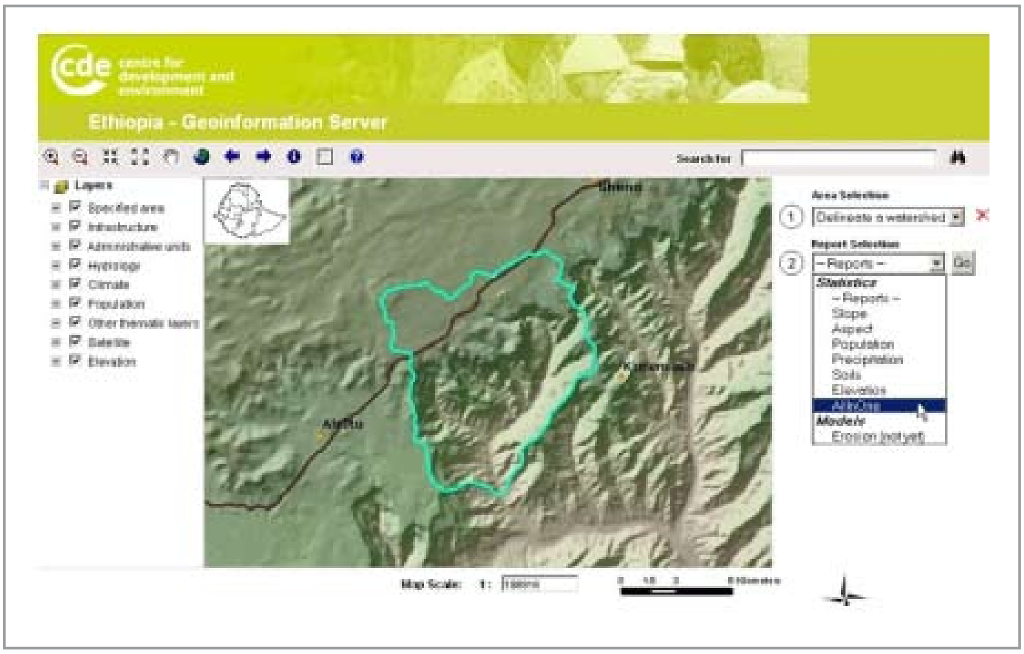

Figure 3.1: *Web browser displaying the real-time delineated watershed*

1) Eastern and Southern Africa Partnership Program, funded by SDC, Switzerland
2) Internet Based Watershed Information and Management System for Ethiopia

3.4 Conclusions

Eventually tests that were run in Ethiopian institutions revealed that the poor Internet connectivity and low bandwidth proved to be the major obstacles for a distributed geo-processing environment fully relying on the Internet. It is to hope that in the medium run the situation will improve, this at least is what the Ethiopian government promised to the people.

From an institutional perspective, the implementation of a centralized database repository proved to be difficult as well, since data and information sharing among institutions is not at all common yet. This tends to lead to deadlocked situations since information sharing often means power sharing which might be very challenging in institutional environments where common goals are not shared among "cooperating" institutions.

Therefore, the more recent NSDI concept of distributed databases linking various repositories (and eventually institutions) through a network and a common clearinghouse interface may be more promising (FGDC, NSDI).

On the application level, future endeavors should hold options for client based application systems to overcome the problem of poor connectivity. This can be achieved for example by the deployment of readily available open-source GIS applications distributed on CD or DVD.

3.5 Comparison of Internet based GIS server vs. stand alone GIS tools

Internet-based versus stand-alone solutions

- Server-side strategies allow the users to submit requests for data and analysis to a Web server.
- Server processes the requests and returns data or a solution to the remote client
  - Little processing power is required of the client computer, only the ability to submit requests and display responses.
- Stand-alone strategy works independently from any remote server
  - Full processing power needed on client side

Potentials of Internet-based geo-processing tools

- Only low-level GIS knowledge needed („klick-and-go“)
- Centrally managed application workflow
- One central database = one db to be updated!
- Reduced licensing costs
- No need for expensive stand-alone GIS workstations

- Reduced need for trained staff
- Ease of application

Limitations of Geo-processing tools

- High bandwidth internet connection needed
- High performance server architecture needed
- Limited applications („Out-of-the-box" tools)
- One central database = prone to „empire building" effects
- High entry (development) costs
- Few highly skilled IT and programming personnel needed
- Widening the gap between „doers" and „programmers"
- Data access and exchange policies needed

Sources and further reading: http://www.fgdc.gov/nsdi/nsdi.html

4 Free Spatial Databases and Open-source Tools - Underestimated Means for Supporting NSDI and Natural Resources Management Projects?

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4.1 Background

In order to achieve the requirements determined by initiatives like the Millennium Development Goals there is an important demand for methods and instruments to effectively assess and to manage natural resources. It is beyond dispute that spatial information technology (GIS and remote sensing) can play a pivotal role when implementing strategies and workflows to reach these aims. Meanwhile spatial information technology is well established and accepted as a powerful tool to survey the state of natural resources. This is also the case for Ethiopia, where a very active community consisting of different governmental agencies and other institutions is pushing forward the appliance of spatial information technology. During more than 15 years Ethiopia has collected an unprecedented amount of geographical and spatial information about environmental, infrastructural and cultural phenomena, compiled by various stakeholders working on it. A lot of this information is collected and stored in different formats and at diverse scales. Such issues but also various other obstacles such as limited access to information, difficulties in finding the correct information, reproducing it, and applying it in GIS challenge the success of the endeavor whose focus is on supporting development activities. As a consequence, there are strong efforts going on in establishing a National Spatial Data Infrastructure in order to support standardization of formats, archival storage and to make the data accessible to a wider audience.

The current situation is characterized by an alarming heterogeneity which leads to the assumption that Ethiopia is lacking a concerted strategy and common data collection and storage standards. In this regard Ethiopia is facing the same challenges as many other countries aiming to implement a National Spatial Data Infrastructure. As a consequence, institutions collecting data start to develop their own standards. To prevent the proliferation of further non standard compliant data there is urgent need to streamline the process of data collection, compilation and storage. This fact has been acknowledged by institutions like UNECA, who put the topic high on the agenda (http://geoinfo.uneca.org/sdiafrica/).

4.2 Elements of a National Spatial Data Infrastructure

In a few words, the NSDI is a cooperative effort to promote geospatial data sharing throughout all levels of government, the private and non-profit sectors, and academia; consisting of technology, standards, policies and people necessary.

The American FGDC defines National Spatial Data Infrastructure (NSDI) as:

> *„an umbrella of policies, standards, and procedures under which organizations and technologies interact to foster more efficient use, management and production of geo-spatial data". A SDI consists of „organizations and individuals who generate or use geospatial data, of the technologies that facilitate use and transfer of geospatial data, and of the actual data".*

From an integrating perspective, the development of a NSDA builds on at least eight pillars as discussed hereafter.

Standards

Standardization guarantees the use of a wide range of data. The most crucial aspects encompass data content, geographic referencing, resolution and metadata. Designing standards for spatial data means to look beyond the immediate information community of which one is part, to standards in place or in development in other sectors, neighbouring countries or even regions. The development of formal standards through national standard bodies as well as through international standard organizations (ISO, FGDC, OGC…) can best be achieved through a consultative process.

Metadata

Metadata (also called meta information) is defined as “data about data”. Metadata is necessary to:

- locate appropriate datasets (using spatial or attributive features)
- evaluate the usefulness of the dataset
- extract the relevant data

While capturing of metadata is necessary, it is never sufficient on its own, to ensure wider knowledge of a dataset, and hence wider usage. Using tools like online catalogs, metadata has to be published to enable users to identify the datasets that match their requirements.

Communication network

Since the NSDI is a concept developed last but not least on the rapid development in ICT, its implementation and use depends on the availability of appropriate and reliable network communication structures (intranet, internet).

Data policy

The development of a NSDI requires appropriate data policies and an enabling legal framework. Therefore it is of paramount importance to formulate information and data exchange policy or legislation regulating issues like access to data and information, use of spatial data, copyright.

Developing NSDI capacity and capability

The implementation of NSDI needs encompassing human capacity development. Training cannot be reduced solely to technical know-how transfer. Partnership is an important aspect in building an NSDI since a single institution is unlikely to have all the resources, skills and knowledge necessary to undertake the development of all aspects of a NSDI.

Technical setup

The "most" physical part of the NSDI is to be found in data servers located at various institutions collecting data or simply providing computing power and hardware setup. State-of-the-art web portals (clearinghouses) act as "one-stop-shops", efficiently serving the customer's needs due to eliminated bureaucratic obstacles.

Institutional framework

To enable the NSDI and to ensure its sustainability and performance, the responsible steward who will ideally be a government authority, has to make sure the NSDI aspires to (after NSDI - Strategy and Action Plan, 2001):

- build on, facilitate and support existing initiatives
- support sustainable development
- be flexible and adaptable to change
- facilitate new initiatives especially those relating to the use and sharing of data
- be as simple, transparent, open and democratic as possible
- enhance decision making processes
- engender partnerships

For a more thorough discussion of the institutional requirements please refer to the institutional dimensions section below.

Clearinghouse

The basis for the NSDI clearinghouse is its means to search, query, and retrieve geographic data. In fact, the clearinghouse is a distributed, well connected network of spatial data providers and users. It is important to understand the clearinghouse is not a central repository storing data; it is rather a comprehensive listing of data produced by government institutions, universities, and any other organizations.

It goes without saying that no elements must lack to successfully establishing a NSDI. However, these prerequisites may not be sufficient; very often technical, institutional, legal or monetary shortcomings impede the advancement of standardization processes or its successful implementation. The next section strives to highlight some crucial issues related to the design of a NSDI and tackles major challenges.

4.3 Cross cutting dimensions

Participatory approach

Even though the government has a major stake in managing the spatial information the NSDI has to evolve and expand with strong participation of committing institutions and agencies, namely the private sector, NGO's, academia and citizens. The leading agency has to be able to balance the various needs expressed by any actors. The needs of private business corporations must not neglect the concerns of organizations collecting data for natural resources management.

To act as a successful mediator, the leading agency should meet the following requirements:

- Foster meaningful partnerships between states, local governments as well as the non-profit and private sectors
- Promote best practices and standards to ensure consistency of data

To keep it up-to-date, a NSDI should be considered as a work in progress, being kept alive by the common interest and broad acceptance of all contributing and participating stakeholders, underlining its character as a national resource supporting sustainable development.

Institutional dimension

By its definition, NSDI seeks to harmonize data sharing and exchange between institutions and to facilitate access to data. This exigency deserves special attention in a developing country context. As Dunn notes, Data sharing may be especially problematic in environments which are not "information - driven" and in which bureaucracy presents particular obstacles. Competitiveness and empire building prevent the free flow of data because common goals are not shared.'(Dunn et al.). So it is often reported that data sharing may be impeded by power motivations within governmental administrations and civil society organizations. Most governmental rules and laws concerning data exchange were enacted before the "digital revolution" took place and they are therefore not yet adapted to today's requirements, being a major source of problems (Heinimann et al.).

The imminent alteration of power relations within governmental agencies through liberalization and opening access to data and information tends to create tensions and unhealthy competition between institutions.

Therefore, it is necessary and important to convince all stakeholders of the benefits of a common NSDI. Beside "democratization" effects, opening access to data and information is observed to have a stimulating impact on the private sector development on the one hand, and eliminates an important source for corruption on the other hand.

Legal dimension

Besides of data availability, data exchange policy and legal issues are of paramount importance for the successful implementation of any NSDI. Ownership, access rights and potential users should be defined before the NSDI becomes operational. There is need to consolidate the issues of a spatial information policy. At this stage it may be necessary to clarify the position of spatial information as a societal good or a national resource, including satellite imagery, cartographic services and the GPS; at least any data that is government funded. Such prospective clarification is especially important if the data and information provides baseline support for development strategies. The focal point of any information policy is the access right which has to be clearly documented and publicly available, since transparency is critical to endorse the policy.

Before establishing and enacting a policy a review of existing data access policies may be helpful. While the strict cost recovery models practiced by most European countries has prohibitive effects on the valorization of expensive and unemployed datasets, the U.S. model which releases state funded data to the public domain triggers a lot of value adding activities. The LANDSAT satellite imagery collection is only one very successful example, providing the global community with medium resolution datasets for free (http://landsat.usgs.gov/). Similar is true for digital elevation datasets such as the SRTM, provided by the NASA and USGS (http://srtm.usgs.gov/).

Technical dimension

As mentioned earlier, the technical setup consists of a network of spatial data providers. Usually multiple servers are being installed in different agencies to support the NSDI. For instance, the Water Department has generated surface water datasets and sets up a server storing all digital hydrologic information. The Agriculture Department will put all the land cover information any satellite imagery on separate servers and so forth. Hence, NSDI provides a single portal allowing users to retrieve and extract the information they need, being stored on multiple servers.

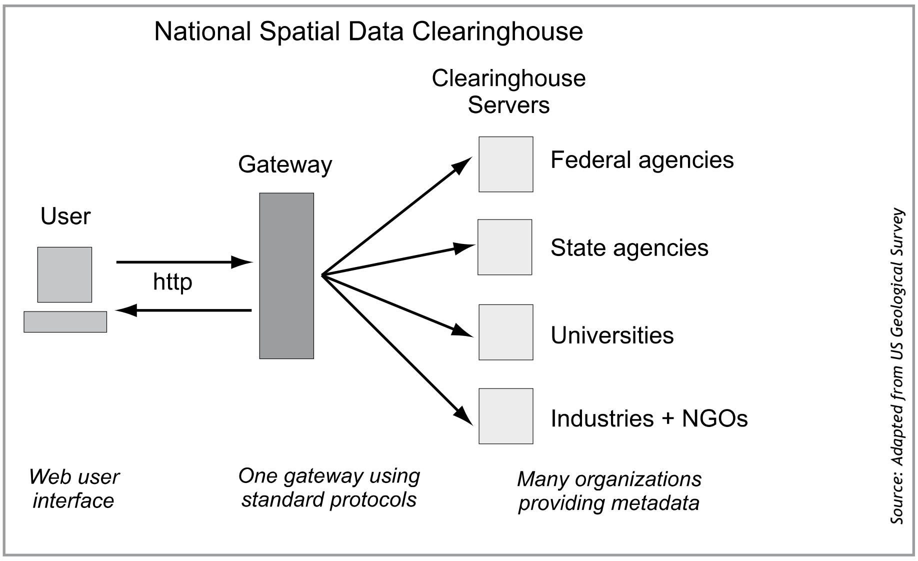

Figure 4.1: *Possible architecture of the metadata clearinghouse.*

Figure 4.1 gives an overview on the possible architecture for the clearinghouse in which the metadata from different agencies are stored and maintained in computer systems possibly widely distributed across the country. Requests from users are carried out through search interfaces communicating requests from users to the dispersed servers and upon receiving results, pass the search results to the user who requested the information.

4.4 The Role of open access data bases and open-source tools

The establishment of a NSDI can happen detached from any considerations concerning public access to the data; nevertheless the concept of a NSDI itself can be perceived as an advocacy for the promotion of an open access strategy. The rationale is simple - the availability of open access databases and datasets in the public domain turned out to be a major boon for the research community and in the meantime also for many NGOs. The release to the public domain of the Shuttle based SRTM digital elevation data enabled many institutions dealing with Natural Resources Management to include a third dimension into their considerations; a novelty, since before that the inclusion of topography often failed due to the prohibitive costs.

The list of positive effects resulting from open access databases is quite long and it is beyond the scope of this article to numerate and specify them; however the interested reader is referred to the featured list at the end of this article.

To fully exploit the potential of a NSDI the users are in need of spatial data processing tools, provided in various manners by software development enterprises. Too often the licensing of software tools in institutions in developing countries is not clarified. The main reasons for this situation are:

- Inadequate funds for uniform software setup
- Poor support for commercial software packages
- Diverging needs within one organisation

The open-source concept provides an appealing approach to overcome the majority of the above made statements. Open-source is a development methodology offering full accessibility to software program’s source code.

Definition of open source licensing models by the “Open Source Initiative”:

1. Free redistribution

The license shall not restrict any party from selling or giving away the software as a component of an aggregate software distribution containing programs from several different sources. The license shall not require a royalty or other fee for such sale.

2. Source code

The program must include source code, and must allow distribution in source code as well as compiled form. Where some form of a product is not distributed with source code, there must be a well-

publicized means of ob-
taining the source code for no more than a reasonable reproduction cost preferably, downloading via the Internet without charge. The source code must be the preferred form in which a programmer would modify the program. Deliberately obfuscated source code is not allowed. Intermediate forms such as the output of a preprocessor or translator are not allowed.

3. Derived works

The license must allow modifications and derived works, and must allow them to be distributed under the same terms as the license of the original software.

4. Integrity of the author‘s source code

The license may restrict source-code from being distributed in modified form only if the license allows the distribution of „patch files“ with the source code for the purpose of modifying the program at build time. The license must explicitly permit distribution of software built from modified source code. The license may require derived works to carry a different name or version number from the original software.

5. No discrimination against persons or groups

The license must not discriminate against any person or group of persons.

6. No discrimination against fields of endeavor

The license must not restrict anyone from making use of the program in a specific field of endeavor. For example, it may not restrict the program from being used in a business, or from being used for genetic research.

7. Distribution of license

The rights attached to the program must apply to all to whom the program is redistributed without the need for execution of an additional license by those parties.

8. License must not be specific to a product

The rights attached to the program must not depend on the program‘s being part of a particular software distribution. If the program is extracted from that distribution and used or distributed within the terms of the program‘s license, all parties to whom the program is redistributed should have the same rights as those that are granted in conjunction with the original software distribution.

9. License must not restrict other software

The license must not place restrictions on other software that is distributed along with the licensed software. For example, the license must not insist that all other programs distributed on the same medium must be open-source software.

10. License must be technology-neutral

No provision of the license may be predicated on any individual technology or style of interface.

Open-source concept - benefits

- Access to source
- Enables development of highly customized applications based on client's needs
- Development priorities are driven by end-user needs
- No Licensing Fees
- Resources are allocated to building applications, not licensing multiple machines
- Interoperability, adoption of Open Specifications
- Active users community - Mailing lists
- Developers listening to users directly
- Issues can be resolved in-house
- Frequent releases, new features and fixes quickly available

Open-source concept - drawbacks

- Limited documentation (sometimes)
- Software is in perpetual development
- Sometimes advanced technical skills needed

Conclusions

- Open Source Software is perfect to act as the glue between multiple proprietary systems
- No interest in locking the user into a single system
- Wide adoption of open specifications and standards
- Complex workflows can be assembled to replace internet-based watershed management application

Compiled sources and links

Digital data sources

Digital map archives:	http://library.stanford.edu/africa/map.html
World gazetteer data:	http://bserv2.rrzn.uni-hannover.de:8080/fuzzyg/query/

African data dissemination service:	http://earlywarning.cr.usgs.gov/adds/index.php
National Geospatial Agency (NGA) provides VMAP (vectors 1: 250k / 1:1mio) data:	http://geoengine.nima.mil
Shuttle Radar Topographic Mission (SRTM) produced Digital Elevation Models (DEM) at 90m almost globally:	www.jpl.nasa.gov/srtm
Global Land Cover Facility (GLCF) from University of Maryland provides free access to an archive of mostly worldwide satellite data (Landsat, MODIS, AVHRR, ASTER) sets:	www.landcover.org

Selected lightweight Desktop GIS applications

OpenJump	www.jump-project.org/
uDIG	http://udig.refractions.net/
MapWindow	www.mapwindow.org/

Full-featured GIS applications

GRASS	http://grass.itc.it/
QGIS	www.qgis.org
gvSIG	www.gvsig.gva.es
SAGA	www.saga-gis.uni-goettingen.de
ILWIS	www.itc.nl/ilwis/default.asp
SPRING	www.dpi.inpe.br/spring/english/

DBMS

PostGIS	www.postgis.org/

WebGIS

UMN MapServer	http://mapserver.gis.umn.edu/
MapBender	www.mapbender.org/Main_Page
Clearinghouse	http://clearinghouse4.fgdc.gov/registry/clearinghouse_sites.html

Further reading and references:

Dunn C.E., Atkins P. J., Townsend J.G. 1997. GIS for development: a contradiction in terms? Area Vol. 29, No. 2, 151-159

Heinimann A., Breu T. and Kohler T., 2003. The Challenge of Applying Geographic Information System to sustainable mountain development. Mountain Research and development No. 23, 312-319

Accessed internet sources:

www.opensource.org/	Open Source
http://gisserver.nic.in/nsdiportal/gos	Initiative Indian NSDI Initiative
http://www.fgdc.gov/	The Federal Geographic Data Committee

5 National Spatial Data Infrastructure (NSDI) in Ethiopia

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5.1 Introduction

Demand for spatial data has dramatically increased in the past three decades. Advancement in IT has facilitated processing, production and application of spatial data. Currently, almost all the socio-economic, political and physico-environmental sectors are users of the spatial data in one or other way.

Major deriving forces for the establishment of NSDI in Ethiopia:

- Duplication of efforts in the spatial data processing and production activities
- Inaccessibility of spatial data
- Disintegrated approaches of stakeholders
- Non-Standardized approaches
- Ethical issues

Organization	***Activities concerning spatial data***
Government organizations	*coordinate, collect, process, produce, distribute and use according to their mandate*
NGOs	*collect, process, produce, distribute and use*
Inteligent organizations	*collect, process, produce, distribute and use*
Research institutions	*collect, process, produce, distribute and use*
Private sectors	*collect, process, produce, distribute and use*
Highly disintegrated approaches	

5.2 Initiatives undertaken by EMA

- Identifying major stakeholders
- Awareness creation of the stakeholders
- Organizing workshops
- Discussion on the Issue

- Facilitating the working environment
- Currently considering NSDI as part of the BPR

Two workshops were organized by EMA concerning NSDI. The first workshop was attended by high level government officials at State Minister or Director General levels. In 2003 a National Steering Committee has been established which is composed of the following government organizations:

- Ministry of Agriculture and Rural Development
- Ministry of Water Resources
- Geological Survey of Ethiopia
- Ethiopian Mapping Agency (Leading Institution.)
- Ethiopian Science and Technology Agency
- National Meteorology Agency
- Environmental Protection Agency
- Ministry of National Defence

During the workshop the following major activities have been performed:

- Discussion on how to work together
- Identification of major problem areas
- Initiating the legislative and policy issues concerning NSDI
- Encouraging EMA for the ground work and facilitating the working environment

5.3 Limitations of NSDI in Ethiopia

- Limitation of fund for capacity building
- Engagement of most of the government institutions on other duties
- Additional work for the staff because they are volunteers
- Absence of full time workers
- Misunderstanding its role by most of the stakeholders
- Undermining its value in national as well as institutional level.
- Assumption as an organization rather than infrastructure
- Looking from personal or very specific point of view
- Assuming as say of the day
- Global dynamism of outlooks: NSDI, GeoIT etc.

5.4 What should be done concerning NSDI in Ethiopia

- Strengthening the already established Ethiopian NSDI through capacity building
- More awareness creation among the stakeholders
- Developing interest on integrated and mutual benefit approach.
- More attention and much effort on geoinformation science and its ethics.

5.5 Unless measures are taken on strengthening of the existing NSDI

- More disintegration among the stakeholders
- Many NSDIs in one country
- Negative effect on spatial data quality, and accessibility
- Socio-economic information crisis
- Negative effect on the national economy

6 Data Management, Data Dissemination and GIS Activities at the Central Statistical Agency

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6.1 Introduction

A top priority for CSA is to aggressively deal with improving its data collection, management and dissemination system by making effective use of ICT. Since July 2004, CSA has started working towards this goal and established a new unit called the ICT Department.

- The development of a central data bank,
- The establishment of socio-economic database, and
- The deployment of a user friendly archiving and dissemination system.

To ensure that the system is compatible with universally accepted standards, CSA adopted the Data Documentation Initiative (DDI) as a core component for study-level metadata. This DDI based data archiving and dissemination framework is used for all surveys and censuses conducted by the agency. The IT framework is designed considering international metadata recommendations and best practices in data archiving to facilitate data dissemination and metadata exchange at the global level.

The capacity of the agency has to be strengthened by making effective use of the existing ICT in order to provide high-quality information to its users in a friendly format. This implies proper utilisation of ICT such as:

- Internet
- Databases
- GIS and
- Electronic methods of data archiving and dissemination

Provision of data also involves:

- Harmonising and integrating statistical data
- Filling the gap between data produced and data available
- Laying down efficient ICT infrastructure
- Improving the quality and comparability of data
- Solving the challenges emerging from data and metadata exchange and
- Harmonising the different standards available in data-management systems

6.2 The Central Data Bank Project

The Central Data Bank Project is engaged in modernising statistical production and dissemination by harnessing new ICT tools

In general, improvement of the CSA's internal ICT capacity covers the following:

- Development of an integrated Central Data Bank of survey and other data as well as creation of an Ethiopian Socio-Economic Database for basic indicators
- Development of database management systems
- Strengthening the Local Area Network (LAN) and
- Development of a Wide Area Network (WAN) to connect Branch offices
- Web Site Development
- CD_ROM publishing
- Comprehensive Program of Documentation of existing and new data, especially related to socio-economic indicators
- Utilisation of GIS for Geo referencing, spatial data analysis and other referencing of new and existing data
- Appropriate training and capacity building

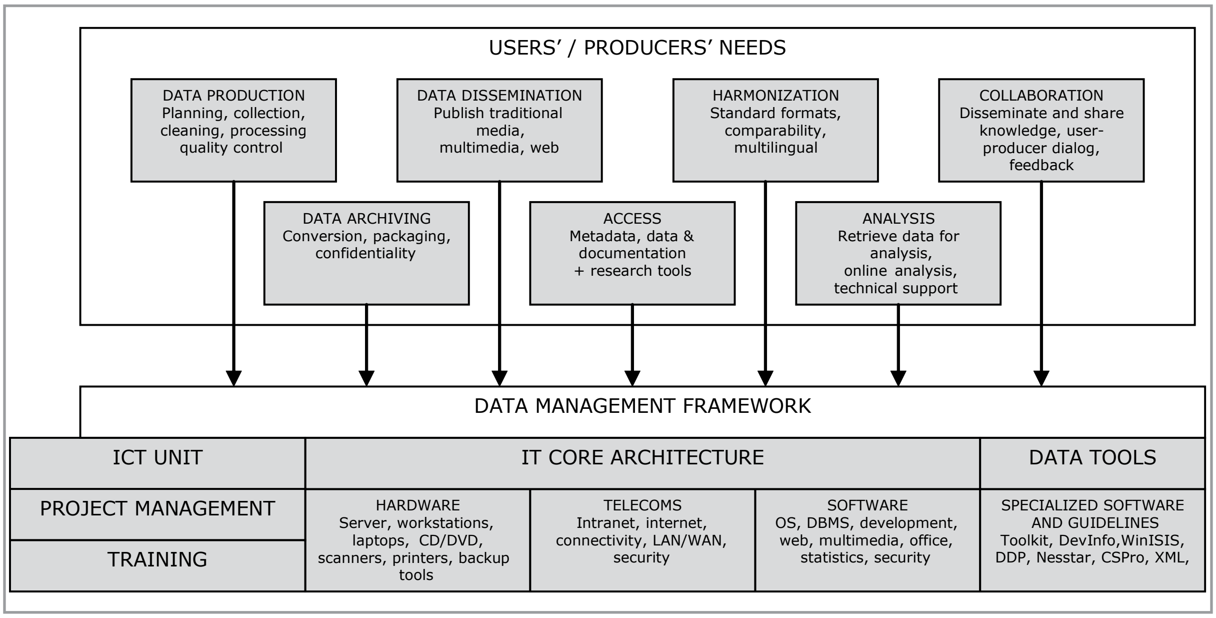

Figure 6.1: *Framework of the Central Databank Project*

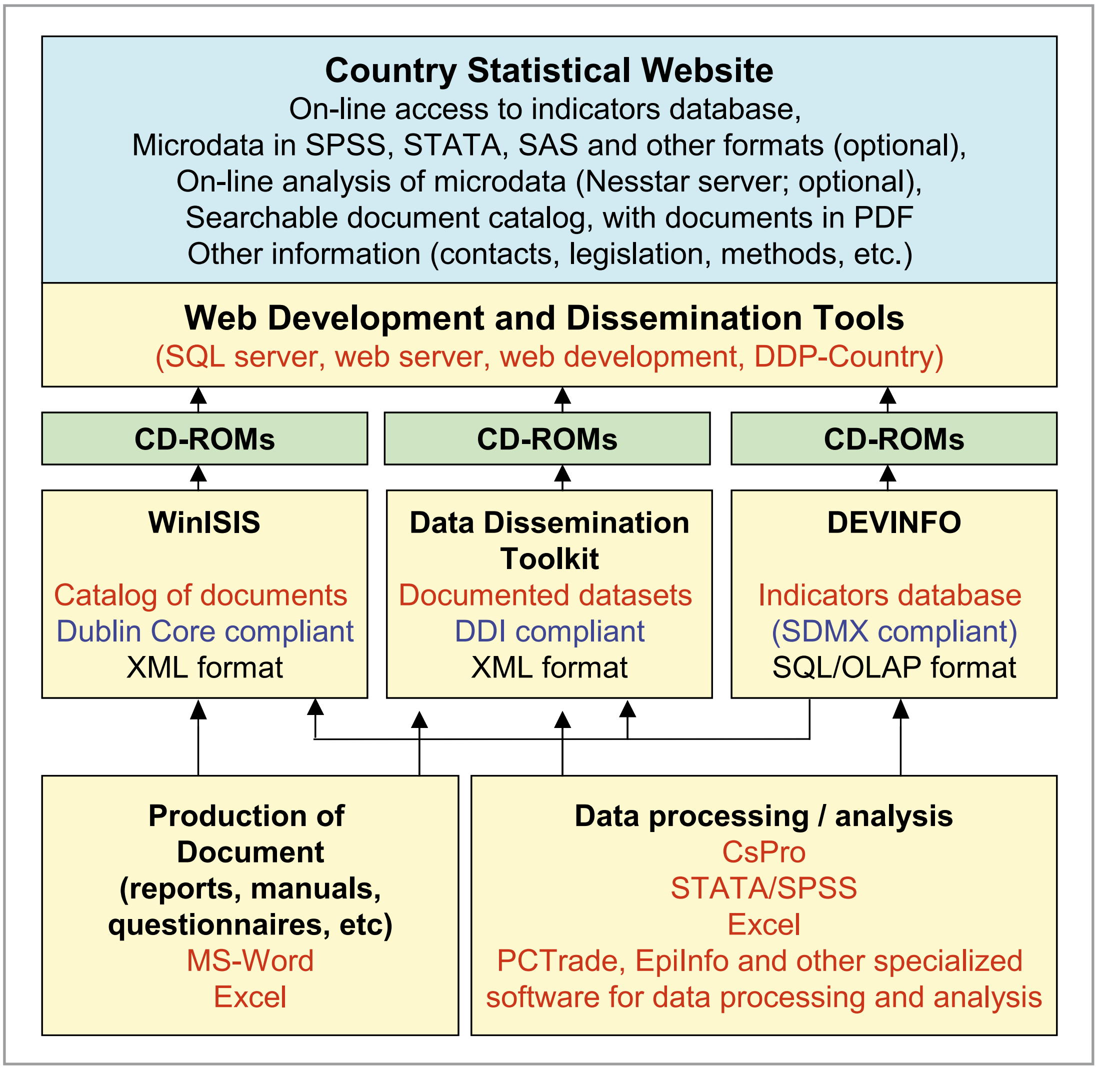

Figure 6.2: *Country Statistical Website*

Status of the Project

- CSA staff have been trained in project management techniques, archiving and dissemination of microdata, advanced used of CSPro software, XML technologies, and basic scripting techniques
- A Central Databank has been established for the microdata and now contains over 5000 data and documentation files covering about 70 surveys
- More than 45 surveys archived with the IHSN Microdata Management Toolkit à Metadata available in DDI-XML and Dublin Core formats
- CD-ROM products available for these surveys and metadata and documents published on the web server for selected surveys
- An official domain name (csa.gov.et) has been registered for CSA and the web site has been launched

- The EthioInfo v1.1 database was released in 2006 and is available on CD-ROM
- The Web-enabled and the second version of Ethioinfo, containing indicators on MDGs and PRSP, was released on 20 November, 2007
- CSA has an official presence on the Internet (www.csa.gov.et)
- Different spatial data analyses were made and various maps have been produced using the 2004 Welfare Monitoring Survey

The digitisation work for most parts of the country at wereda level has been completed.

- Editing and creating regional geospatial data for Tigray, Benshangul-Gumuz, Harari, Dire Dawa, and Oromia has been completed.
- We expect the whole spatial data creation to be completed at the end of February

The national census, except pastoral areas, has been completed successfully. All the field questionnaires have been returned to the headquarters safely and have been reorganised for scanning. Staff members have been trained in the scanning process, both on hardware and software. All the necessary network environments, with all required servers, back-up devices and installation of a generator have been established.

The data capturing system has been set as

- PS900 Photoscribe OMR / Image Scanner
- Up to 8,000 double-sided forms per hour
- Simultaneous data validation
- Bitonal & /or greyscale images & clips (200dpi)
- 3 programmable output hoppers
- SOSKitW software utilities

6.3 Integration of GIS and census findings

By integrating the findings from the census, the GIS team at CSA aims to provide spatially analysed output on:

- Sanitation
- The socio-economic situation, i.e. education, health, etc

In addition, the team will investigate different social and economic aspects of communities, such as access to schools, hospitals, water supply, sanitation, employment, income, etc. The result of the analysis will be presented in the form of maps (atlas) such as the Rural Economy Atlas of Ethiopia. Using a combination of GIS and statistical techniques, we will be able to highlight and propose areas that need further or improved services in light of the number of people likely to be served by these facilities.

6.4 The Satellite Imagery Project

Data from satellites have been acquired for demarcation of EAs in the Somale Region. These spatial data will be used further for development plans. The Project involves:

- 5m SPOT Panchromatic Satellite Imagery (10m SPOT where 5m SPOT is not available), pan sharpened with LansSat7 ETM+ (7 bands)
- 60 cm QuickBird for highly populated areas (1m IKONOS where QuickBird is not available)
- Image processing: Enhancement, Mosaicing and Orthorectification
- Establishment of GIS infrastructure - manage and maintain database system
- Capacity building
- Hardware & software with a well-equipped GIS lab has been established.

6.5 The ICT Department at CSA

The ICT Department at CSA is well organised, as shown in Figure 6.3.

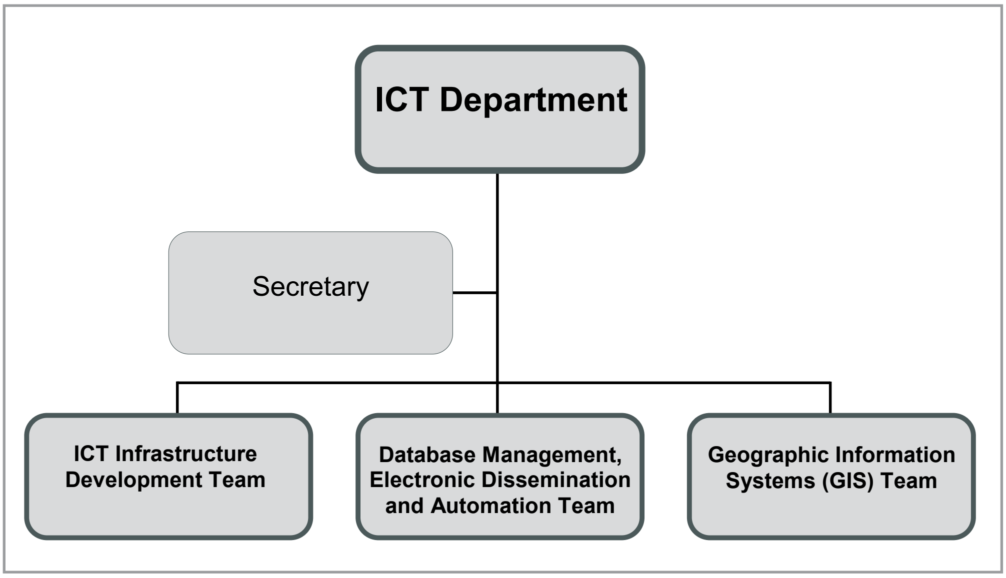

Figure 6.3: *Organisational structure of the ICT Department at CSA*

In general, for efficient utilisation of the geospatial data available at the CSA, a great deal of work has to be done

- Human capacity building:
- Introductory courses on GIS
- A set of short- and long-term training sessions

7 Update of the Ethiopian Road Network

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7.1 Introduction

Road infrastructure plays a vital role in a country's development. Inventory, monitoring and management of road networks are essential for an organisation like ERA to perform its duties and carry out its responsibilities. The ERA is interested and motivated to make use of modern GIS techniques to enable efficient management of existing roads and expansion of new ones.

A road network map was prepared by the Ethiopian Mapping Authority (EMA) in 1984; however, there has been a lot of road construction, which makes the data out-of-date. The EthioGIS group also produced a digital road network map in 1999. Since then much effort has been made by regional road authorities to use GIS to survey their road network and make use of GIS as a planning and monitoring tool. Some of these regions are Southern Nation nationalities and peoples: Amhara, Oromiya and Tigray. Some effort has also been made by FinnRoad of Finland to use handheld GPS to survey road networks in the Somlia, Benshangul Gumz and Gambella regions. These data are stored in AutoCad, Map source, and Word files. Different consultants have done road design and design review studies at different times, hired by the ERA and regional RRAs. The data were collected using GPS/Total stations and stored as Cad drawings.

Roads are dynamic and need to be updated because of the following changes:

- Road pavement changes from time to time – earth to gravel or gravel to asphalt of different standards
- Road conditions change due to traffic and other factors
- Bridges and culverts are damaged from time to time
- Ditches are silted and blocked
- Road alignment is improved and modified

7.2 Main objectives

- To update the existing road network map of the EMA using all the available data at hand and prepare a digital copy using GIS techniques
- To store additional road network attributes such as
  - Road name, road class, road surface, etc.
  - Road width, pavement condition, sub-grade material, etc
  - Geometric nature of roads, such as horizontal and vertical curve information

  - Location of structures such as bridges, culverts, etc.
  - Drainage facilities and conditions
  - Location of construction materials
  - Road facilities such as traffic signposts and guide posts
- To prepare web maps of the road network for users and the public
- To make the system ready for road network analysis and easy future updates
- To improve the capacity of the ERA in GIS and its applications

7.3 Methodology

- A hierarchy of data users such as data owner, data editors, and data viewers
- Systematic road identifiers and naming by segmenting roads as links and sections
- Capture of GPS road tracks and their attributes
- Easy sharing of data which are stored as a spatial database
- Linking spatial data with an attribute database using identifiers so that maps are automatically updated by only updating the database
- Automatic update of maps on the web by updating the database
- Linking of the GIS/Spatial Database with a PMMS module
- ArcGIS/ArcView and ArcGIS/ArcInfo 9.1 software with floating licenses were used
- SQL server 2000 for database management was used
- ArcSDE 9.1 as data access engine for multiple users were used
- ArcIMS 9.1 was used for web map solutions

7.4 Steps

- Gathering all road network data such as regional road network studies, design drawings, maps, GPS survey data, total station survey data, etc
- Gathering other relevant topographic data such as contours, rivers, lakes – mostly from EthioGIS.
- Fix and design standards for road attributes, map units, scales, etc.
- Design and develop a system to manage and share GIS data through intranet and internet
- Designing and developing a suitable database that fits the intended purpose
- Collecting, verifying and populating all the available data through

scanning, digitising, and other GIS techniques

- Routes and dynamic segmentation tools for both point and line attributes
- Storing most attributes (non-spatial data) on the SQL server and lin-
king them with the road data using unique road identifier
- Analysis tools such as origin – destination tools to check connectivity and network deficiency, and accessibility tools such as surface area/travel time and distance coverage from a certain node (towns or other important location); route identifier tools

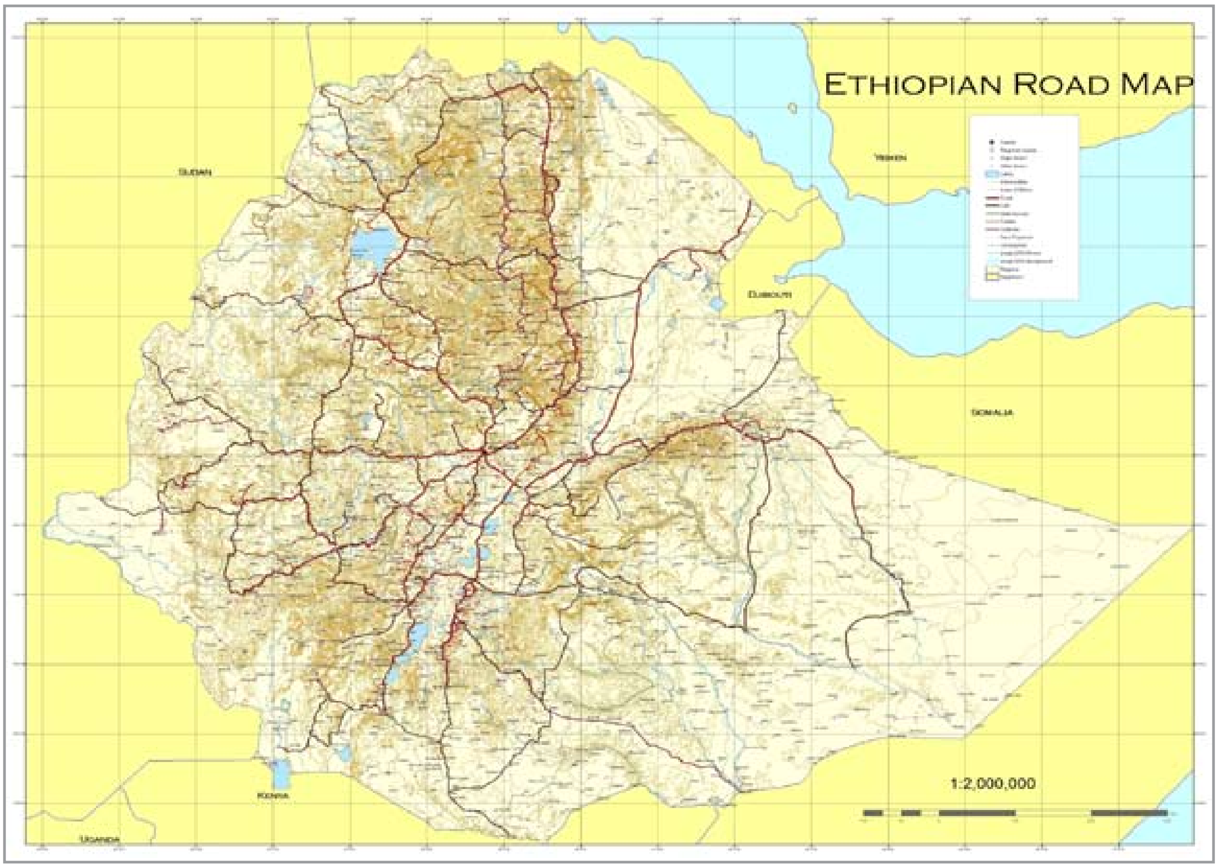

Figure 7.1: *Road Network Map by Functional Classification*

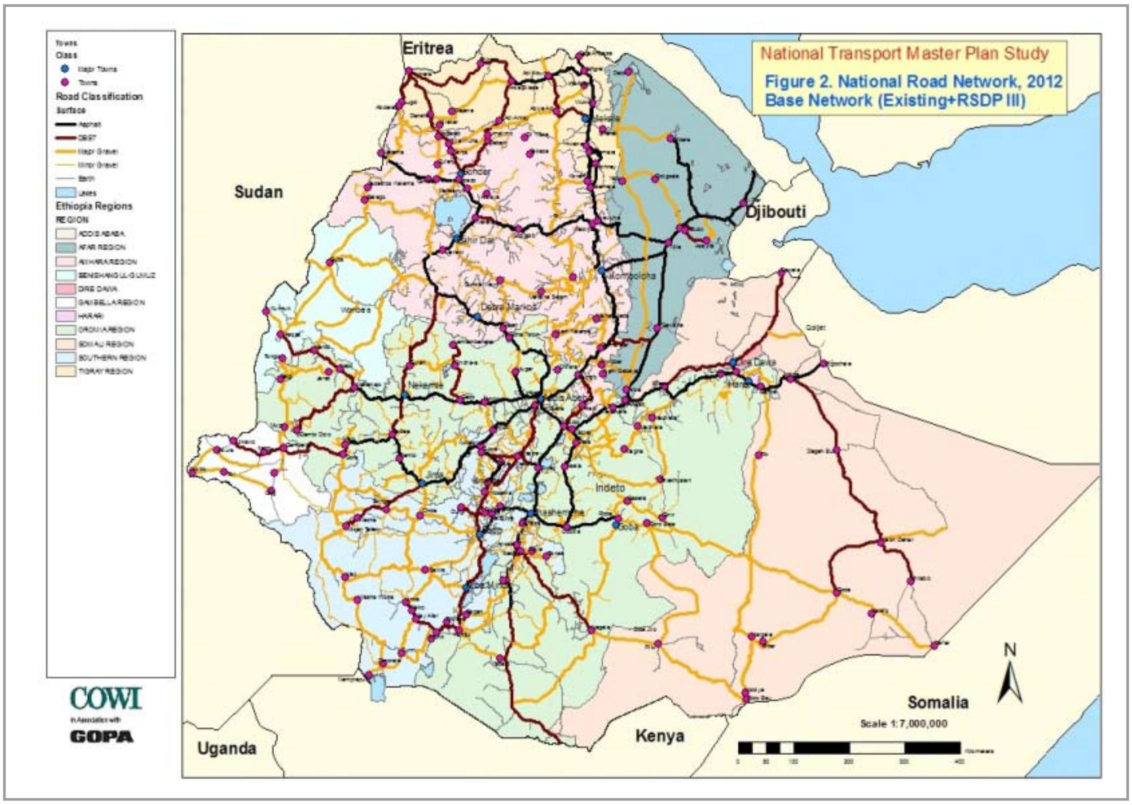

Figure 7.2: *National Road Network, 2012. Base Network (Existing+RSDP III). National Transport MPS*

Figure 7.3: *Road Network Map by Surface Type*

8 Spatial Knowledge Support System for Harnessing Rural Urban Linkage

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8.1 Introduction

Knowledge is the most determinant power for economic development in this era of globalisation (Derek et al, 2005). Even though the initiation of knowledge management in the developing economies is at a very early stage, knowledge has been created, accumulated, shared and used at various levels in social and economic structures.

Ensuring the proper flow and use of information and knowledge at various levels of the economy and the way they are fed into policy processes requires effectively operational knowledge systems. These systems, in turn, require skilled knowledge workers and reliable information technology infrastructures and tools that enable fast communication, easy access and sharing of information and knowledge. Therefore, the smooth operation of these systems at various sectors improves economic performance and enables rapid decision-making. On the contrary, imbalance in the realisation of knowledge systems at various levels of the economy may result in poor communication, disrupted flow and impaired access to information and knowledge. A knowledge support system comprises data, tools, and knowledge, which are compiled, analysed, and disseminated for the purposes of identifying a set of priority investment and policy options to promote agricultural growth and rural development" (Johnson et al. 2004).

Geographic Information Science has advanced greatly in areas where its uses and applications are not limited to geographers or IT professionals; all man-made and natural processes and functions that have a geographic distribution are dealt with through GIS. Modern data generation techniques are now being used to integrate the spatial dimensions of such phenomena. Particularly, remote sensing techniques have become very helpful in identifying and locating man-made and natural phenomena. Spatial data representation techniques have also advanced from mere digital representation of geographic features to a geodatabase, where the behaviour of a spatial feature is integrated through definition of relationships, networks and connectivity. With the raster environment neighbourhood, overlaying and reclassification become very useful for understanding spatial phenomenon. However, in the developing world, spatial data and information are seldom used for creation of knowledge that is critical for decision-making; use of such data is limited by comparison with its potential. Infrastructures and tools need to be developed for fast communication, easy access and sharing of information and knowledge.

Rural and Urban Linkages (RUL) under different environmental and socio-economic conditions become acute and need to be harnessed for balanced and hence sustainable economic development. Land degradation in rural and upper-stream areas is causing several environmental problems in urban and downstream areas. Agricultural and forestry products and labour are also being supplied from rural areas. The urban areas are markets and sources of commodities and technology for rural areas.

This paper attempts to portray how knowledge is generated spatially from spatial data and information to make better decision-making. It examines how spatial data are organised and processed for use by non-GIS users for efficient decision-making. Spatial data that have been generated and processed need to be utilised by a wider community to have an impact in society. We also consider packaging of information and customisation of essential available functionalities to enable non-GIS professionals to undertake spatial data navigation, characterization and classification in essential decision-making units with low levels of training.

8.2 Data, information and knowledge

Data, information and knowledge are sometimes used interchangeably in confusing ways, without distinction in the ways they are addressed. The confusion between information and knowledge is even more pronounced than confusion between data and information.

To make the distinction among these terms, the following definitions are adopted from Bouthillier and Shearer (2002):

- Data is an unorganised and unprocessed collection of facts from which conclusions may be drawn. E.g. “1500 m”
- Information can be considered as an aggregation of data (processed data) that makes decision-making easier. Information is usually labelled as data made meaningful by being put into a context. E.g. “Lowland areas below 1500 meters elevation are moisture deficient”
- Knowledge is the combination of information and context in a way that makes it actionable. E.g. “Rain-fed agriculture is not possible in possible in dryland areas without irrigation”.

Knowledge differs from information in that knowledge is predictive and can be used to guide action, while information is merely data in context. However, there is no hard and fast rule in the way these terms are communicated contextually - they are context-sensitive. For instance, information generated at a certain point in time can be considered as an input data to generate new information, and similarly knowledge can be considered as information in the context of use. This type of contextual attribution shouldn’t be confused with the meanings of data, information and knowledge. The following schematic drawing shows contextual attribution and how transformations are made between data and information, and information and knowledge.

8.3 Spatial data availability, maintenance and sharing in Ethiopia

In Ethiopia, spatial data have recently become available in different governmental and non-governmental organisations. However, there are several problems regarding quality, maintenance and sharing of data. The following are among the major issues that need attention.

Spatial data availability

Spatial data are stored in printed hard copies and digitally in their geographic space. There are still essential spatial data sets that are not converted from hard copy to a digital format. The following are the most essential sets of spatial data for harnessing RUL in Ethiopia:

- Administrative boundaries
  (kebele, wereda, zone, region)
- Agricultural production (area and production)
- Climate
  (rainfall, temperature, length of growing period)
- Disease and pests
  (malaria and tsetse)
- Land use/ land cover
- Hydrology
  (drainage and lakes)
- Topography
- Soils
- Geology
- Population
- Infrastructure
  (roads, telecommunication, electricity and education)

Spatial data maintenance problems

- Missing or incomplete documentation
- Poorly organised data, information and knowledge resources
- Outdated data, information and knowledge

Information and knowledge sharing problems

Some of the problems associated with information and knowledge sharing within the institutions and the county in general include the following:

- Duplication of efforts

- Data and information access policy
- Organisational and cultural problems
- Poor computer networking
- Few spatial datasets in CD-ROMS and DVD-ROMS

The ArcGIS system for a spatial knowledge support system

system is divided into the following components (ESRI, 2005):

- ArcGIS Desktop, which includes ArcView, ArcEditor and ArcInfo.
- ArcGIS Engine: embedded GIS, which is purely for developers creating custom solutions in VB, VB.Net, C++ or Java.
- ServerGIS, which has ArcIMS for serving on the Internet, and ArcGIS Server for building and maintaining a centrally-managed geographic Information System.
- Mobile GIS with ArcPad, for going into the field to do data capture and analysis
- ArcSDE handles data access and data administration in the geodatabase

ArcObjects

ArcObjects are C++ software components that ESRI's developers create and build for use in products, such as ArcView and ArcGIS Server. ArcObjects are also available for you - the developer - to use to build your own application or to customise ESRI applications. Options for developers with ArcObject include:

- Customise and extend ArcGIS Desktop applications, such as ArcMap and ArcCatalog
- Build and deploy custom GIS applications
- Create GIS web applications and services
- Build your own ArcObjects to work with any of the ArcGIS products

ArcGIS desktop applications

ArcGIS Desktop applications, such as ArcMap and ArcCatalog, include Microsoft's VBA, which integrates a customisation environment when working inside ArcGIS Desktop. User interface can be customised, without writing any code, by dragging and dropping the different commands, menus, and toolbars. Or write simple VBA macros with the VBA Editor. Through VBA you can leverage the application framework that exists in ArcGIS Desktop for a wide range of different tasks, such as data management or map presentation, and also extend the application with custom dialogues, or specialised forms, commands, or tools to help your users get the job done.

More Advanced ArcGIS Desktop Developer's Options:

- Build custom objects with VB.NET or VB6
- Unlimited customisation
  - New tools, toolbars, menus, dialogues, custom layers, etc.
  - Extensions to add new functionality

ArcGIS engine for developers

ArcGIS Engine for Developers is a core set of ArcObjects that developers can use to build custom applications using VB, VB.Net, Java and C++. ArcGIS Engine consists of two products, i.e. ArcGIS Develoopers Kit and ArcGIS Runtime.

ArcGIS Developer Kit provides help resources and tools necessary to build ArcGIS applications:

- ArcObjects Help System
- Developer documentation
- Productivity tools
- Object model diagrams
- Sample code

8.5 Schema of a spatial knowledge support system for development planning in Ethiopia

A spatial knowledge support system could be just a map viewer or a customised analysis tool. The map viewer helps to visualize spatial data in pre-defined decision classes, while the tools enable analysis of spatial data and produce outputs in a map or report format. The map viewer is essential, as it requires less skill for non-GIS professionals to make use of it, while the developers should carefully organise essential datasets and tools for effective use of spatial data. A schematic spatial knowledge support system is presented in Figure 8.1 (p.50) It has a list of data sets and variables, which could be previewed as a map or table. The map features could be classified into convenient decision-making units. A short description of the data is also included at the bottom.

Processed data could also be packaged with inclusion of essential GIS tools for query and classification of geographic features. Figure 8.2 (p.52) shows how long it takes to travel from any place to the nearest hospital in Ethiopia. After such cost-distance spatial analysis has been made by a GIS professional, it

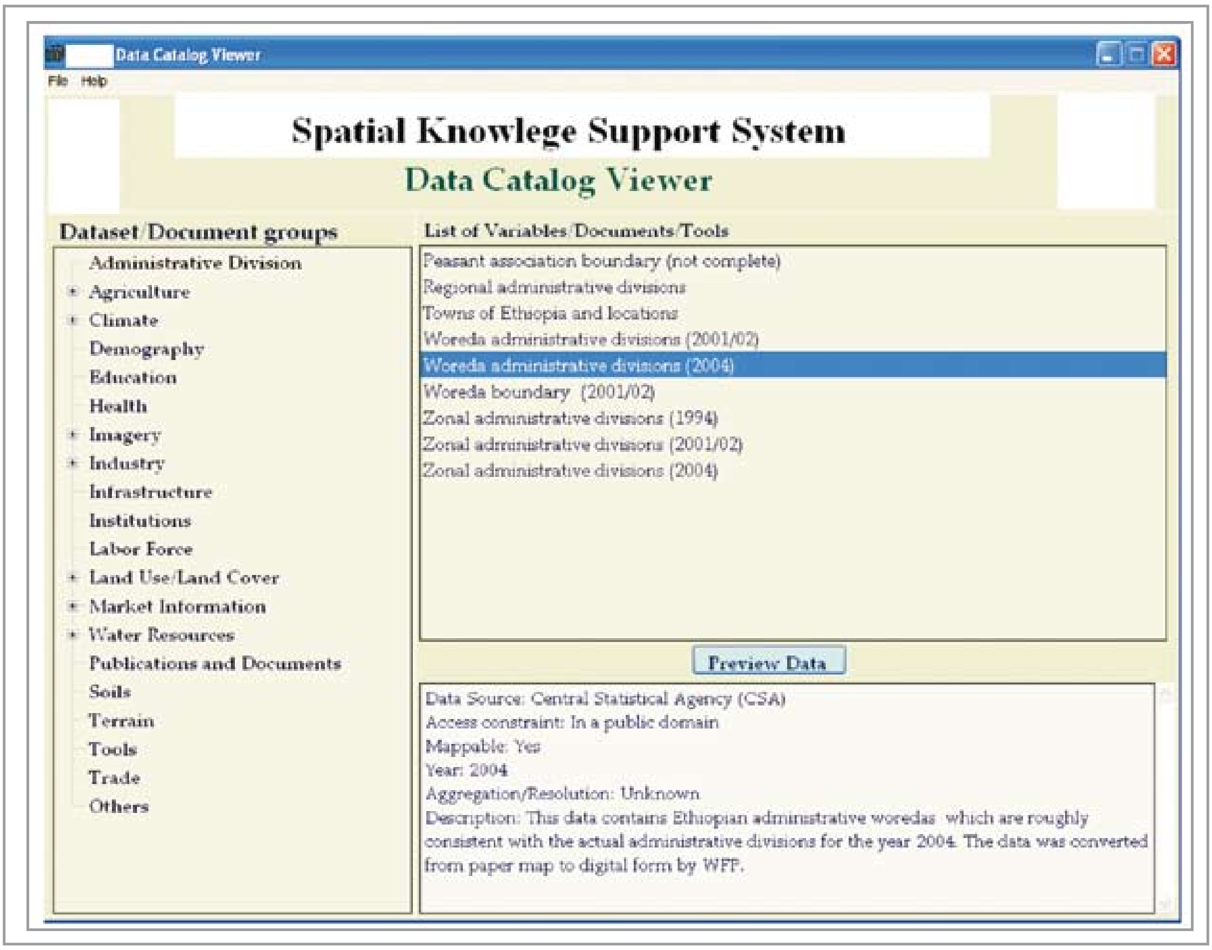

Figure 8.1: *Schematic overview of a spatial knowledge support system*

could be customised for non-GIS users to identify accessibility at any location and characterise accessibility to hospitals from any destination.

8.6 Conclusions

- Rural-Urban Linkages have become acute and need to be harnessed
- A spatial knowledge support system is essential to facilitate effective use of spatial data by GIS and non-GIS professionals
- ArcGIS Desktop developers' kit and ArcGIS Engine enable unlimited customisation of tools, toolbars, menus and dialogs boxes.

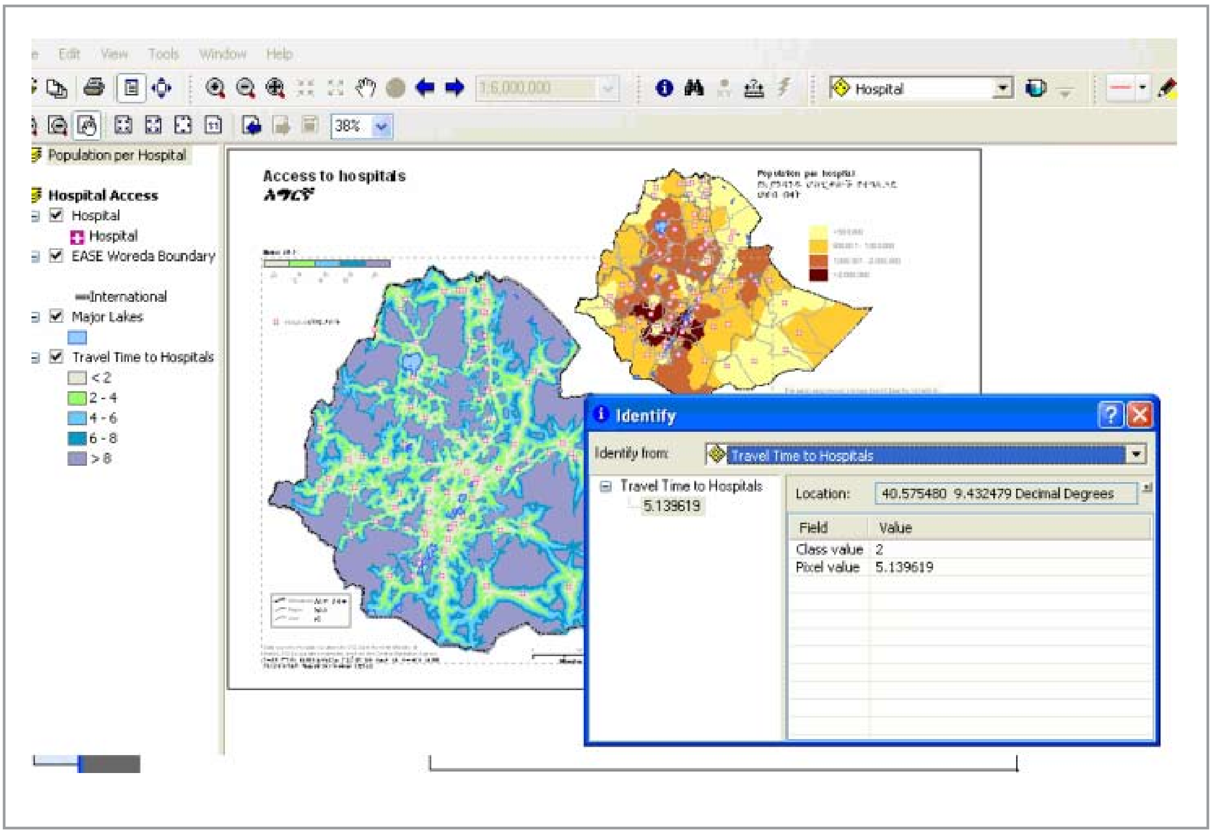

Figure 8.2: *Querying accessibility to a hospital for the non-GIS user*

8.7 Reference

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9 Information Portal in UN-ECA

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9.1 Introduction

Use of appropriate information in decision-making improves the quality of the decision-making and reduces the need for other inputs: money, time, labour, etc. Information use should be made explicit, quantified and 'commoditised'. Information can be copied and disseminated without loss. For re-use of data and information products, cooperative, multi-stakeholder approaches need to be adopted in the production, management, and dissemination of data. There should also be appropriate policies, standards and institutional arrangements.

Before the information age, mapping was done "just in-case" people needed it. Only pre-determined common themes were mapped with estimated periodic demands. Little attention was given to intermediate information products, dissemination and 'non-standard' uses. Stockpiles of maps were prepared at predetermined scales "Just-In-Case" people needed them. Accordingly, recent changes, developments and conditions were not represented.

In the Information Age mapping is 'Just-in-Time'. Geography meets technology with digital mapping. Data are stored in databases. Digital processes make production easy and fast. Multiple layers can be integrated digitally in complex analysis. Maps are produced as and when needed, just in time for the decision to be made.

9.2 ECA response to the Information Age

- Arrange the widest possible dissemination of available information
  - Unlock the hidden potential in the data
- Shift from mapping as a stand alone activity to mapping as a component of information management
  - Move beyond single agency needs to community needs
  - Provide an enabling environment, basic framework and thematic components for "JIT" maps
  - Empower users to do as much as possible by themselves
- Put in place policies, resources and structures:
  - Make information available to decision-makers and the community when they need it, where they need it, in a form they can use (almost) immediately
- Policies and coordination
  - Assign custodianship responsibilities as appropriate
- Data (Re-engineering)
  - Fundamental, core datasets, thematic data

- Capacity building and retention
  - Critical mass of awareness of GIS (Producers & Users)
- Standards and interoperability
  - Common geodetic framework
  - Metadata Standard (e.g. ISO 19115)
  - Common base themes
- e-Services (find and share data)
  - “Just-in-time” attitude to “maps”

9.3 An ECA information portal distributed data and services

- Exploit the vast opportunities provided by the Web
- Make it easy and rapid to search, retrieve, access & exploit geospatial information from multiple locations on the Internet (Including “maps”)
- Enable standards and interoperable web-based exploitation of Geodata and sharing of processing service
- Develop value-add products and services
- Building core data sets
- Different line specialists still need purpose-specific data layers, but they need to depend on the same fundamental or base layer or core data sets (Table 1)

Table 9.1: *Core data sets developed by ECA information portal*

Raw Data	– Satellite Images – Location coordinates – Facilities – Socio-economic
Processed Data	– Land cover – Soil aptitude
Analysed Data	– Dynamics and seasonality – Trends

9.4 Building metadata

To use data produced by another person/agency, potential users need to know:

- That the data resource exists
- How the data were produced

- When data were produced or last updated
- Why data were produced
- How to access the data

UN-ECA has developed a Metadata Explorer for Ethiopia.

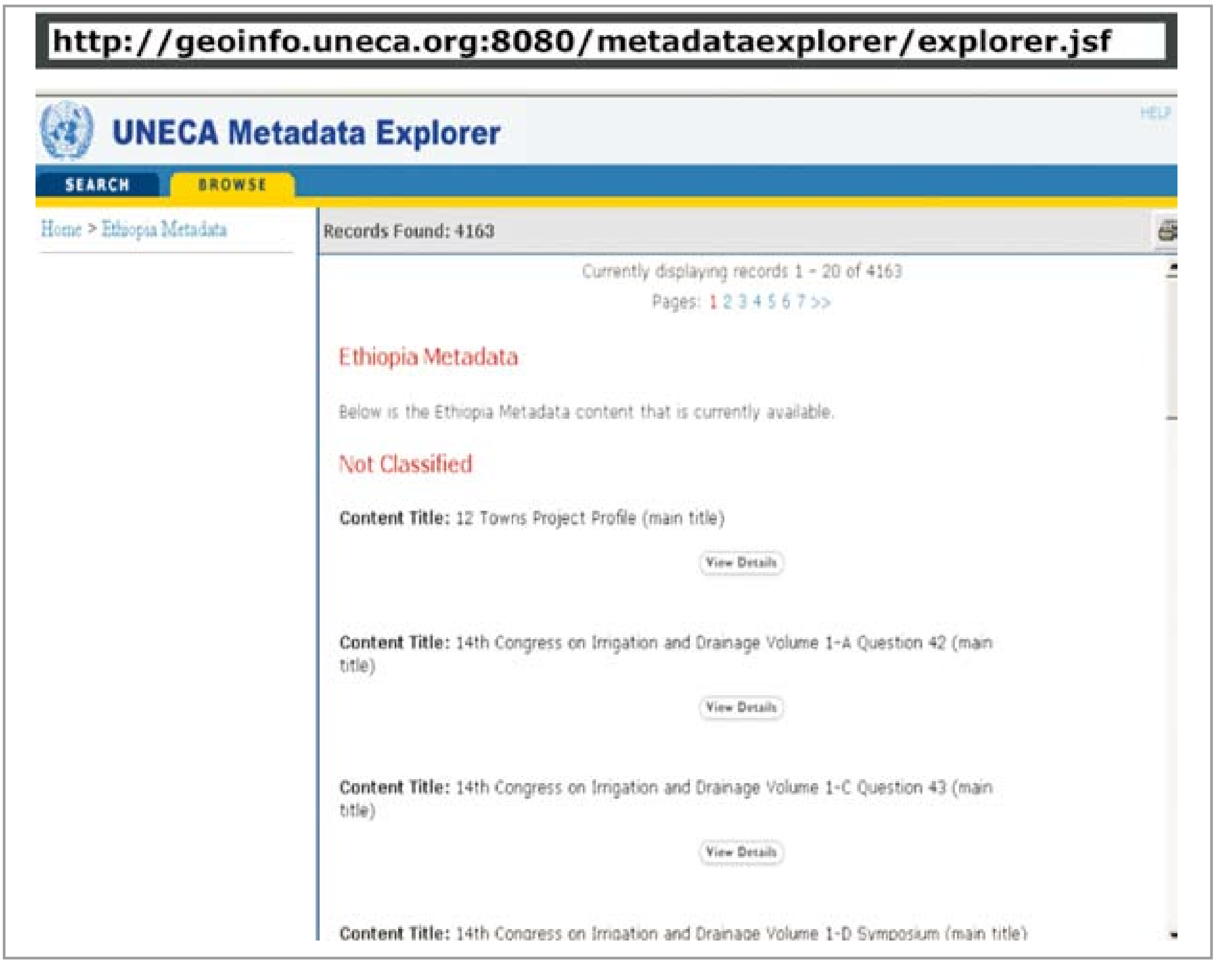

Figure9.1: *UNECA Metadata Explorer on the web.*

9.5 Building clearinghouse services

The metadata collections are best maintained by the producers of the data as an integral part of the data production process, but they should be accessible to potential users. Hence, there should be on-line metadata clearinghouse services to

- Search and discover what exists, and where and how to access it
- Publish and advertise what you have and do
- Undertake field-level, location and other criteria-based searches

9.6 Building interoperability and standards

- Requires that data sets and services be interoperable
- Only if all producers adhere to agreed standards
  - Metadata standards, data models, encoding, presentation, transfer, naming conventions, etc
- African Profile of ISO 19115 metadata standards

9.7 Online Mapping

- Data integration
- Dynamic theme selection
- Decentralised mapping
- No need for full GIS by all users
  - May require a viewer that is free

9.8 On-line tools for analysis

Building new map themes

- Previously unthinkable map themes are now common on demand:
  - Visualising MDG Progress
  - Including raw data, derived data, summary statistics, charts, dynamic maps

9.9 UNECA's resources

- ArcGIS 9.x Server
- Webserver with ArcIMS
- Database server with ArcSDE and SQL Server 2000
- GIS portal toolkit license
- In-house skills to implement, maintain and manipulate the system

9.10 ECA's current services

- Assist member states to develop metadata systems and clearinghouse services
  - Point of reference for member states
  - Training and capacity building

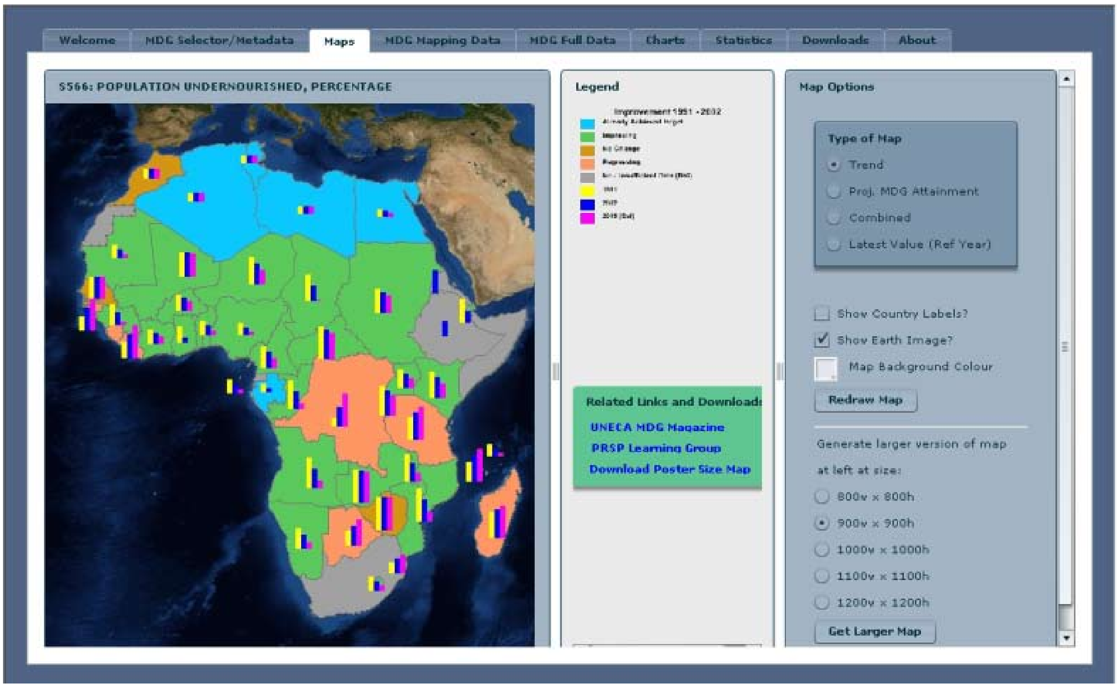

Figure 9.2: *Geoinfo: an online mapping portal of UNECA*

- Provide "country spaces" for interim hosting of meta databases
  - Ethiopia Node, AWICH Node, RCMRD Node, RECTAS Node, etc.
- Awareness workshops
- Other advisory services on request
  - e.g. Central African Transport Infrastructure GIS, Gazetteer prototype for Ethiopian Mapping Authority

9.11 UNECA's ongoing activities

- Point of reference for member states on how to implement data sharing in NSDI
- Assist member states in the implementation of NSDI (technical / policy component) and link with NICI
- Involve more partners who are willing to share their datasets
  - Link to cooperating map services
  - Assist in configuring map services to be accessible through the portal
  - Interim hosting of map services if required

9.12 Major problems in Africa

- SDI Implementation
  - Lack of policies
  - Getting government to implement policy guidelines
  - Lack of clarity on roles and responsibilities at national, provincial and local levels of government spheres
  - Very limited funding is allocated to SDI
- Mapping
  - Lack of facilities
  - Obsolete equipment
  - Weak Internet connection
- Capacity building
  - Staff in place consist of technicians and/or graduates without skill in GIS web portal
- Data sharing
  - Incompatibility of data format amongst institutions
  - Major data still in analogue format

9.13 Challenges

- Shift of paradigm
  - From mapping as a standalone activity
  - To mapping as a data collection activity
  - At the beginning of the knowledge management continuum
- Organise data so that maps can be produced as and when needed
  - Just in time maps on demand
- Move beyond single agency needs to community needs
- “Decentralise” mapping
- Provide basic framework and thematic components for “JIT” maps
- Empower users to do as much as possible by themselves

9.14 The vision

- Knowledge generation, sharing and dissemination
  - Ensure that spatial data permeate every aspect of society and that they are available to people who need them, when they need them, and in a form that they can use to make decisions with minimal pre-processing
  - Ensure that generated information is put to the greatest use possible by publicising its existence and making it easily available to the widest possible audience

10 Digital Geological Spatial Dataset for NSDI in Ethiopia

Teshome Kumbi, Geological Survey of Ethiopia e-mail survey@ethionet.et

10.1 Introduction

The Geological Survey of Ethiopia was established as a Department within the Ministry of Mines and Energy (MME) in 1968. It became an autonomous government organisation accountable to the Ministry in 1982. The Geological Survey of Ethiopia (GSE) was re-organised in 2000.

The main objectives of the GSE are:

- Geological and hydrogeological mapping at 1:250,000
- Prospecting and mineral exploration at reconnaissance level
- Delineate and estimate deposits and groundwater as required
- Collect, classify, store, display, publish and disseminate user-oriented earth science information
- Provide geo-technical consultancy services
- Accelerate the economic growth of the country by means of mineral-based resources

10.2 Outputs of GSE

- Geological and hydrogeological map of Ethiopia at a scale of 1:250,000 (40% coverage)
- Geological map of Adola area at a scale of 1:100,000
- Hydrogeological map of Ethiopia 1:2,000,000
- Geological and mineral occurrence maps of Ethiopia at scales of 1:4,000,000 and 1: 2,000,000
- Geological map of Ethiopia at a scale of 1: 2,000,000
- Geological map of Omo River basin at a scale of 1:100,000
- Geological map of Ogaden at a scale of 1: 1,000,000
- Geological map of Southern Afar at a scale of 1: 500,000
- Geological map of Debre Zeyt at a scale of 1:50,000
- Geological map of Nazret Dera at a scale of 1:50,000

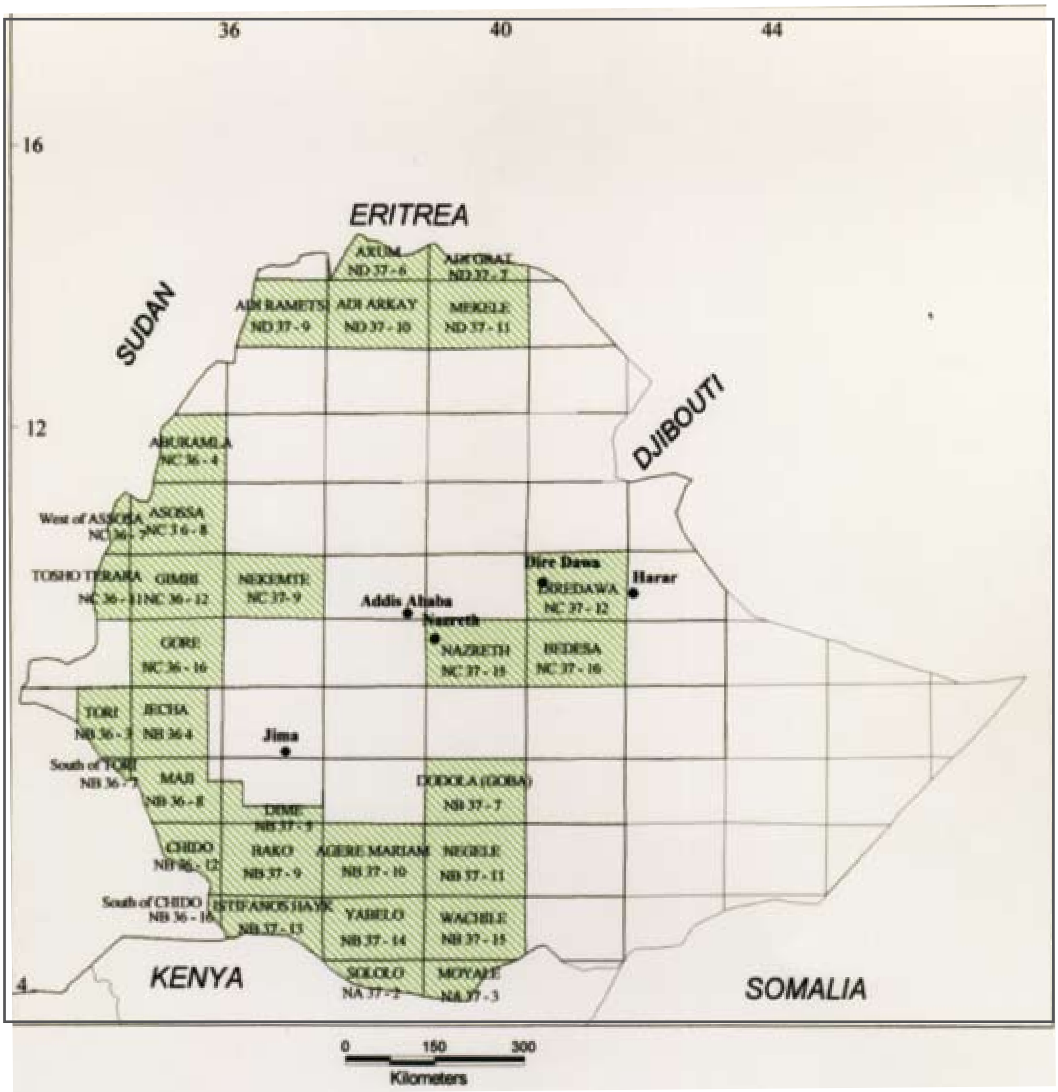

Figure 10.1: *Index map showing the extent of 1:250,000 Geological Map Coverage of Ethiopia*

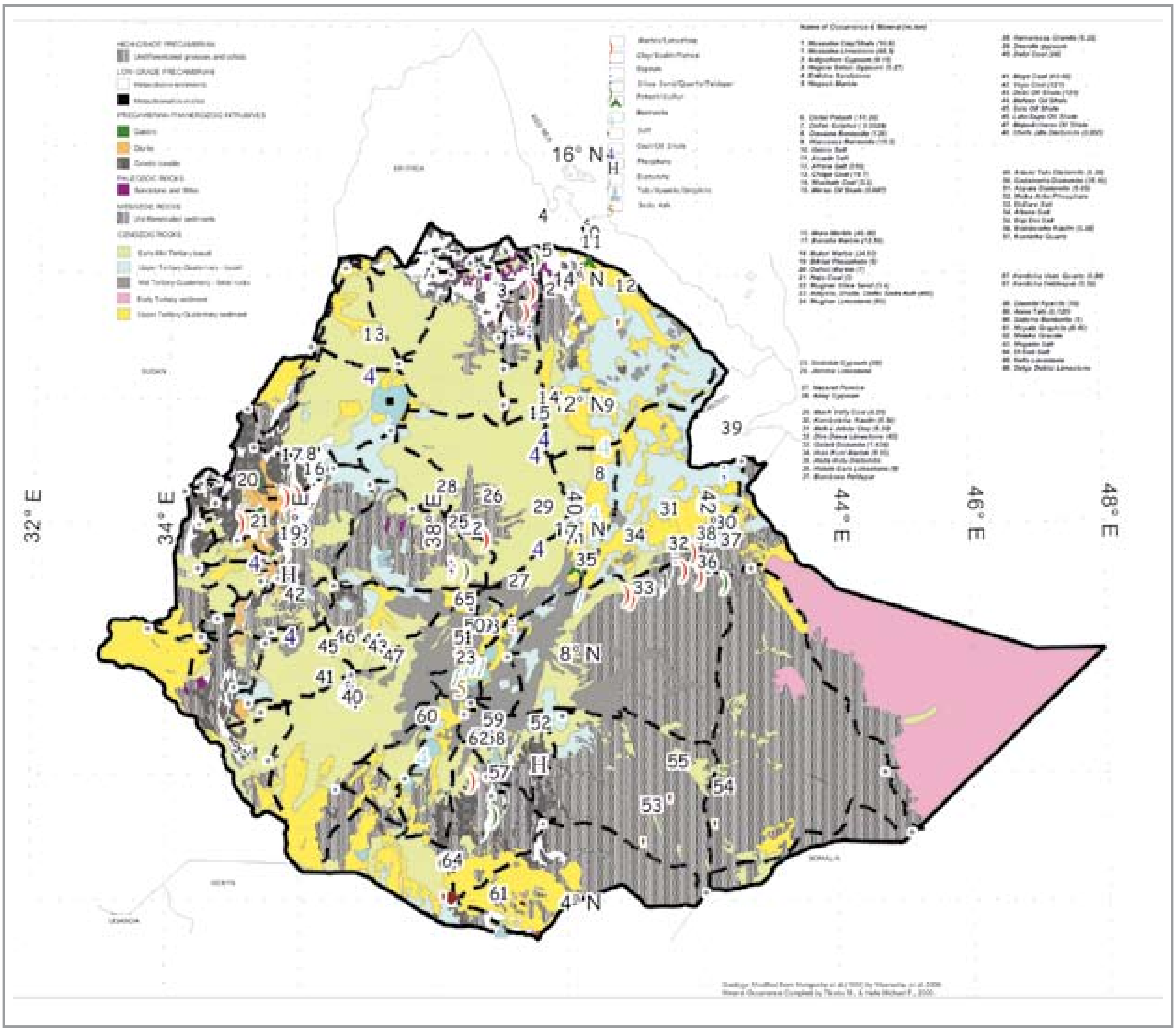

Figure 10.2: *Industrial Mineral Occurrences Map of Ethiopia*

11 The Role of the GIS Society of Ethiopia for NSDI

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The GIS Society of Ethiopia was officially inaugurated on October 25, 2007. The society has more than 150 registered members. The number of GIS and remote sensing professionals and applications of GIS are increasing in Ethiopia, ranging from simple data display and visualisation to complex data processing, storage, map preparation and printing tools. Many governmental, non-governmental organisations, private companies and individuals are using GIS for various applications.

As far as I am aware, the country's largest and best organised geo-spatial data is EthioGIS. These data have been compiled by the Soil Conservation Research Project of the Ministry of Agriculture and the Centre for Development and Environment of the University of Bern, Switzerland. The data have been available since 1999 and are being widely used by many people in Ethiopia, although most people are not aware of the authors of the database. The source of the database is topographic maps from the Ethiopian Mapping Agency, soil data from FAO, population data from the Central Statistical Agency, and unofficial administrative boundaries based on the 1994 population census data. This database, however, has limitations for detailed studies at local level. We are pleased today to share ideas with the producers of EthioGIS and how we proceed with the 2nd release of EthioGIS, and its contribution to NSDI in Ethiopia.

Among the various organisations that use GIS in the country today, some produce their own data and disseminate it at a reasonable cost or free of charge, while others compile and use secondary data. For example, the Ethiopian Mapping Agency produces aerial photographs, topographic maps and other derivative geo-spatial data and makes them available to users at reasonable prices. Most of these data are often obtained in paper (analog) format. The user has to convert them to appropriate digital formats. The most widely used base maps are the topographic maps produced at different scales by the Ethiopian Mapping Agency. They are considered to be of very good quality and level of accuracy by world standards.

The Woody Biomass Inventory and Strategic Planning Project (WBISPP) is another research office established under the auspices of the Ministry of Agriculture, responsible for creating land use and land cover maps of the country at a reasonable scale from satellite images and field verification. This project has produced good quality land use-land cover maps in digital and paper formats. However, this output is not yet public. Another project is called Environments Support Project Component 1: Establishment of a National Environmental and Natural Resources Information Meta-database conducted by DHV (DHV Consult in Ethiopia) in collaboration with the Ministry of Agriculture and the Ministry of Water Resources. The Ethiopian Development Research Institute (EDRI), in collaboration with the Central Statistical Agency (CSA) and the International Food Policy Research Institute (IFPRI), have established a geo-spatial database and prepared the national atlas on CD and printed versions, mainly focused on agriculture.

Many universities and research institutions in the country have compiled a considerable amount of geo-spatial data and satellite images of the entire country. These data are often used by researchers and students for different projects. Among the most prominent in this regard is the Department of Erath Sciences at Addis Ababa University.

Generally, most of the above works are done in different offices virtually independent of one another. This has the side effect of creating redundant and inconsistent data. Had there been one body controlling the standards and quality of the spatial database, serving as a central database warehouse to which people could have access, some of the problems could have been alleviated. The concept of NSDI is to organise such data with adequate standards and quality and develop tools and infrastructure for its effective sharing and dissemination. The GIS Society of Ethiopia has given due attention to this issue and established a sub-committee to deliberate on NSDI.

There are a number of on-going processes in the country for establishing geo-spatial data at regional and national scales. To mention but a few: The Ethiopian Road Authority (ERA) developed a comprehensive geo-spatial database on roads and associated infrastructure at federal level. Many regional offices are also making use of the technology to collect spatial and associated attribute data of their assets. For example, the Amhara and Tigray Rural Road authorities are currently undertaking a detailed survey of all the roads in their respective regions to establish a robust GIS database system that is it is believed will aid decision-making and policy formulation processes in the sector. The Oromiya and SNNPR Rural Road authorities have undertaken similar projects and are now enjoying the benefits of the new system. Many municipalities in the country, including Addis Ababa, Dire Dawa and Adama, have established a digital cadastral information system. Some cities are already seeking professional services for the same purpose.

Although until very recently there was no separate department of cartography in most of the prominent higher education institutions in the country, many relevant courses are offered both at undergraduate and postgraduate levels. However, most of the digital cartographers in the country are trained either abroad or are self-taught professionals. These professionals are very limited in number. This has created an acute shortage of skilled manpower in the discipline. This may contribute to the non-standardisation and inconsistency in maps produced by different offices for various purposes in the country.

To alleviate some of the shortage of trained manpower in the field, Addis Ababa and BahirDar universities established an MSc Program in the field of GIS and remote sensing. We also believe that GIS requires continuous training so as to catch up with rapidly changing technology and the huge volume of data produced in many offices. Many governmental and non-governmental organisations spend a lot of money to acquire state-of-the-art equipment and software products. However, since they fail to invest enough in manpower, the facilities cannot provide the required services.

Applications of remote sensing and GIS have become wider and deeper due to rapid growth of space, satellite, computer and software technologies. There is a large spectrum of applications ranging from natural resources exploration, exploitation and management to applications as diverse as pollution detection, navigation and various military activities. Environmental change detection and land degradation quantification, disaster prediction and designing prevention strategies are almost impossible without applying this new field. Thus there is an acute need for trained manpower at the expert level that can work to define problems and development of methods to solve real problems using GIS and remote sensing skills and techniques in our country. Collection of geo-referenced field data, surveying and thematic mapping space and processing and interpretation of aerial images, integration of multi-disciplinary data and spatial data management are in general supervised by individuals who need to be well trained.

One of the major problems that the world is facing today in the field of geo-information is the problem of data inconsistency, lack of proper documentation of the data (lack of metadata) and regular updating. GIS data are data put in a certain spatial context called coordinate systems. In short, if we collect data using instruments set up using one system and a colleague collects data using another system, there will be some shift in the data between the two results. Therefore, one has to know a priori the type of coordinate system that was used to collect the data. Unfortunately, most of the data that we obtain from various sources lack this very crucial information. This is creating a big problem in the country.

It is against this background that the Geographic Information Systems Society of Ethiopia, or GISSE for short, was inaugurated. GISSE is a society of GIS and remote sensing professionals and others interested in the promotion and use of GIS and remote sensing. One of the main aims of GISSE is to promote National Spatial Data Infrastructure (NSDI) in Ethiopia by setting up a national level GIS infrastructure, standardisation, and providing professional assistance by establishing a network of GIS professionals in the country.

GISSE also expects to fulfil a long-cherished wish to provide an opportunity for processionals, researchers and practitioners in the country to meet and keep abreast of the latest developments in the field. Moreover, GISSE will adhere to and execute its responsibility to contribute its share to the achievements of poverty reduction and national development in Ethiopia. It strives to empower communities by disseminating scientific knowledge through publications, awareness campaigns, meetings, discussions, seminars and symposia. GISSE will be coined as an excellent forum for qualified professionals to meet the challenges ahead. A forum of its kind can play a constructive role towards developing GIS systems at national level.

In general, GISSE will have a great role to play in the NSDI for Ethiopia in the following ways:

- Sharing data and experience among its professional members
- Building standards and quality as stakes for future consistent use of data among GIS users in the country
- Enabling efficient means of sharing and dissemination of spatial data
- Bringing all relevant institutions in the country together to work towards the same goal
- Awareness creation and training
- Data updating and follow-ups

We believe the producers of the 2nd release of EthioGIS should work together with GISSE to share data and experiences among our esteemed professional members and obtain their advanced contributions so that the NSDI will be a reality.

12 The Way Forward

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Three pertinent NSDI issues have been identified by the organisers of the workshop, and the participants were arranged in groups of three to deliberate each of them. The participants identified the major problems and potential solutions regarding adequate NSDI in Ethiopia

12.1 Data sharing, dissemination and networking

Problems

- File size of spatial data is demanding
- File Format compatiblity
- Data quality differences
- Awareness among producers and users
- Security
- Accessibility
- Readiness of data for dissemination
  - Institutional capacity
  - Human resources
  - Finance
  - Proper documentation

Potential solutions

- Capacity building
  - Human, institutional and communication
- Metadata establishment to regularise data communication
- Alleviate financial problem
  - Sponsor
  - Cost sharing
- Awareness raising
  - Owners
  - users

- Creating platform of sharing ideas among owners and users
- Centralisation
  - Enabling a lead organisation to coordinate networking of data through standard
- Data dissemination should be the responsibility of agencies
- Security
  - Segregating the data
  - Agreement on use
  - Camouflaging sensitive areas

12.2 Data quality, standards and updating

Definition of data quality

- accuracy of data
- compilation history
- depending on data acquisition method
- last update time
- lack of metadata

Standards

- Data from different institutes don't fit with what is needed
- Data quality info are missing
- Standards to be decided when collecting and disseminating the data
- Missing exchange policy – standards???

Updating

- Regular revision according to the nature of the data acquired
- Some data needs more frequent updating than other data, depending on requirements
- Updating requires significant financing
- Availability of funding determines how thoroughly the data will be updated

Recommendation

- No data quality without defining metadata standard!
- To keep the standards we have to make regular updates

- In the end all spatial data have to undergo a quality check
- Standards have to include updating intervals
- Developing and providing general standards should be done by one leading and responsible institution (set standard, regulate and control) Who???
- Sharing of experience and knowledge to create awareness is important
- Standards have to be defined, including all stakeholders
- Handling of data by different specialised institutions is not a luxury but an opportunity to control quality

12.3 Capacity building (institutional and human), data acquisition, data quality and data sharing

Key issues/limitations

- Big gap between project needs and available capacity (experts, hardware & software)
- Stronghold on GIS projects by government and other users (lack of outsourcing)
- Difficulty in retaining trained and seasoned professionals in their respective institutions.
- No distinctive level and quality of training for various user groups (e.g. technicians, specialists, decision makers etc.)

Solutions

- Capacity building of the project hosting institutions should be considered when housing such projects.
- The project planning process should take human and institutional capacity into consideration.
- Distinctive training should be given to decision-makers, technical staff and general users. The uses of GIS as a science and as a tool need to be distinguished while providing training.
- Government and other user organisations should resort to a more supervisory role rather than trying to accomplish the whole cycle of project work by themselves
- Government agencies will have time to dedicate effort to their major line of work if they opt for outsourcing. Hence they will not have to come up with highly qualified staff, which is probably needed only during the project period as day-to-day tasks might not require high levels of expertise.
- While outsourcing, quality control and standards should be heavily emphasised
- Incentives and a better working environment for seasoned GIS professionals
- Incorporating GIS in the educational policy planning process

13 Question and Answer Session

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- There should be control of the quality of data that is generated and disseminated in the country. I would like to relate an incident that occurred in Ethiopia. River basin master plan studies have been done all over the country. All the basin studies used the FAO soil classification system to map soil units, while in the Tekeze basin, a French consulting firm used another classification system. This has made understanding and sharing of the spatial data and creation of national spatial data very challenging. Hence, we should have standards and quality control. I don't have a problem with whoever is doing the mapping, because there is already a mandated organisation to do the job. However, I insist that every thing should be according to the rule of law.
- NSDI should not be left to only one organisation. All concerned governmental and non-governmental institutions need to be involved and benefit from NSDI. However, the Ethiopian Mapping Agency should play a leading role to avoid unnecessary duplication of efforts, maintain standards and quality, and share and disseminate spatial data.
- One of the challenges in spatial data quality is administrative divisions. Administrative boundaries change frequently all over Ethiopia. Hence we have to use nationally accepted administrative boundaries. CSA is now updating the administrative boundaries for the population census being carried out. We shall have a common reference boundary to share our data within those divisions. But it has been stated that boundary demarcation is done by the Ethiopian Mapping Agency, not CSA. In any case, the information is expected to be available for GIS users for consistency in sharing information.
- It is recommended that interested partners in the NSDI of Ethiopia work with the producers of 2nd release of EthioGIS during the process of preparing the 2nd release of EthioGIS
- It has been agreed by all participants that the GIS Society of Ethiopia will adopt all the recommendations made during this workshop and move ahead in collaboration with the EthioGIS group.
- The Global Mountain Program and the Centre for Development and Environment (CDE) of the University of Berne will monitor the recommendations made during this workshop.

14 Appendix: List and Address of Participants

Consultation Workshop on National Spatial Data Infrastructure and Ethio-GIS (2nd Release)

November 28, 2007, ILRI, Addis Ababa, Ethiopia

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