Conceptual Design of the Ecuadorian Geospatial Data Clearinghouse

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by

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Abstract

There is growing nation-wide pressure to create a National Spatial Data infrastructures (NSDI) that makes geoinformation hosted in geographically distributed geographic information systems in the country accessible and sharable to the Ecuadorian GIS community timely to support governmental decision making processes.

In Ecuador, one of the Strategic objectives of the Instituto Geografico Militar (IGM) for the next 10 years is putting forward a new project named " Ecuadorian Geospatial Data Infrastructure" aiming to form and promote standardized and modernized geospatial activities in Ecuador. One goal is to establish and maintain the National Geospatial Data Clearinghouse.

To better appreciate the role of the clearinghouse, it is important to understand the interrelation of the components presents in the NSDI. These elements are not independent activities; they must be viewed as complementary to constructing a viable infrastructure.

In this research, a preliminary diagnosis of the current situation in Ecuador in terms of SDI activities is presented. This analysis is made on the basis of a survey and workshop carried out in Quito during fieldwork.

Then, different clearinghouse system architectures have been analyzed and an appropriate architecture for the National Clearinghouse is proposed. The clearinghouse architecture is based on the World Wide Web and consists of three main components: Web Client (client tier), clearinghouse gateway (middleware tier) and clearinghouse nodes (server tier). The functions and specifications of these components and the interaction between them are also analyzed. This architecture can offer efficient search capabilities to users, and provides flexibility for data producers to update and maintain metadata. It also provides possibilities to monitor all the datasets within the whole clearinghouse system.

An approach for the implementation of the National Clearinghouse is presented. Considering the nature of the clearinghouse, the implementation is planned in phases. The first phase is the establishment of catalog service and then an evaluation phase is recommended.

For this evaluation, a list of possible criteria has been identified: content criteria, form criteria and process criteria which reflect the main areas to be considered in the evaluation of the National Clearinghouse.

And finally the Institutional issues and organisational implications related with the implementation of the National Spatial Data Infrastructure and clearinghouse are analyzed.

The results of this research are expected to contribute with IGM for the future development of the Ecuadorian Geospatial clearinghouse.

Acknowledgements

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LIST OF ABBREVIATIONS

CEPEIGE	Centro Panamericano de Estudios e Investigaciones Geograficas or Pan-American Center for Geographic Studies
CLIRSEN	Centro de Levantamientos Integrados de Recursos Naturales por Sensores Remotos or National Remote Sensing Center
CONATEL	Consejo Nacional de Telecomunicaciones or National Council for Telecommunications.
CSDGM	Content Standard for Digital Geospatial Metadata
DINAREN	Direccion Nacional de Recursos Naturales or National Office for Natural Resources
FGDC	Federal Geographic Data Committee
GIS	Geographic Information System
GITR	Global Information Technology Report
GSDC	Geospatial Data Service Centre
GSDI	Global Spatial Data Infrastructure
HIGEODES	Centro de Investigacion y Estudios para la Prevencion de Desastres Hidrogeodinamicos y Antropicos
ICT	Information and Communication Technology
IEPI	Instituto Ecuatoriano de Propiedad Intelectual or Ecuadorian Intellectual Property Institute
IGM	Instituto Geografico Militar or Military Geographic Institute
INAMHI	Instituto Nacional de Hidrologia y Meteorologia or National Institute for Meteorology and Hydrology
INOCAR	Instituto Oceanografico de la Armada or Navy Oceanographic Institute
NGO	Non Governmental Organisation
NSDI	National Spatial Data Infrastructure
ODEPLAN	Oficina de Planificacion de la Presidencia de la Republica or National Planning Office
OGC	OpenGIS Consortium
SDI	Spatial Data Infrastructure
SIGNAC	Sistema de Informacion Geografico Nacional or National Geographic Information System
UNDP	United Nations Development Program
UNISIG	Unidad de Inteligencia Artificial y Sistemas de Informacion Geografica or Geographic Information Systems Center.
UTICE	Unidad de Tecnologia de Informacion y Comunicaciones del Estado or Governmental Communication and Information Centre
WWW	World Wide Web

1. Introduction

1.1. Background

The concept of data infrastructure as a mechanism for providing more effective access to geospatial data emerged in the early 1980s in Canada and has evolved continually up to now around the world.
A Spatial Data Infrastructure (SDI) is often referred to as the collection of technologies, policies, and institutional arrangements that facilitate the availability and access to spatial data. It provides for the discovery, evaluation and application of spatial data for users and providers within the global community. Some of the major components of a SDI include geographic data, metadata and the means to search, discover, and access data.
This Spatial Data Infrastructure can be effective only when reliable and efficient computing and communication technologies are in place. Thus more databases can be linked for the transfer of data or to provide a basis for inter-operability of heterogeneous software and hardware systems.
One of the key components of SDI besides standards, institutional framework, network architectures, policy, legislation and human resources, is the national spatial data clearinghouse. The clearinghouse allows the users explore what geographic data exist, the condition of the data and instruction for accessing the data.
Issues of geospatial database architecture and design, their data distribution over different physical locations, and the need to acquire information about the availability of geospatial data deal with the concept of geospatial data clearinghouse
The US Federal Geographic Data Committee (FGDC) defines a clearinghouse as a 'system of software and institutions to facilitate the discovery, evaluation, and downloading of digital geospatial data'

1.2. Prior Work

Staff members of Military Geographic Institute of Ecuador (IGM) had carried out research studies at ITC last years:

- The Thesis "Towards the development of National GIS programme in Ecuador" (Cardenas F, 1998) provides the strategic framework to develop a NSDI as the first step to develop homogeneous, efficient and effective GIS application programmes.
- The Thesis " Guidelines for the implementation of a service oriented strategy in a mapping organisation" (Dominguez, 1998), emphasizes on designing products and processes involved in different level of aggregation (product hierarchy and product diversity) and the role of modern mapping technology as enabling tool to implement a service oriented strategy.
- The thesis " Business process to design a cadastral data infrastructure as a part of a land administration system in Ecuador" (Salazar, 2001) provides guidelines to create a National council for an Ecuadorian Spatial Data Infrastructure with cadastral data infrastructure as the main component.

- Many countries around the world are initiating research and developing projects towards a comprehensive National Geoinformation Infrastructure including a National Clearinghouse.

1.3. Research Context

1.3.1. Geographic Information Infrastructure

The concept of Geographic Information Infrastructure is beyond the objective of this research. Groot and McLaughlin have introduced the concept of Geospatial Data Service Centre (GDSC) as a facility or organisation, which is intermediary between the data users and the suppliers for the applications in the enterprise or domain (figure 1-1). It facilitates the integrity of access to the required data by ensuring system technical services as well as the administrative, data security, and financial services necessary to broker between data suppliers and data users within the information policies governing the GDI. Within this context, the National Mapping Agencies (NMAs) in every country play an important role in contributing to the development of clearinghouses, metadata standards, institutional framework and resolving information policy issues (Groot R, 2002).
In many countries GDSCs are evolving from clearinghouse implementation as a first step.

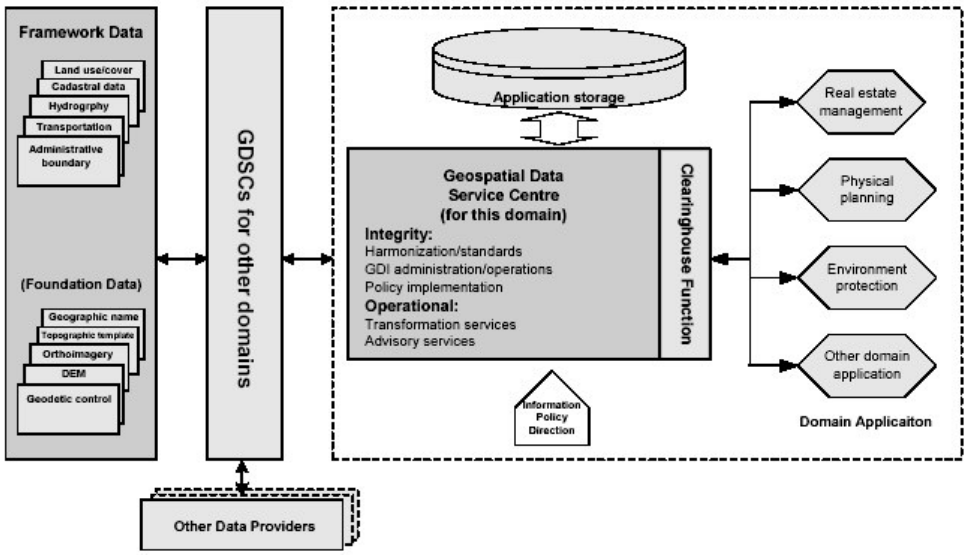


Figure 1-1 Role of a Geospatial Data Service Centre (From Groot & McLaughlin, 2000)

1.4. Research Problem

Nowadays, one of the challenges facing many National Mapping organisations, especially in Latin America, is to develop an Infrastructure at National Level to improve access to geoinformation and to promote data sharing. Developed countries have implemented GDI with relative success, however their approaches are different for developing countries due to the differences of institutional, technical, economic and cultural background.
An analysis of the institutional, economic and technical aspects in every country is essential to implement the SDI.

1.5. Research Objectives

1.5.1. Main objective

The main objective of this thesis is to establish a conceptual design for the Ecuadorian Geospatial Data Clearinghouse and to provide IGM with guidelines, initial models and steps to develop the National clearinghouse as a part of the National Spatial Data Infrastructure.
IGM is conducting and guiding efforts at National level to establish a National Geographic and Cartographic Information System.

1.5.2. Specific Objectives

a) To identify the main geospatial market players and their needs.
b) To Identify and analyse the current Ecuadorian geospatial market mechanism, regulations, and restrictions.
c) To analyse the different system architectures for clearinghouse and select the most appropriate for the National Clearinghouse.
d) To identify institutional and organisational issues for the implementation of the National Spatial Data Infrastructure and clearinghouse.

1.6. Research Questions

The questions raised by the research are:

1. What are the current problems for acquisition, dissemination and data maintenance of geospatial information in Ecuador?
2. What are the main components of the National Spatial Infrastructure?
3. What is the current situation of Ecuador in terms of Information and Communication technologies and how it might influence the implementation of the National Clearinghouse?
4. What are the current SDI and clearinghouse initiatives in the region (Latin American countries)?
5. What are the different system architectures for clearinghouse?
6. What is the best architecture for the national clearinghouse and Why?
7. What are the components of the National Clearinghouse and what aspects should be considered for its implementation?
8. Which institutional and organisational aspects must be considered to ensure a successful implementation of the NSDI and the clearinghouse?

1.7. Research Methodology

1.7.1. Literature Review

a) Study on concepts of SDI.
b) Study on clearinghouse and related concepts.
c) Analyse technologies and prior work of clearinghouse implementations abroad with emphasis in clearinghouses implementation in the region.
d) Identify the requirements for establishing a National Clearinghouse.
e) Identify and analyse the different systems architecture for the Clearinghouse
f) Study on ICTs development in Ecuador and its influence in the establishment of the NSDI.

g) Study on metadata standard and metadata management.

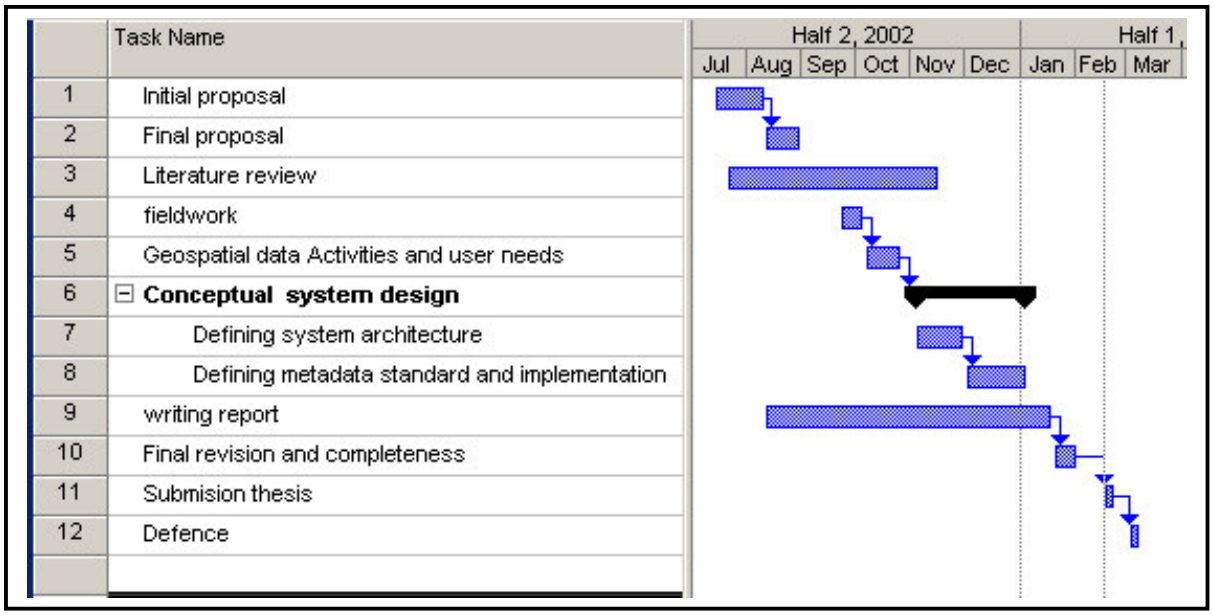
1.7.2. Survey of National Spatial Data Activities and user needs

a) Making a Questionnaire for surveying the current geospatial data activities and user needs in order to:
   - To Identify and analyze the current Ecuadorian geospatial market mechanism, regulations, and restrictions.
   - To identify the main problems for geospatial data sharing.
   - To identify data needs of the main users of geospatial data in Ecuador.
   - Identify the needs for the national geospatial data clearinghouse.

b) Questionnaire analysis.

A fieldwork has been carried out in Quito-Ecuador from 27 September 2002 until 18 October 2002; an interview-guided questionnaire will be used to identify the information needed. This survey mainly addresses to Governmental organisations, Non governmental Organisation (NGO), and academia involved and concerned with geoinformation activities in Quito.

1.8. Time Planning



1.9. Thesis Structure:

This thesis consist of 7 chapters:

CHAPTER 1. Gives an outline of the general context of this research including the background, the research framework, the questions raised, its objectives and the methodology used to carry out this research.

CHAPTER 2. Explains the concepts of SDI at global and regional level. The current situation of the National Spatial Data Infrastructure is explained as well as the initiatives promoted by the National government for the information society. A comparative analysis in terms of ICT development in the region has been made. The purpose of the comparison is to identify the countries with similar ICT development and then analyze the SDI activities in the selected countries. Finally, the activities of OpenGIS Consortium (OGC) related with clearinghouse development are reviewed.

CHAPTERS 3. Deal with the current geospatial data activities and user needs in Ecuador. A preliminary diagnosis of the existing situation is made on the basis of survey carried out in Ecuador.

The objective of this survey is to identify the current Ecuadorian geospatial mechanism, regulations, and restrictions.

CHAPTER 4. The different system architectures for the clearinghouse are analyzed and the architecture for the National Clearinghouse is proposed. Issues of metadata standards and metadata management are addressed as well.

CHAPTER 5. Deal with the conceptual design of the Ecuadorian National Clearinghouse, its components and the interaction between them. An approach for the implementation is presented. A proposal for performance criteria for the evaluation of the development of the clearinghouse is presented.

CHAPTER 6. Deal with the institutional and organisational issues of SDI and clearinghouse.

CHAPTER 7. Focus the conclusions and recommendation about this research.

2. Global, Regional and National Spatial Data Infrastructure

2.1. Introduction

The United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro (Brazil) in 1992 took first steps and initiatives to stop environmental deterioration and establish the basis for a sustainable way of life into the 21st century. In this conference, it was recognized that the availability of Geoinformation is important and crucial for decision-making.

Ten years later, The Johannesburg Summit 2002 "The world summit on Sustainable Development" held in South Africa in August-September 2002, reaffirmed the importance of geospatial data for sustainable global development. As a result of these events, many countries around the world have started creating their own infrastructure to cater their geospatial data needs.

Geospatial information is produced, used, maintained and shared in a range of application areas including: transportation, environment, natural resources, agriculture, telecommunications, mapping, health, emergency services, research, planning and development and National Security.

Sharing geospatial data in such applications helps improving the management of public infrastructures, natural resources and national security and produces many other benefits for the community.

Recently, Geospatial data, and information in general, supported with the fast growth of information and communication technologies, are becoming more important and more common tools throughout the world due to their capacity to improve government and private sector decision-making. The advances in technology, data handling and data communication allow the users to think about the possibility of finding and accessing data that has been produced by different data providers.

2.2. Concept of Geospatial Data

Geospatial Data must be considered in four dimensions. These are the three dimensions associated with physical location i.e. X, Y, Z coordinates or latitude, longitude and height which define the positions spatially and the fourth dimension which defines its temporal aspect.

Geographic (or spatial) data can also be viewed as an infrastructure, with the same rationale and characteristics as roads, communications and other kinds of infrastructure.

Some examples of Geospatial Data could be, the topographic data collected by various mapping organizations, climate data, hydrographical data, cadastral data etc. Many Governmental as well as private agencies are engaged in collection of geospatial data for a large variety of human activities and applications.

2.3. Concept of Spatial Data Infrastructure (SDI)

Spatial Data Infrastructure encompasses the networked geospatial databases and data handling facilities, the complex of institutional, organizational, technological, human, and economic resources which interact with one another and underpin the design, implementation and maintenance of mechanisms

facilitating the sharing, access to, and responsible use of geospatial data at an affordable cost for a specific application domain or enterprise(Groot R. & McLaughlin J, 2000).
The purpose of GDI is defined for the same authors as: "to facilitate access to and responsible use of geospatial data at affordable prices". National Geospatial Data Infrastructure, Regional Geospatial Data Infrastructure, and Global Geospatial Data Infrastructure are special cases to be defined in terms of what gives the GDI its regional, national or global character.
GDI appears in this respect as a generalized concept, which can be implemented at the enterprise level or in national or regional context.

2.3.1. SDI Components.

Spatial Data Infrastructure (SDI) provides a basis for spatial data discovery, evaluation, and application, and includes the following elements (GSDI, 2001):

- **Geospatial (geographic) data:** the actual digital geographic data and information.
- **Metadata:** the data describing the data (content, quality, condition, and other characteristics). This permit structured searches and comparison of data in different clearinghouse nodes and gives the user suitable information to find data and use it in an appropriate way.
- **Framework:** includes base layers, which will probably differ from location to location. It also includes mechanisms for identifying, describing, and sharing the data using features, attributes, and attribute values.
- **Standards:** Facilitating the sharing of information, created and accepted at Local, National, and Global levels.
- **Partnerships:** Partnerships can contribute in avoidance duplication of efforts and the cost of collection and leverage local/national/global technology. This is not a technological issue but the concept of clearinghouse and the implicit agreement on data and application sharing requires a strong partnership. The partnerships can include institutions in the government, industry, academia, societies and individuals.
- **Communications networks or Services:** to help discover and interact with data.
- **Clearinghouse:** to obtain the data. Clearinghouses support uniform, distributed search through a single user interface; they allow the user to get data directly, or they direct the user to another source.

These elements are linked in a very explicit way to assure the effectiveness of the SDI (Figure 2-1). Standards are the basement of NSDI, and Standardisation makes clearinghouse work. Clearinghouse is the core component and the engine of the SDI; partnerships are the 'glue' of all SDI components.
To better appreciate the role of the clearinghouse, it is important to understand the interrelation of the components present in the SDI. These elements are not independent activities; they must be viewed as complementary to construct a viable infrastructure.

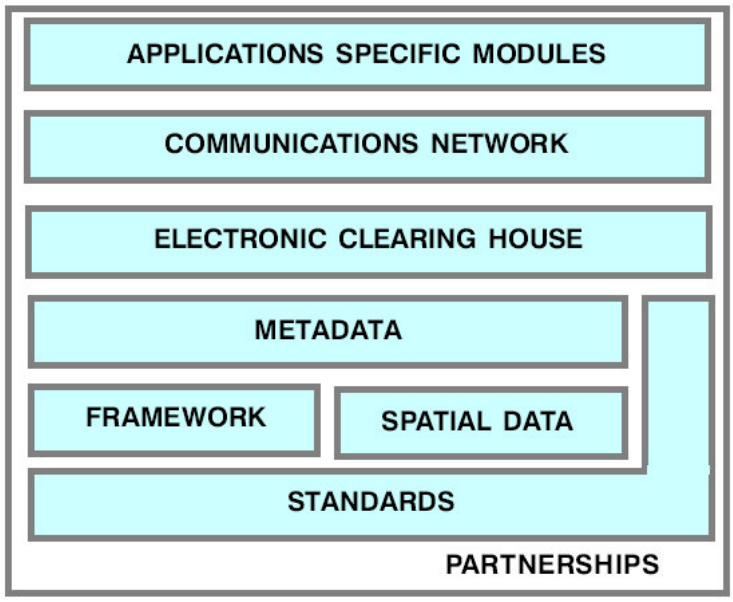


Figure 2-1 Components of SDI (Indian SDI, 2001)

2.4. Metadata for Geoinformation

Metadata is the term used to define data about data. The metadata allow a producer to fully describe a dataset; and users to evaluate the dataset's applicability for its intended use. The Metadata has to be easily accessible and provided in such a way that the GIS community can obtain information that will allow them to compare the suitability of data from different sources (FGDC, 1998).

Considering the diverse sources from which geospatial databases are built, it is extremely important to maintain information about the content, quality, source and lineage (history of use and changes) of the data.

There are several different uses of metadata for geospatial data. The most common uses are:

- Cataloging data
- Searching for data
- Evaluating data's fitness-for-use
- Data documentation for data use and/or maintenance.

For each of these uses, the emphasis on what is read in metadata may vary slightly. For instance, identification information (What, Why) is of primary importance to someone searching for data; data quality becomes important in evaluating its fitness-for-use; and lineage/process steps are important for reviewing that data's history.

The well-known adage 'Quality is fitness for use' refers to the essential connection between quality and use. Metadata are helpful in assessing quality only when it is connected to use. Only when the metadata is easily accessible does it represent and support the users in determining quality (Harvey F, 2000).

There are seven main sections that correspond to complete metadata documentation. Each of the sections is linked to a brief description of what is required for that section.

- Identification information: description, purpose, creator of the dataset and the area and time period it covers
- Data quality information: Sources, processes, accuracy statements
- Spatial organisation information: The data model used (internal structure of the data)
- Spatial reference information: coordinate system/projection and datum
- Entity and Attribute information: details on what the dataset describes
- Distribution information: where/how to get the dataset
- Metadata reference information: Who wrote the metadata and what version it is.

Considering that Geospatial datasets are to become more widely available and their true value recognized by the users, thus finding methods to enable the public to discover their existence and determine their usefulness is important. This means that information about the data must be made available for the users. With the exponential growth in the use of the Internet and its adoption as a service within organizations (Intranets) a means is now available to use World Wide Web based search tools to locate sources of geospatial information through metadata.

2.4.1. Levels of Metadata

The details of metadata can vary with its purpose (Bishr & Radwan, 2000) figure 2-2 shows the different levels of details required for different purposes

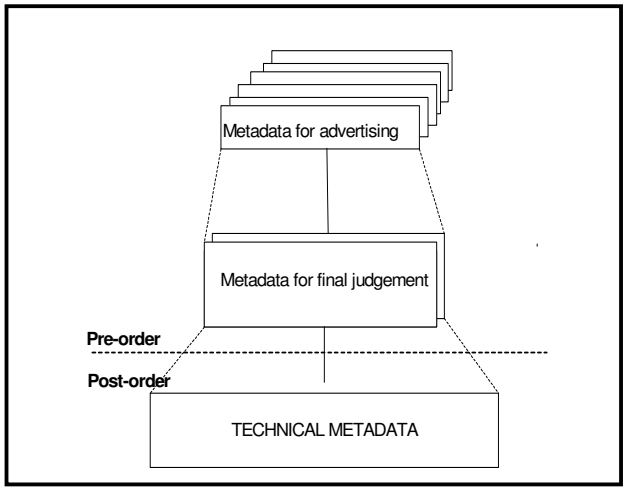


Figure 2-2 Level of detail for metadata (Bishr & Radwan, 2000)

The level of detail depends on the purpose of the metadata. Data providers can use metadata to monitor the status of their data sets, as well as to advertise their data to potential users through the National Clearinghouse.

The information included in the metadata should be selected on base on the following characteristics(Kim J, 1999):

- Availability—data needed to determine the sets of data that exist for a geographic location.
- Fitness for use—data needed to acquire and to identify if a set of data meets a specific requirement or demand.
- Access—data needed to acquire and identify the datasets.
- Transfer—data needed to process and use a set of data.

A number of standardization organizations have developed or are in process of developing standards for storing and maintaining metadata. A brief description about these initiatives is described below:

- CSDGM: Content Standard for Digital Geospatial Metadata. Developed in 1994 by the U.S. Federal Geographic Data Committee as part of the National Spatial Data Infrastructure. It is a full metadata standard with 219 fields to describe digital datasets for all purposes. These fields are grouped into seven information categories: Identification, data quality, geospatial data organisation, geospatial reference, entity and attribute, distribution, and metadata reference. It is mandatory for federal agencies. (FGDC-CSDGM, 1997)
- CEN/TC 287 Env 12657: it is the European equivalent to CSDGM. It is a voluntary pre-standard (i.e. not enforceable) developed in 1997-98 for the European Committee for Standardisation (CEN). It is a full metadata standard, which has provided the basis for many European initiatives.
- ISO 19115: under development. It should bring together both US and European standards under one umbrella. It will have two components: a “core” metadata profile for discovery, and a “comprehensive” profile for applications and
- Open GIS Consortium: industry based consortium to promote interoperability and develop GI market. It is developing Abstract Specifications on a range of topics including Metadata standard, some specifications have been accepted and published.

2.5. Global Spatial Data Infrastructure (GSDI)

The Global Spatial Data Infrastructure (GSDI) is an organisation to help advance awareness, acceptance and implementation of globally compatible SDIs at the local level, national, and regional level.
The definition of GSDI adopted at the 2nd GSDI Conference best articulates its goals: "GSDI encompasses the policies, organisational remits, data, technologies, standards, delivery mechanisms, and financial and human resources necessary to ensure that those working at the global and regional scale are not impeded in meeting their objectives"
GSDI is being advanced through the leadership of many nations and organizations represented by a GSDI Steering Committee, which includes representatives from all continents, and from government, academia, and the private sector (Lachman et al., 2001).
Other permanent committees (regional) working in the same line are for Asia and the Pacific (PCGIAP), the Permanent Committee on SDI for the Americas (PC-IDEA), Africa (PC-AFRICA) and EUROGI in Europe.

2.6. Regional Spatial Data Infrastructure

2.6.1. The Permanent Committee on SDI for the Americas (PC-IDEA)

During the 6th United Nations Regional Cartographic Conference for the Americas held in New York in 1997, a set of recommendations was accepted linking the role of spatial data infrastructures and enabling technologies, the need for establish a Permanent Committee on SDI for the region.
After a three years process, with support from international organizations and cooperation from developed nations, PC-IDEA was established on 29 February 2000, as a result of the International Seminar held on Bogotá.
PC-IDEA is compound by 21 nations representing North, Central, South America and the Caribbean Islands.
The main drivers for PC-IDEA action are (Borrero S, 2001):

1. Increasing production of spatial data, impacting Research and Development activities for regional sustainable development;
2. Migrating from local data to the concept of National Spatial Data Infrastructures, leading to the construction of regional spatial data sets;
3. Increasing knowledge capabilities for all nation members, by incrementing access to data and information dissemination;
4. Contributing to the development of GSDI and Global Map initiatives, as well as other relevant global and regional initiatives for sustainable development;
5. Creating an Inter American forum leading to a better understanding of national, regional and global GIS and SDI issues and
6. Placing geoinformation as one strategic sector for national and regional development.

Ecuador as a member of PC-IDEA is working with others members of the committee towards the establishment of the Spatial Data Infrastructure at regional and national level.

2.7. National Spatial Data Infrastructure (NSDI)

2.7.1. Current Development

The NSDI concept mandates the National Mapping Organisation to take the leadership-initiative role to establish and work towards the goals of the NSDI in every country. In Ecuador, the Military Geographic Institute (IGM) according with the "law of National Cartography" (1978) has the mandate to produce the National Basic cartography and the national Geographic and cartographic files.

One of the objectives of IGM, as stated in the strategic plan of IGM (2001-2010) is to develop the National geospatial data infrastructure. To accomplish with that objective, IGM is proposing the main producers and users of geoinformation to work in a coordinated way towards the development of the NSDI.

However, initiatives to coordinate SDI actions at a national level face significant constraints like decreasing budgets, inter-organisational barriers, lack of high level support, limited capacity for research and development and lack of knowledge about SDI concepts among others.

In that way, diffusion of SDI concepts in order to get awareness in Ecuadorian geoinformation community is essential.

Despite these restrictions, experience has shown that specific steps to define and implement a National Geographic Information strategy can be accomplished, providing that government agencies decide to work together, reduce costs and to avoid duplication of efforts.

The first steps to develop the NSDI had been promoted by IGM; first approach is depicted in figure 2-3. In this approach, the implementation of a legal basis, institutional agreements and an appropriate technical infrastructure are the backbone of NSDI. At the top of this model appears the National Council of Geoinformatics that will be responsible for designing and implementing SDI concepts, coordinating the development of standards and protocols, building and sustaining core data sets and providing guidelines for the establishment and good functioning of the NSDI.

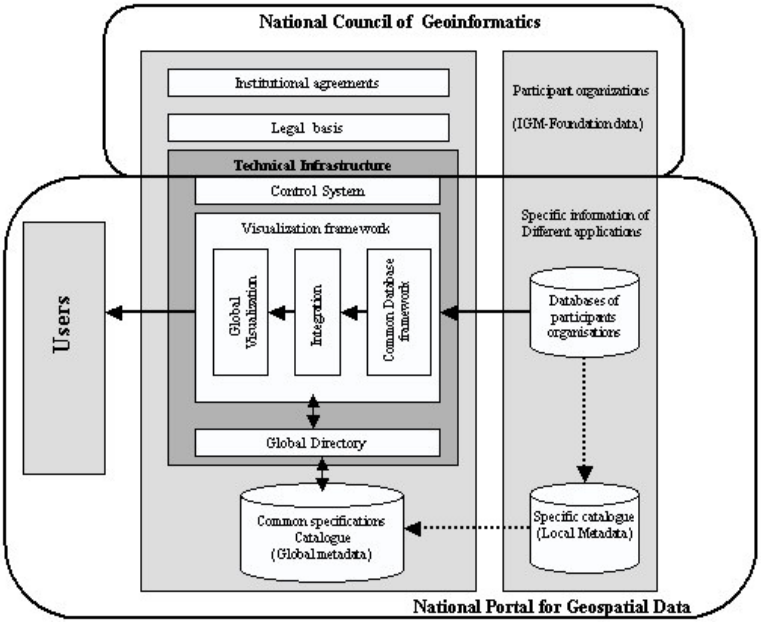


Figure 2-3 Conceptual Model of NSDI (Source: IGM Strategic Plan 2001-2010)

2.7.2. Initiatives of Ecuador for the Information Society

For Ecuadorian Government, the availability of infrastructures for electronically transferring and accessing information is perceived as essential component for the realization of the Economic, Social and Cultural benefits and competitive advantages for the Economy. The Government is, therefore, willing to support and shape the development of an Information Infrastructure as was seen in the UNDP Ecuador 2001Human development Report (UNDP, 2001). Chapter 14 of this report outlines the main policies and initiatives concerned with the development of information society and e-government in Ecuador.

In this sense, issues of e-government have been introduced recently in some governmental organisations where the potential of Internet to diffuse relevant information with low cost is widely recognized.

Looking at the future and considering important actions made by different governmental organisations in Ecuador, although not in a coordinated way; the next step is to focus concern to National Plans and strategies. From that point of view, the Ecuadorian State is making strong efforts not just oriented towards the development of electronic public services but towards a more ambitious objective: The integration of Ecuador in the "Information Society".

In this matter, there are two fundamental actions carried out by the Ecuadorian Government:

1. The creation of "The Governmental Communication and Information Center" which has the responsibility of making studies and projects related to development of communications in the country and
2. The creation of The National Council for Telecommunications, this body has designed a proposal called " National Agenda for Connectivity" (Table 2-1) including an e-government plan as a main component. It has been legalized through Executive order 1781 published in August 21, 2001.

"NATIONAL AGENDA FOR CONNECTIVITY"	
Strategy	Objective
1. Access to Information Infrastructure	▪ Strengthen National Telecommunications infrastructure. ▪ Offer access for information technologies to majority of Ecuadorians within reasonable cost.
2. Use of information technologies for educational processes.	▪ Promote use of information technologies as an educational tool. ▪ Training to governmental organisations and its employees in use of ICT. ▪ Strengthening of manpower for development and maintenance of information technologies.
3. Use of Information technologies in the public and private sector.	▪ Increasing governmental organisations efficiency as well as internal processes by means of appropriate use of ICT.
4. Promoting national sector of information technologies.	▪ Creating suitable conditions for development of information technologies.
5. E-government	▪ Improve government functioning and efficiency. ▪ Improve government transparency and strengthening social control about of the public administration. ▪ Strengthen executive function for citizens through use of information technologies.

Table 2-1 National Agenda for Connectivity (Source: Conatel Strategic Plan 2000-2004)

2.7.3. The Governmental Communication and Information Centre (UTICE)

Traditionally, the governmental development in information sciences has responded to particular interests and needs of every ministry or governmental organisations instead of a global policy arising from national level. This fact has produced technical, administrative and economic problems and consequently inefficiency in public sector.

The Ecuadorian State has at least 10 computational networks covering the whole country belonging to different institutions. These networks are running with different technology and do not communicate between them.

The UTICE was created to delineate a strategy at national level in order to promote policies in relation with basic standards for information transfer, Internet use and computational implementation and regulations to correct deficiencies mentioned previously.

The UTICE made a proposal about Policies and standards for information technologies that can be incorporated and promoted by Ecuadorian government.(UTICE, 2000)

In part II, section 56 of this document, the establishment of a 'Geo-referenced Information Infrastructure' for the country is addressed.

2.7.4. The National Council for Telecommunications (CONATEL)

This Council administrates and regularizes Telecommunications services and policies within the country. At 2001, CONATEL developed a Global Plan named "Ecuadorian Stage for Connectivity" which was the base to delineate the "National Agenda for Connectivity". This Stage or Agenda include as a main component an e-government plan that is summarized below: (Table 2-2)

	Plans	
Ecuadorian Stage for Connectivity	e-government (e-Logistic) (e-Security) (e-Procurement)	Governmental connectivity
		Governmental services on line
		Development of government organisations gateways/portals.
		Information of National Projects on-line
		Governmental Tender
	Internet for everyone	
	National Plan for Tele-education	
	Telemedicine	
	e-Business	

Table 2-2 Ecuadorian Stages for Connectivity (Source: CONATEL 2001)

These two important initiatives promoted by The National Government constitute an important support, and delineate in certain way, the first steps for the establishment of the NSDI.

2.8. Information and Communications Technologies (ICTs) and SDI

One factor affecting success in implementation of NSDI is the capacity of countries to exploit the possibilities and take advantage of the opportunities offered by Information and Communication Technologies.

Locking for information to review the question of how ready Ecuador is for the establishment of NSDI in terms of ICT development and to compare status with other South-American Countries, some documents are reviewed. It could be useful to make a realistic comparison in terms of use and availability of ICT for development of NSDI and clearinghouses.

The expansion rate of Information and Communications Technologies has been increasing rapidly in the world, and the Latin America region is no exception to this trend, although the regional growth rate is generally below that of developed countries(Callaos N, 1999).

The use of new ICT creates pressure for governments to rethink traditional administrations: the pyramidal structure inherited from paper-based practices, localized contact, and 'a culture of billboard information is being transformed by the establishment of network relations' (Callaos N, 1999). For developing countries, ICT provides an opportunity to build an efficient governmental structure linked to world networks by directly adopting the latest technologies and incorporating them into workplace procedures and by using new ICT tools.

The Center for International Development of Harvard University has been assembling *the Global Information Technology report 2001-2002: Readiness for the networked world* (Kirkman et al, 2002) with a major comparative assessment of countries' capacity to exploit these advantages and opportunities offered by ICTs.

At the core of GITR is the Networked readiness index that provides a summary measure that ranks 75 countries on their relative ability to leverage their ICT networks (Appendix 1).

The Networked readiness index goes hand-in-hand with the 75 national profiles made in every country that is also analysed in this report. These profiles explore national ICT trends and ways in which ICTs are contributing to national, social, and development goals in the context of the framework of the networked readiness Index.

A comparison of profiles and key factors of some Latin-American countries is made in order to find out some similarities in availability and development of ICTs with Ecuador (Appendix 1).

It shows that Ecuador is relatively low in the list (rank 71) implying a relative low use and availability of ICT so far.

However, another official document World communication and Information Report 2000 (http://www.unesco.org/webworld/wcir/en/index.html) shows Ecuador in better conditions in terms of ICT development. It could be concluded that, in some cases, the level of confidence in terms of results of ICT development published in surveys are uncertain and specially in areas concerning with ICT development given the fast growth.

Nevertheless, considering the activities and plans executed by the National Government as it is stated in previous section, the current situation can improve in the near future.

2.8.1. Status of clearinghouse development in some countries of the region

From the comparison of countries profiles in terms of ICT development, the countries with major similarities with Ecuador are Colombia and Peru. Although Colombia looks as one of the countries in South America more concerned and where more activities related with the implementation of National Spatial Data infrastructure has been taken (Lachman et al., 2001). However in aspects related with clearinghouse implementation are still not well developed. In Peru, clearinghouse activities have started recently and the official web page http://www.ignperu.gob.pe/clearinghouse/ do not provide enough information about the development of the NSDI and the clearinghouse.

The search for information about development of National Infrastructures and specifically in implementation of clearinghouses in those countries was based on the information published in the World Wide Web and some available documents. Unfortunately it was not always possible to retrieve significant information than those published in the web, thus the final selection of examples was taken in base of availability of information and successfully experiences in implementation of clearinghouse in each country.

The countries selected as examples were USA and Uruguay, both countries appears in 1st and 37th place in the list of countries analyzed in the GITR report and have implemented clearinghouse with relative success, obviously USA is one of the pioneers countries in this type of activities.

Additionally, in studies carried out by Crompvoets and Bregt (2000), an overview of National clearinghouses for Geo-information is presented, in which some factors like level of development, year of implementation, numbers of datasets, standard used and other factor were analyzed. In that overview the more developed clearinghouses in America were: The Canadian Clearinghouse, USA clearinghouse, Costa Rican Clearinghouse and Uruguayan Clearinghouse. These clearinghouses are the most

developed in terms of the "maturity level"; it means that these clearinghouses allow access to metadata files and also real data.
Best experiences of clearinghouse implementation in countries around the world will be revised as well to get a better understanding about SDI and clearinghouse implementation. However given time constraints only a brief explanation of clearinghouse development in the selected cases will be given.

2.9. Review of Clearinghouse examples

2.9.1. USA Spatial Data Infrastructure and Clearinghouse

The adoption of GIS and the huge amount of informal and formal activities in sharing geographic information has encouraged the geoinformation community to find the best way to manage geoinformation. Initiatives on data sharing, mechanisms, infrastructure, institutional arrangements and standards are crucial for assisting data sharing practices and for building the NSDI.
In the U.S., The federal Geographic Data Committee (FGDC) has played a leadership role in promoting and developing the U.S. NSDI. This role was strengthened by a presidential executive order 12906 in 1994.
The FGDC pursues three main avenues towards building the NSDI: Enacting spatial data and metadata standards, creating clearinghouses, and coordinating creation of framework data.
The framework initiative is probably the most relevant from the institutional and organizational aspect of data access, this initiative calls for partnerships among organizations such as private companies, government agencies, and utility companies concerned with the same geographical area.(Pinto J and Nedovic-Budic Z, 2001).
One of the key components of U.S. NSDI is the national Geospatial clearinghouse. The FGDC defines a clearinghouse as a 'system software and institutions to facilitate the discovery, evaluation and downloading of digital geospatial data'. It is, in essence, an assembly of distributed servers, which contain metadata that can be accessed by the client by browsing through different server nodes through a web browser.
Nowadays, the U.S. Geospatial Data Clearinghouse comprise a collection of over 250 spatial data servers, located not just in U.S but also in some countries around the world sponsored by FGDC. These servers contain digital geographic data primarily for use in Geographic Information Systems (GIS), image processing systems, and other modeling software.

2.9.2. Uruguayan Geographic Information System and The National Geographic Clearinghouse.

In Uruguay, the main public organisations and many private companies have developed the geographic information system at national level. Through the project named "SIGNAC" promoted by the Ministry of Transportation and Public Works, the Uruguayan Government convoked national organisations to works towards the establishment of the Uruguayan Geographic Information System.
This system has as basic components:

- A Digital Geographic dataset that allows producers and users to have a common reference for their specific projects;
- The National Geographic data clearinghouse (CNDG) that promotes coordination and access to information generated by producers and users of spatial data.

The Uruguayan clearinghouse is a distributed network of producers, administrators and users of geographic information connected electronically. Every public or private institution producing geographic data or services in Uruguay has opportunity to become a node of CNDG.
The Ministry of Transportation and Public Works administrates the Central node; its mission is to coordinate activities in the network. The users are connected through a common access to Uruguay Net/internet. As a network of producers, administrators and users of geoinformation, CNDG has the following functions and responsibilities (Bertola I, 1998):

- Elaboration of standards for describing information (metadata standard) and collaboration with other data producers making their metadata.
- Systematize metadata for public use.
- Announce available geographic information and facilitate access to geoinformation through Uruguay Net/internet.
- Promote inter-institutional, public and private cooperation projects for production and dissemination of geographic information.

Unlike others global SDI initiatives driven by Federal or National Government, three private companies: AEROTERRA S.A., COASIN S.A. and I.C.A drive the Uruguayan clearinghouse.

2.10. Clearinghouse and OpenGIS activities

The Open GIS Consortium, Inc. (OGC) is a non-profit trade association dedicated to promote new technical and commercial approaches to interoperable geoprocessing (OGC, 1998).
The OGC consensus process involves all the participants in creating a software specification, the OpenGIS Specification, which is a comprehensive specification of a software framework for distributed access to geospatial data and geoprocessing resources. Figure 2.4 shows the Role of OpenGIS Specification in heterogeneous environment.

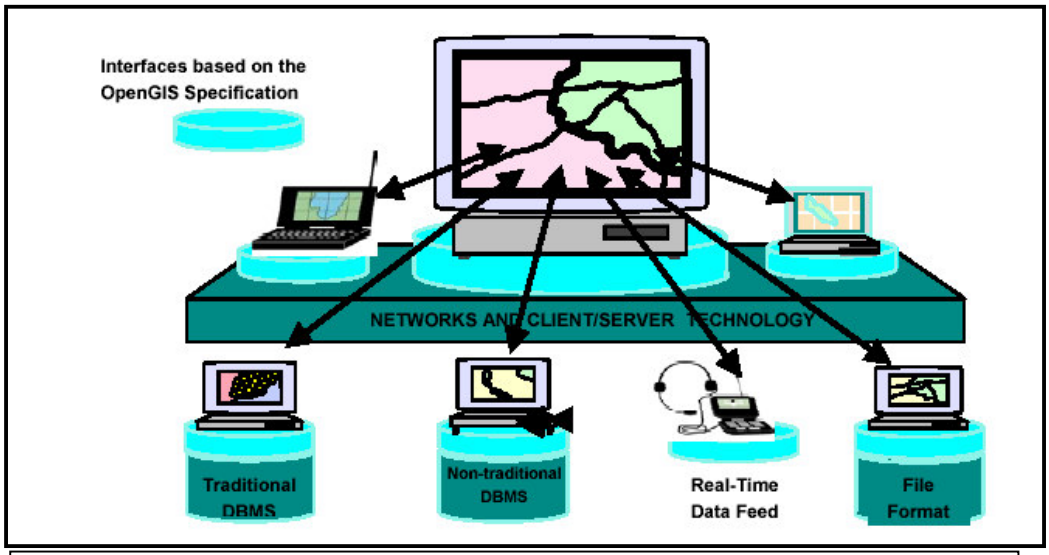


Figure 2-4 Role of OpenGIS Specification in heterogeneous environment (From OGC, 1998)

The goal of OpenGIS is to provide a comprehensive set of open interface specifications that enable software developers to write interoperable components that provide transparent access to geodata and geoprocessing resources over networks (Reed C, 2001).

2.10.1. Open GIS Specification (OGIS)

Open GIS Specification has been widely accepted by GIS communities including software vendors, governmental agencies, standardisation organizations and academies. The Open GIS Consortium (OGC) seeks to obtain interoperability through common specification. It means that software developers achieve interoperability by writing their software conform to a common specification. The Open GIS Specification provides an object-oriented framework for access to geodata, independent of the specific data structures and file format used to model the data.

2.10.2. Catalog Services and Metadata

A catalog services is a methodology that allows search and retrieval of information from catalogs (Nebert D, 2001). The catalog services allows for field-level searching of GIS servers' metadata to help a user determine where appropriate geospatial data and geoprocessing resources are available.
The OpenGIS® Catalog Services (Catalog 1.0) was approved in 1999 and its development includes(Nebert D, 2001):

- Consideration for legacy systems,
- Search and retrieval approach derived from Z39.50 (ISO 23950),
- Messages (search and response) will be formed in formal XML,
- Catalog services can be implemented under HTTP, Z39.50, and CORBA,
- Protocol gateways allowing communication across communities.

Metadata in catalogs represent properties of spatial data, such as geographic areas of interest, which can be queried and presented for evaluation and further processing by both humans and software.
With respect to the contents and structure of the metadata, the OGC has adopted the work done by ISO TC 211.
This standard and the catalog services specifications will be used in implementing clearinghouses for geoinformation all over the world (Van Oosterom P. Lemmen C, 2002). e.g., the New NCGI in the Netherlands will be based on this OpenGIS standard.

2.10.3. Internet GIS

Strongly related to the previous standards (metadata and catalog services) are the activities in the area of Internet GIS or web mapping. The rise of the Internet and specifically the World Wide Web (WWW) has created expectations for ready access to geospatial information on the web through a common web browser. Mapping on the web includes the presentation of general purpose maps to display locations and geographic backdrops, as well as more sophisticated interactive and customizable mapping tools. The intention of online or web mapping is to portray spatial information quickly and easily for most users, requiring only map reading skills. Web mapping services can be discovered using clearinghouse service through metadata (Blake et al, 2001). In fact, web-mapping services are often used to assist users in geospatial search system, showing geographic context and extent of relevant data.
Web based mapping provides the functionality to help discover and visualize spatial information referenced from Clearinghouse service systems. Figure 2-6 shows one scenario of a client accessing a clearinghouse to discover data and web mapping services and then requesting and displaying maps form different servers.

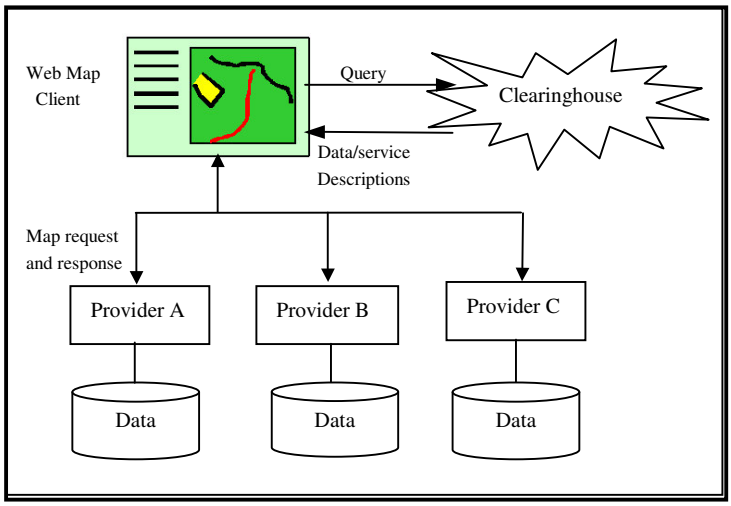


Figure 2-5 Interaction of web map client with clearinghouse and map server (from GSDI, 2001)

The OGC Web Mapping Test bed or WMT has delivered, among others specifications, a set of common interfaces for communicating a few basic commands/parameters that enables automatic overlays. This set of interfaces is known as the OpenGIS® web map server interfaces implementation specification. The Web Map server interface for query utilizes three basic functions: GetCapability (what is available on the server), GetMap (raster images, graphic primitives or data) and Get feature info (fetch attributes)(Van Oosterom P. Lemmen C, 2002a). The web feature server interface can be used for updating information, has functions for locking and committing transactions and utilizes the geographic Markup language (GML) for vector data transfer. GML is an XML based encoding standard for geographic information that encodes feature geometry and properties. The eXtensible Markup Language (XML) is the standard for the exchange of structured information and plays an important role in the Internet.

The OpenGIS Consortium (OGC) Web Mapping Specification (WMS 1.0) allows map servers to create and send standard map images over the Web as GIF, PNG, of JPEG in a manner that lets client software overlay and display multiple maps from multiple servers and even different vendors. The use of WMS as an extension to the Clearinghouse allows existing data holdings, described in metadata, to be viewed in this standard way, giving prospective data clients the chance to visually explore the spatial data behind the Clearinghouse from potentially multiple sites.

The use of these specifications, and in particular the Web Profile (ISO 23950), has increasing support from information locator activities on the Web.

It is evident that further integration of clearinghouse services with web mapping, live access to spatial data, and additional services can lead to exciting user environments in which data can be discovered, evaluated and used in problem-solving.

2.11. Concluding remarks

Spatial data infrastructures have been implemented in developed countries and it is widely believed that also developing countries can benefit by the implementation of National SDI.

Hence, initiatives at Global, regional and local levels have been promoted to support this kind of activities.

In Ecuador, the first steps to build the NSDI had been promoted by IGM. Willingness of some organisations and support of the government to improve current situation can be observed.

The lack of an appropriate Communication Infrastructure represents serious constraints for the establishment of the clearinghouse and the SDI in the country.

Some countries in the region have started actions to implement Clearinghouses and SDI with relative success; Uruguay is one of these cases.

It is obvious that capabilities of the clearinghouse will change in next years; it means that the users not just will get metadata but the data itself. Clearinghouses will be redesigned as the basis for One-Stop Portal to locate, access, or download geospatial data. In that way is working OpenGIS Consortium and specifically OGC Catalog services.

'The essence of the GDI concept is that there is no master architect' there cannot be, nor will there be, a single organisation for designing and implementing GDI specially at national level, instead it should be an almost organic web of partnerships and relationships evolving purposefully.(Groot R. and McLaughlin J, 2000)

The evolution of any GDI concept will most likely emerge from a combination of 'top-down' and 'bottom-up' strategies.

3. National Spatial Data Activities and User Needs

3.1. Introduction

One of the main problems in Ecuador when dealing with geospatial data is the lack of standards for acquisition, processing, delivery and sharing of geoinformation among different stakeholders. This results in duplication of work, non-standardised products, double cost, outdated information and complex access to data. (Salazar. R, 2001). Considering these problems, the implementation of a National Spatial Data Infrastructure could contribute to solve those problems. As is mentioned in previous chapter a GDI encompasses institutional, economic and technical components. In this chapter the current problems for acquisition, dissemination and data maintenance as well as some institutional and technical issues of geospatial Information are analysed. On the basis of a questionnaire conducted to main producers and users of geospatial data in Ecuador. The topics addressed in this questionnaire will help in the diagnosis of existing situation in Ecuador concerning to geospatial data. The recognition of those topics became a catalyst for establishment of Ecuadorian Geospatial Data Infrastructure and the National Clearinghouse.

3.2. Purpose of the questionnaire

The purposes of this questionnaire are the following:

- To identify the main geospatial market players and their needs.
- To identify obstacles for accessing and sharing geospatial data.
- To Identify/Interpret the current Ecuadorian geospatial market mechanism, regulations, and restrictions.

3.3. Methodology for data collection

Data have been collected using the questionnaire about Geospatial data activities and user needs (Appendix 4) conducted to main producers and users of geoinformation as well as some academic institutions in Ecuador concerned with the management of geospatial data. In previous research done by Mr. Rodolfo Salazar (2001), the main producers and users of geospatial data in Ecuador were identified. For the purpose of this research 12 organisations were considered (Table 3.1). Most of them deal with the production of core or framework data and others are regular users of geospatial data for specific applications.

A questionnaire containing 21 questions was distributed over 12 organizations in Quito during fieldwork conducted from 30th September 2002 to 18th October 2002.

Category	Organisation Name
Governmental	National Planning Office (ODEPLAN)
	National Office for Natural Resources (DINAREN)
	National Bureau of Statistic and Census (INEC)
	Ministry of Environment/Center for Environmental Information
	National Institute for Meteorology and Hydrology (INAMHI)
	Military Geographic Institute (IGM)
	National Remote Sensing Center (CLIRSEN)
	Navy Oceanographic Institute (INOCAR)
NGO	Natura Corporation
	Ecociencia Foundation
Academia	Geographic Information Systems Center (UNISIG)
	Pan-American Center for Geographic studies (CEPEIGE-head office Ecuador)

Table 3-1 List of respondent's organisations

The Response rate in this questionnaire was High. From Twelve (12) organizations selected, all returned completed questionnaire for a 100% response rate.

Moreover, during the fieldwork a workshop called " Implementation of Clearinghouse as an instrument of geospatial information management" has been organized; the purpose of this workshop was to introduce the concepts of SDI and specifically those related to clearinghouse. This event was conducted by IGM, CLIRSEN and HIGEODES and under the auspices of United Nations Development Program (UNDP- ECUADOR).

Replies to the questionnaire was collected one week after the workshop to give the participants the time needed to thoughtfully consider the answers. The following section presents the results.

3.4. Questionnaire results.

The main topics addressed by questionnaire are the following:

3.4.1. Use of geospatial data

Question related with use of spatial data, the respondents are expected to answer what spatial data sets are necessary to fulfill their requirements and the corresponding data sources.

The different spatial data sets introduced were:

1. Topographic maps
2. Administrative boundaries
3. Cadastral data
4. Vegetation data
5. Soil data
6. Geological data
7. Population data
8. Aerial photography
9. Satellite images
10. Others

Table 3.2 shows the results for each one of the options

Data-Types / Organizations	1	2	3	4	5	6	7	8	9	10
National Planning Office (ODEPLAN)	X	X		X	X	X	X			
National Office for Natural Resources (DINAREN)	X	X	X	X	X	X	X	X	X	X
National Bureau of Statistic and Census (INEC)	X	X	X				X	X		
Ministry of Environment –Center for Environmental Information	X	X	X	X	X	X	X	X	X	X
National Institute for Meteorology and Hydrology (INAMHI)	X	X		X	X	X		X	X	
Military Geographic Institute (IGM)	X	X	X	X	X		X	X		
National Remote Sensing Center (CLIRSEN)	X	X	X	X	X	X		X	X	
Navy Oceanographic Institute (INOCAR)	X				X	X		X	X	X
Natura Corporation	X	X		X	X	X	X	X	X	
Ecociencia Foundation	X	X		X	X	X	X	X	X	
Geographic Information Systems Center (UNISIG)	X	X	X	X				X	X	
Pan-American Center for Geographic studies (CEPEIGE-head office Ecuador)	X	X	X	X	X	X	X	X	X	
TOTAL (12)	**12**	**11**	**7**	**10**	**10**	**9**	**8**	**11**	**9**	**3**

Table 3-2 Spatial Data Requirement

It can be concluded that the most required data are foundation data; these data form the backdrop for display or analysis of other data for other applications.

The results show that the spatial data sets mostly used by these 12 organizations are: topographic maps, administrative boundaries, aerial photography, vegetation data and soil data, three respondents mentions another set of data such as hydrographical and weather data.

3.4.2. Data Usability

Respondents were asked about usability of geospatial data to fulfill their requirements.

- Seven (7) respondents indicated that data are available to fulfill their requirements and objectives.
- Five (5) respondents indicated that there are not enough data available to fulfill their requirements and objectives.

3.4.3. Data Maintenance

Most of respondents mentioned that their organizations maintain their data according to their planning. Generally, organisations draft a plan to update their data every 5 years, however these plans cannot be executed due to lacks of budget, it depends very much on availability of funding allocated for the central government.

3.4.4. Data collection and co-ordination

In the question related to activities to produce and update geographic information in a coordinated way, seven (7) organizations are working in a coordinated way; this coordination is more evident in militarily driven organisations and those working in environmental projects.

Some organizations have signed agreements between them to share information; five (5) organizations do not have any mechanism or policy to work in a coordinated way.

The lack of agreements and coordination brings on overlaps functions in data production, collection and supply and consequently waste of money.

3.4.5. Mechanisms to share data

In this part, two questions were addressed. The first one asked about the current mechanism used by organisation to share information with other organisations.

The different mechanisms evinced were:

1. E-mail
2. World-Wide-Web (WWW)
3. On line transfer programs (ftp) and
4. Others

Table 3-3 shows the results for each one of the options

Mechanism / Organizations	1	2	3	4
National Planning Office (ODEPLAN)				X
National Office for Natural Resources (DINAREN)	X			X
National Bureau of Statistic and Census (INEC)				X
Ministry of Environment –Center for Environmental Information	X		X	X
National Institute for Meteorology and Hydrology (INAMHI)		X		
Military Geographic Institute (IGM)	X	X		
National Remote Sensing Center (CLIRSEN)			X	
Navy Oceanographic Institute (INOCAR)	X	X	X	X
Natura Corporation	X			
Ecociencia Foundation	X	X		X
Geographic Information Systems Center (UNISIG)	X	X	X	X
Pan-American Center for Geographic studies (CEPEIGE-head office Ecuador)	X			
TOTAL (12)	**8**	**5**	**4**	**7**

Table 3-3 Current Mechanism to share data

Many organisations use more than one mechanism to access and share data but two or three mechanism.

The mechanism most used is e-mail, however this service presents some limitations especially when data files are big in size and exceed the allowed limits.

Others mechanisms used to share data are Intranet and use of magnetic devices like CDs, and paper format.

The second question was related over which mechanism would prefer the users to share geoinformation in the future (Table 3-4). Three options were offered to respondents:

1. Download from public web page
2. Via National Network (clearinghouse)
3. CD-ROM

Mechanism / Organizations	1	2	3
National Planning Office (ODEPLAN)		X	X
National Office for Natural Resources (DINAREN)	X	X	X
National Bureau of Statistic and Census (INEC)		X	X
Ministry of Environment –Center for Environmental Information	X	X	X
National Institute for Meteorology and Hydrology (INAMHI)		X	
Military Geographic Institute (IGM)		X	
National Remote Sensing Center (CLIRSEN)	X	X	
Navy Oceanographic Institute (INOCAR)	X	X	X
Natura Corporation		X	
Ecociencia Foundation			X
Geographic Information Systems Center (UNISIG)	X		X
Pan-American Center for Geographic studies (CEPEIGE-head office Ecuador)	X		
TOTAL (12)	**6**	**9**	**7**

Table 3-4 Future Mechanism to share data

The preferred mechanisms for discover and accessing data in the future are via a national network (clearinghouse), followed by using of CD-ROM and downloading from public web page

3.4.6. Perceived obstacles for sharing data

Respondents were asked about obstacles or impediments for sharing data (Table 3-5) Options evinced were:

1. Lack of hardware and software
2. Lack of qualified personnel
3. Financial problems
4. Lack of data quality
5. Lack of copyright policies
6. Security and commercial restrictions
7. Others

Obstacles / Organizations	1	2	3	4	5	6	7
National Planning Office (ODEPLAN)	X		X		X	X	
National Office for Natural Resources (DINAREN)			X	X	X	X	
National Bureau of Statistic and Census (INEC)				X		X	
Ministry of Environment –Center for Environmental Information		X	X		X	X	X
National Institute for Meteorology and Hydrology (INAMHI)		X		X		X	
Military Geographic Institute (IGM)			X	X			
National Remote Sensing Center (CLIRSEN)	X			X		X	
Navy Oceanographic Institute (INOCAR)	X	X	X	X	X	X	X
Natura Corporation			X		X	X	X
Ecociencia Foundation	X			X	X	X	

Geographic Information Systems Center (UNISIG)				X		X	X
Pan-American Center for Geographic studies (CEPEIGE-head office Ecuador)	X	X	X		X		
TOTAL (12)	**5**	**4**	**7**	**8**	**7**	**10**	**4**

Table 3-5 Perceived problems for accessing data

The main perceived obstacles to access data are:
Organisations accuse many security and commercial restrictions to access data, lack of data quality, lack of copyright policies and financial problems.
Other reasons perceived are the lack of coordination, lack of willingness to cooperate and lack of awareness about these issues.

3.4.7. Participation and involvement of organizations

Questions about participation and involvement of institutions in developing NSDI were addressed.
In spite of the NSDI concepts presented in the workshop, this question raises some doubt at respondents given the use of new terminology and concepts. Considering that SDI activities in Ecuador have been introduced recently, such participation and involvement is almost inexistent. However, there are some coordination initiatives that need to be mentioned. For instance IGM, CLIRSEN and INOCAR are conducting seminars about NSDI, courses about GIS and remote sensing, workshops, etc. The Ministry of Environment is working with some NGO's in projects about environmental protection with the aim of implementing the "National Environmental Information System."
Four (4) organizations are not working in any project or activity related to NSDI development, however these organizations are willing to participate and cooperate in activities to promote development of NSDI in the future. There is a consensus to create a National Council with a mandate to coordinate those activities.

3.4.8. Standardization

This question explores availability of policies for standardization and creation of metadata documentation in every organization.
Due to complexity of this issue and the lack of national standards for geospatial data, there is a considerable confusion about the use of standards. Although, organisations recognize the significance to apply standards, they refuse applying them. Only Governmental Organizations producing foundation data are following, in certain way, standards for map design and map presentation. Other organizations have no policies for standardization nor are following any standards for creation of spatial data.
In relation with creation of metadata, seven (7) organizations are providing informal and unstructured metadata documentation and only when the client is asking for it. This 'metadata' is described without specific format or standard. There is not policy about metadata implementation and content of metadata. The other five organizations do not document their data on a 'meta' level.

3.4.9. Funding

Although funds have not been assigned by the central government for specific SDI tasks, some organisations are seeking funds to promote this kind of activities.
Five organizations get funding to support development of projects related with environmental issues. These institutions have funds or loans from international organisations. Seven organizations have no specific funding assigned to this kind of activity and the budget allocated for the government is barely enough for its specific tasks.

3.4.10. Pricing

The following responses are related to pricing policy:

Seven organisations have defined policies for determination of prices of their products, the methods used to calculate prices are as follow:

- 5 organisations use Production cost accounting (cost recovery),
- 1 organisation fixes the prices in base of product-demand. (market research) and
- 1 annotated that authorities fix prices.

Five (5) organisations have not well defined policies to fix prices of their products.

3.4.11. Spatial data requirements

Respondents were asked about what products they are generating and what spatial data they require to produce such products and precision required (table 3-6).

User	Products generated and Specifications	Data required	Scale needed and precision required
National Planning Office (ODEPLAN)	Definition of policies and coordination of the National Information System among different governmental institutions.		
National Office for Natural Resources (DINAREN)	Land use Map 1:250000 Geomorphologic map 1:250000 Different thematic maps 1:250000 Geological maps 1:250000	Satellites images, Databases, Topographic maps Aerial photographs, orthophotos	1:1000000 1:250000 1:50000 1:10000 Precision: Between 1 m and 10 m.
National Bureau of Statistic and Census (INEC)	General Statistical data of the country. Census Maps 1:50000 Census plans 1:5000	Satellite images Orthophotos Cadastral maps	1:50000 1:10000 1:5000 Precision: Between 1 m and 10 m.
Ministry of Environment– Center for Environmental Information	Protected areas Maps 1:250000 Forest Reserve Maps 1:250000 Sustainable Management Maps. 1:50000 National System of Protected Areas.	Satellites images, Databases, Topographic maps Aerial photographs, Orthophotos	1: 250000 1: 50000 1: 10000 1: 5000 1: 1000 Precision: Between 1 m. and 10 m.
National Institute for Meteorology and Hydrology (INAMHI)	Hydrological and climatologic information	Satellites images, Databases, Topographic maps Aerial photograph,	1: 1000000 1: 250000
Military Geographic Institute (IGM)	Geodetic network: Horizontal and vertical control points. Aerial photographs Scale: 1:30000 and larger Topographic maps	Satellites images, Databases, Topographic maps Aerial photographs, orthophotos	IGM is the national mapping agency and uses its own data produced. Precision needed to

	Scale: 1:10000 and larger Cadastral maps Scale: 1:1000 Geographic names		produce its data is very high.
National Remote Sensing Center (CLIRSEN)	Satellites Images. Landsat, SPOT, ERS Land use maps. Scales 1:250000-1:50000 Land cover maps. Scales 1:250000-1:50000 Natural resources maps. Scales 1:250000-1:50000	Satellites images, Databases, Topographic maps Aerial photographs, Orthophotos	1:250000 1:50000
Navy Oceanographic Institute (INOCAR)	Nautical chart. Scale: 1:10000 1:12:500 1:25:000 1:50000	Satellites images, Databases, Topographic maps Aerial photographs, Orthophotos	INOCAR produce the national nautical chart. Precision needed to produce its data is very high
Natura Corporation (ONG)	Land use maps 1:50000 Land cover maps 1:50000 Ecological Distribution maps 1:50000		1:250000 1:50000 1:10000 Precision: Between 1 m and 10 m
Ecociencia Foundation (ONG)	Land use map 1:5000 Rural cadastral maps: 1:20000	Satellites images, Databases, Topographic maps Aerial photographs, Orthophotos Statistical data	1:50000 1:10000 1:5000 1:1000 Precision: Between 1 m and 10 m.
Geographic Information Systems Center (UNISIG)	Most of the time is dedicated to education; lecturing at pre- and post-graduate level, seminars about geostatistics, remote sensing, etc. However, They carry out some specific projects to get funds.	Satellites images, Databases, Topographic maps Aerial photographs, Orthophotos	1:50000 1:10000 1:5000 1:1000 Precision: Between 1 m and 10 m.
Pan-American Center for Geographic studies (CEPEIGE-head office Ecuador)	Educational organisation. Seminars and different Courses.		

Table 3-6 Spatial Data Requirements

3.5. Workshop Results

In the Workshop organized along with main stakeholders the following issues were addressed and considered relevant for the creation of the NSDI:

- To define and create in a near future a National Council. This national coordinating body must have legal mandate for designing and implementing SDI concepts, coordinating the development of standards and protocols and providing guidelines for the establishment and good

functioning of the NGDI. Figure 3-1 shows the first approach for the constitution and level of hierarchy of this body presented and discussed by participants.

- The coordinating body needs to be mandated to manage the required activities and devise an action plan to coordinate the activities. Consideration should be given to the necessary resources for implementing strategy, policy or plans and activities, considering staff, technical know-how, material, and funding opportunities.
- Formal working groups should be organized around well-defined objectives, strategies, plans, programmes, and actions. These working groups would be made up of interested parties and experts to deal with specific aspects of NSDI such standards (metadata, exchange, etc) national data sets, policies, clearinghouse and how to assimilate existing technological solutions into the local context.
- To promote initiatives of IGM, CLIRSEN and HIGEODES for the development of Clearinghouse nodes for geospatial data and spread these initiatives to other organizations involved with the creation of geospatial data in Ecuador.
- In countries like Ecuador where GIS implementations are, in the majority of the cases, dependent on donor involvement in terms of funding and technical expertise, donor representatives should be considered as stakeholders and included in the process of building the NSDI. The role of donors should be clarified to support activities by way of following national priorities e.g. interoperability of Different GIS implementations rather than to be associated with a particular type of activity that fit with the broader national objectives.

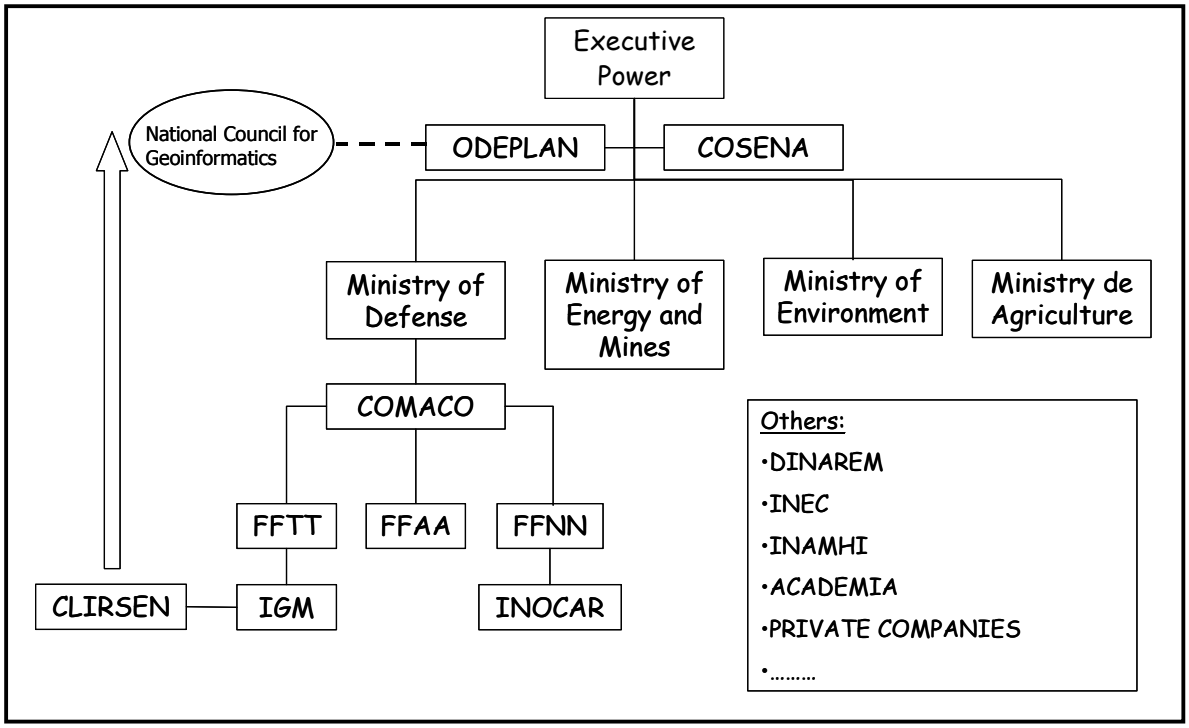


Figure 3-1 Proposed constitution and level of hierarchy of the National Council of Geoinformatics

At the end of this workshop, participants signed an understanding agreement (Appendix 2) in which they compromise its better efforts to work towards the development of the NSDI and implementation of the National Clearinghouse.

3.6. Concluding remarks

From analysis done, the more important findings are summarized below:

- The majority of the institutions are motivated by their own mission therefore a great extent do not subscribe to a common national objectives. The lack of national policies concerning with the management of geospatial data is the main problem. Existing systems serve primarily their own customers, without concern for the needs of other potential users. This leads to the duplication of efforts and inefficient use of resources, both financial and human.
- Organizations mentioned that regularly maintain its data, however some organizations complains lack of updated information to fulfill its requirements, apparently there is a lack of knowledge about What data is produced by other organizations.
- Some organizations are working in a coordinated way to produce geospatial data specially those are involving in environmental projects and those militarily driven. However the cooperation and coordination between governmental organizations is limited. Due to the lack of coordination, the different data structures will not be compatible to facilitate data exchange. Although networking relationships exist between people, these are based on individual contacts and friendship and are not reflected in an operational coordination of activities.
- The lack of agreements and coordination brings on overlap in data production, collection and supply and consequently a huge waste of money.
- Some spatial databases being built up are "stand alone systems", using individual philosophies and technologies (concepts, structures, hardware and software). Most of these implementations are technology and donor driven and as such are isolated implementations and related to environmental issues.
- The current mechanism used to access and share information between organisations are: e-mail, on line file transfer protocol and CDs, the majority of organisation uses more than one mechanism to access and share information. All organisations have access to Internet.
- For future desired mechanism to discover and access data, organisations would prefer knowing and getting information from a National clearinghouse.
- Many organisations comply about many security and commercial restrictions to get spatial data from IGM especially those data related with border areas that authorities consider it sensitive from the national security perspective. Authorities of IGM should revise existing data security policies and define more realistic policies and according with SDI perspective. There is no complete confidence about quality of data produced by organisations; obviously it is a result of the lack of policies for data quality management within organisations.
- On May 1998, Ecuador enacted an Intellectual Property Law (IPL), which covers all aspects of intellectual property, from copyrights to trademarks to patents. Although this copyright law created the IEPI (the Ecuadorian Intellectual Property Institute) to implement the country's Intellectual property laws, the central government has not provided the IEPI with an adequate budget to fully perform its obligations. Furthermore, not everyone acknowledges IEPI as the National Copyright Office, and there is no clear understanding of what IEPI's role is with respect to the protection of intellectual property. With respect to geospatial data, there is no a well-defined copyright law to protect geospatial data and its appropriate use, it has not been addressed simply because it is not seen as a priority.

- The lack of policies for geographic data standardization in national level is one of the major constraints; there are tremendous increases of digital data set, but heterogeneous (different host, data sources and data structure), therefore standardization activities become a high priority.
- There is no formal metadata produced at all, agencies are documenting their data without specific format or structure.
- There are no clear policies for determining prices of data. Therefore organisations have fixed prices according with their own propriety.

4. Clearinghouse Architectures and Metadata Standard

4.1. Introduction

In the previous chapter current problems for acquisition and dissemination of geospatial data as well as its regulations and restrictions were identified and analyzed. The Ecuadorian geospatial user community identified a need for tools that help them knowing who has data, where and how to get them, conditions related to the use of the data and ultimately data sharing.

Given today's technological capabilities, availability of internet and Information and Communication Technology available in national context, these needs can be partly solved. Many users envision the introduction of a clearinghouse as the solution of some of these problems.

In this chapter, the Client/Server Architecture is introduced, the functional requirements for a geospatial data clearinghouse are identified and different architectures for clearinghouses are analyzed to find out the most appropriate architecture for the national clearinghouse. In the second part of this chapter, a metadata standard for the national clearinghouse is selected and proposed and issues regarding metadata management are pointed out.

4.2. Client server Architecture

The Client Server Architecture is a common form of a distributed system where software is split between client-and server-tasks.

A client is a process running on a computer requesting for services on another process available on a server using rules (protocol). The server processes the request and sends the result back to the client (Figure 4-1). The most common client program is a Web browser (e.g. Netscape Navigator, Microsoft Internet explorer). By means of an URL the browser programs sends a request to the server and finally a file is transmitted from the server to the clients. The server side usually consists of many technologies that are working together such as databases and middleware. Middleware has the function of dividing information in small packets and checks if it received by the client.

In a distributed system, a user does not see which computer is performing which functions

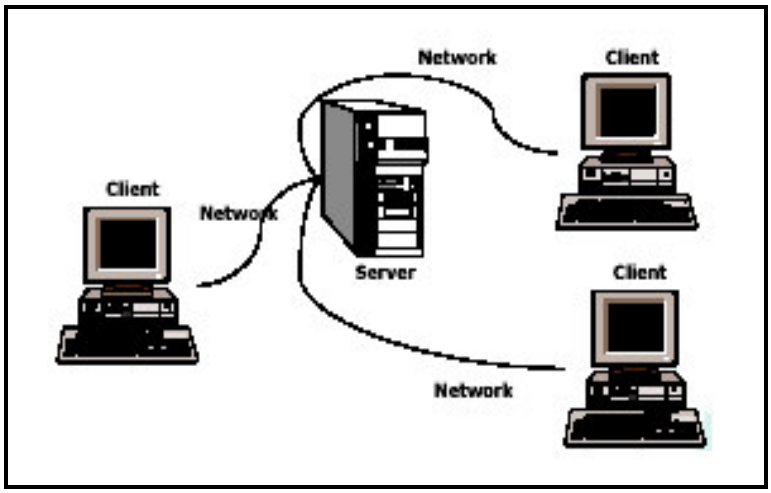


Figure 4-1 Client-server architecture

In client- server set-up, there are usually many clients using few servers. A major difficulty in the client-server model and consequently in Distributed Computing Environment (DCE) is that many standards apply.

A clearinghouse is an example of a client-server architecture; the server machines contain metadata and the client requests information about the availability of data by visiting the server nodes, usually through a web browser. Providers of a clearinghouse must have access to a machine directly connected to the Internet. In the ideal case not only metadata are available but the server also provides a link to the data itself.

Figure 4-2 shows the typical clearinghouse architecture consisting of many inter-operating metadata servers.

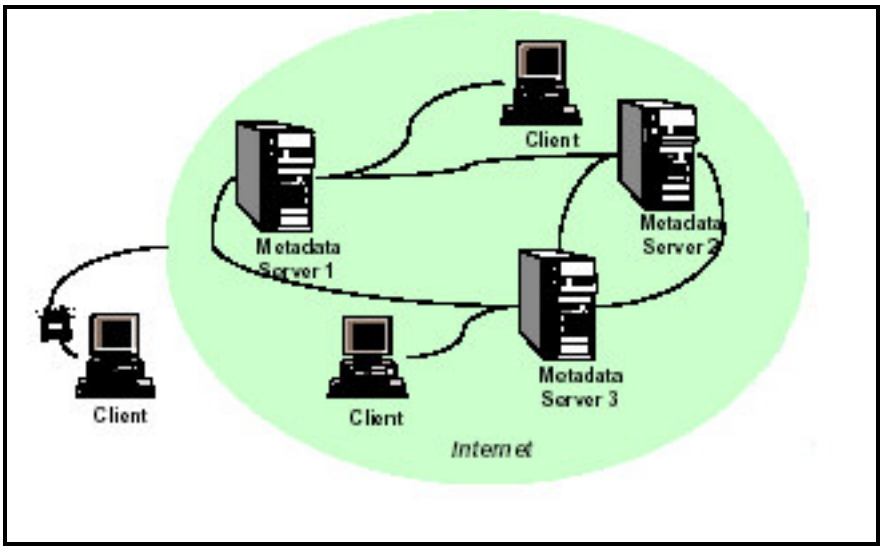


Figure 4-2 Clearinghouse Concept

4.3. Geospatial Data Clearinghouse

A Clearinghouse is a decentralized system of servers on the Internet, which contain field-level descriptions of available spatial data (metadata) (Nebert 2001). Metadata are collected and served in a standard format to facilitate consistent queries and data-presentation across multiple participating sites. A fundamental goal of a clearinghouse is to provide access to digital spatial data through metadata. From users perspective, the clearinghouse is a service to discover which organization has which data and its fitness to use.

A clearinghouse allows individual agencies or geographically defined communities to work together and to promote the use of their available digital spatial data. Servers are installed at local, regional or central offices dictated by the organisational and logistical efficiencies of each organisation.(Rocca S, 1999)

For the NSDI, the clearinghouse provides a virtual consolidated information space across which searches may be conducted through a single query. A user interested in locating geospatial information interacts with a single search form, specifying queries against geographic, temporal, and text fields as well as free-text while targeting one, several or all registered servers.(Nebert D, 2000).

4.4. The conceptual design of geospatial data clearinghouse

The first logical step in the design of most hardware/software configurations is a conceptual design that focuses on the functional requirements of users. (Antenucci et al., 1991)
The conceptual design should be based on:

- Sound familiarity with the intended applications of system users;
- Knowledge of the fundamental concepts of computer hardware, software and data communications;
- Familiarity with site conditions, existing systems and communication facilities already in place that may influence the design and knowledge of the current status of ICT and new developments that may affect the system;
- A description of the function and purpose of hardware and software and the interrelationship between devices and applications in a configuration.
- Provision of an initial basis to review system requirements, to make refinements, to estimate costs, and to establish a foundation for the definition of more detailed specification that precedes system procurement;
- A description of the expansion of the system in phases reflecting expected growth with new applications, new users, and an expanded database.
- Provision of added value to the users; either by replacing tasks, or offering new opportunities.

The functional requirements for a geospatial Clearinghouse could be derived from the analysis based on the database management perspective and the users perspective.

4.4.1. Functional requirements based on database management perspective.

From the database management perspective, there are generally two approaches to store and manage geospatial data.(Ozsu et al., 1990): centralized data storage and a distributed data management system. In the centralized approach data storage of all relevant geospatial data from the various providers are collected and stored in a central location, while a distributed database consists of a number of sites interconnected through a communication network with each site. In each site a autonomous Data Base Management System (DBMS) is accessible. Important features of a distributed database environment are distribution transparency, fragmentation and replication. Distribution transparency means that the user does not see where the data in the database are physically located. Even if the same data are stored in duplicate at different locations for reasons of efficiency (using replication technology) or if different columns of a table are physically located at different local databases (fragmentation), the user perceives a central database (Bishr & Radwan, 2000).
Traditional databases design involves conceptual, logical and physical design, while distributed databases also involve distribution design.

4.4.2. Functional requirements from user's perspective

The functional requirements for a clearinghouse have been defined as follow (Radwan et al., 1997):

- Support both search and browse on the Internet. Increasing number of datasets demands efficient searching mechanism rather than browsing arbitrarily all scattered information page by page. Searching is more efficient to find relevant information which the user needs. . A National Clearinghouse is required to use several searching criteria; theme name, the geographic

coverage, the last update for the dataset, the context in which information has collected, the conditions for access and use, and so on.

- The search mechanism must accommodate the experienced of Geoinformation user as well as potential users. The experienced user can directly enter the specific terms instead of scrolling down the pre-defined selectable items, so a free text search is preferred to selectable items. On the other hand, selectable items and thesauruses that define the meaning of words used in specific disciplines are required to prevent confusion of the word. For the non-experienced user, the search mechanism ought to use simple and non-technical language.
- The interface must be friendly, simple to use, and largely intuitive in style. Point and click interface is preferred to a form-based interface for the spatial query. Normally, form-based query demands the user to enter the bounding coordinates of the area of interest by using the keyboard, which is more cumbersome than clicking a rectangular area or pointing to a predefined area using the mouse.
- The interface should present the results from a search in a predictable form with a simple language. It is also preferred to provide a simple map browsing tool to show a sample map, if available. Data quality information is required for most purposes, but the degree of detail can vary according to applications.
- A clearinghouse could support in on-line (meta-)data access, data ordering, and data delivering. Those who do not have an on-line access facility however require both CD-ROM version and paper-version for the off-line searching and browsing.
- A clearinghouse provides metadata capturing tools and an updating mechanism trough the Internet. It should, as much as possible, minimize investments in software development for an interactive user interface for spatial query, metadata conversion, entry and update using existing (off-shelf) cross-platform tools that can run on top of a common web browser.
- A clearinghouse also provides a “data forecasting” capacity to prevent duplication of efforts on data collection.

4.5. Different System architectures for Geospatial data Clearinghouse.

A Clearinghouse architecture can be defined as a set of components and the interconnection between them. These interconnections are defined in terms of the services that a component provides and the protocols for interaction between components. According to the number of clearinghouse servers and the detail levels of metadata, there are potentially three basic system architectures for a clearinghouse, i.e. centralised metadata service, decentralized metadata service and hybrid metadata service (Radwan et al, 1997).

The following table summarizes the main features, pros and cons of different architectures for clearinghouses:

Centralized Metadata service	Decentralized Metadata service	Hybrid Metadata service
Main features: ❑ Metadata are controlled by one metadata service provider ❑ Metadata service relies on 'donation" of metadata from data providers ❑ Users have direct access to a central pool of metadata (metadatabase) **Pros:** 1. This concept shows the advantage of a relatively simple technical infrastructure. 2. It should enable fast and efficient searches. 3. It should be easy to maintain and monitor wide geospatial datasets and consequently in reduction of data duplication. 4. It provides ability to ensure that data quality standards are maintained, security restrictions are enforced and integrity is maintained. **Cons:** 1. Poor Update frequency, since data and metadata are maintained in different locations by different organisations. 2. The central organisation needed to run the clearinghouse is cumbersome and probably not financial sustainable in the long run(Bregt. A, 2000) 3. To store detailed metadata in one metadatabase, the system would be expensive and complex to implement. 4. This service may run the risk of being over-engineered (database becomes too large) which compromise the performance. 5. It gives much burden for data providers to maintain the central metadata copies as well as the local copies on their own locations.	**Main features:** ❑ There is no central metadata service ❑ Users access data providers via a small number of service providers ❑ Each service provider has their own metadata and data and can also provide pointer to other service providers and data providers. ❑ Metadata service providers are also data providers **Pros:** 1. Data and metadata are maintained together by data providers. 2. More flexibility for data producers to update and maintain metadata. 3. It gives more responsibilities to organisation providing data. **Cons:** 1. It does not provide a means to monitor the datasets in a national level, which might result in data duplication. 2. To find the suitable data for their applications, users have to know the relevant metadata servers and usually a number of servers have to be visited.	**Main features:** ❑ It is a mixture of centralized and decentralized metadata service ❑ Provision of a gateway to metadata service providers; ❑ Users access all metadata via one single clearinghouse gateway and then the search for information is distributed over various sources ❑ Different levels of metadata are maintained. **Pros:** 1. It is easy to monitor national wide datasets to avoid duplication. 2. More flexibility for data producers to update and maintain metadata. 3. It gives more responsibilities to organisation providing data. **Cons:** 1. Since two levels of metadata are required, one for the local metadata and other for the global metadata, more work has to be done. 2. In order to make the global metadata is needed to develop an abstraction mechanism that converts local metadata into global metadata. 3. After searching the global metadata, users still have to search the local metadata again to get detailed metadata.

Table 4-1 Main features, pros and cons of different architectures for clearinghouses

According to this analysis, the most suitable architecture for the clearinghouse is the hybrid system. A mentioned, one of the features of the hybrid system is the provision of a clearinghouse gateway. There are two different approaches for clearinghouse gateway (Aimin G, 2000): one is by maintenance of global metadata and the other one is by registration of clearinghouse nodes. The difference between global metadata and registry of servers is the level of 'generalisation'. The registry of servers is more generalized, it only contains information about the metadata server and does not contain any information about the local metadata served by the metadata server (Aimin G, 2000). Maintenance of global metadata is more difficult than that of server registry (or server-level metadata) in the host of the clearinghouse gateway.

Due to the cons of maintaining two levels of metadata, the server registry approach is recommended.

4.6. The selected Client/Server clearinghouse architecture

This architecture is a hybrid system, it is implemented using a multi-tier software architecture that includes a client tier, a middleware or gateway tier and a server tier as is illustrated in figure 4-3.

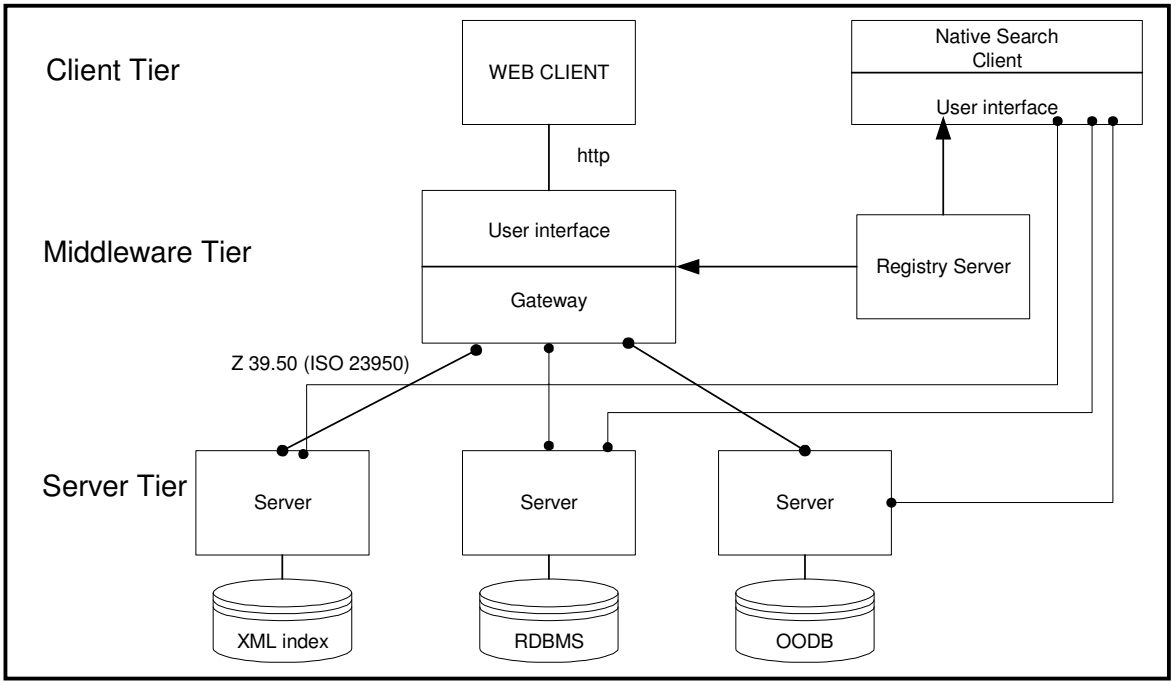


Figure 4-3 Implementation view of distributed clearinghouse services (from GSDI, 2001)

It is composed of three main components: Web Clients, Clearinghouse Gateway and clearinghouse Nodes.

The different components, functions and specifications are discussed in more detail in the next chapter.

4.7. Clearinghouse nodes in Relation to other Web Resources

Given the current Web technology, World Wide Web sites can be developed for querying and distribution of spatial data. These sites allow users to easily view or acquire data, and they represent a great resource to the users.

The different focus of these web sites complement, rather than compete with, the clearinghouse nodes. These web sites offer unique views of a particular agency's data and its resources. In contrast, Clearinghouse technology offers the ability to use a single query to search a network of data sites, and provides a standard view and documentation scheme for the metadata from all of those sites. Metadata entries discovered through a clearinghouse search can link to effective networked agency resources for the particular data located. The term “clearinghouse” denotes a method of referencing and accessing the vast amount of data that is available. The detailed treatment of a particular data resource is not the focus of a clearinghouse. Furthermore, the comprehensive query and reference of data resources is for the most part beyond the capabilities or strengths of typical web sites.

Performing a standard internet search program on the Web for "land use", for example, users might haphazardly locate a good net resource quicker than using a geospatial data clearinghouse node.

These searches are full-text searches and are consequently less selective. Furthermore, the only leads found would be those from existing web sites that happened to be indexed by that search engine, and these may often have out-of-date pointers. In contrast, a Clearinghouse query can locate a data resource, which is not available from a Web server, but is available as a hard copy map, a compact disk that can be ordered, or is in a particular organization's digital archives. Clearinghouse and Web sites each have their strengths and they can complement each other.

4.8. Content of metadata

As is mentioned in section 3.4.8 there is no policy for metadata implementation neither a standard for metadata content established at national level.

The metadata standard suggested to adopt in the clearinghouse implementation is the FGDC Content Standard for digital Geospatial Metadata (CSDGM).

Despite the size and level of complexity of this standard, one advantage of using this standard is that it is fairly flexible (SEDAC, 2002). It can be modified for specific data types by employing an endorsed "profile" or "extension", which is simply an addition or a simplification to the standard.

Another reason to suggest this standard is that almost all NSDI in the region have adopted this standard in its clearinghouses implementation, and in support of GSDI concepts, the adoption of this metadata standard would facilitate further integration with other clearinghouses in the region.

However, in the future, it is highly recommended that the National Council of Geoinformatics defines the national Metadata standard with the participation and agreement of participants of the National Geospatial Data Infrastructure, considering International standards.

4.9. Managing and maintaining metadata

Metadata need to be created and maintained in a standardized, electronically searchable format to become the basis for a clearinghouse online catalog.

A major challenge for this component of the clearinghouse is the production and maintenance of metadata that can be searched from a single World Wide Web site

Once metadata standards have been agreed, the implementation is, by and large, not a major technical problem (GISFORM, 2001).

However, the high level of detail of metadata contents, the technical terminology, and a confusing variety of metadata formats are reasons that may impede the use of metadata. The same reasons also contribute to the avoidance of creating metadata. Formal studies of metadata implementation (Gelbman R and Maathys T) have discovered that even though a majority of data-producers recognize the benefits of metadata, there continues to be reluctance to commit time to create metadata. This is because a commitment to metadata would take too much time away from more important or necessary responsibilities. However some actions and procedures can be lay on practice to facilitate implementation of metadata:

- Incorporate metadata in every organization's mission, and job descriptions.
- Determine the appropriate level of detail for metadata in every organisation.
- Make metadata creation and maintenance part of the data process.
- Provide adequate training and tools up front (get help from other organisations using metadata) Once trained, develop programs/workshops to help other organisations.
- Use free metadata tools.
- Include metadata specifications in all acquirements for geospatial data.

- Metadata support needs for data security and privacy.
- Possess examples of completed metadata on hand in the moment when metadata is created could be helpful.

4.9.1. Principles of Metadata Management

There are 4 Principles of Metadata Management considered important at the moment of implementing metadata standard (IGGI, 2001):

a) *Establishing a metadata policy*. The first and most significant step for any organisation wishing to implement systematic, organisation-wide Metadata is to define a Metadata Policy. This is a set of broad, high-level principles that form the guiding framework within which the Metadata management can operate. This Policy must be adopted formally by senior management, and supported by appropriate resources and authority. Experience has shown that Metadata Policy implementation must have backing at the highest level within an organisation. A clear high-level directive is absolutely essential. It is essential that such policy statements have a 'Policy Champion' who will own the Policy at Executive level within an organisation.

b) *Adopting a Metadata Standard*. When choosing a standard to adopt for an organisation it is essential to identify the Metadata published. This is to ensure that all the mandatory information required by the clearinghouse specification will be collected during the initial compilation of Metadata.

c) *Initial compilation of the Metadata*. The first major task following the adoption of a standard is to initiate compilation of Metadata across the organisation. This is best done as a single project to identify all data assets and assign knowledgeable individuals to complete the Metadata entry. Ideally, a nominated Metadata Steward who reports to the Metadata Policy Champion will manage the project. One key factor to consider is that Metadata compilation should be a thorough process that builds a comprehensive description of the datasets available within an organisation. The role of the Metadata Steward is key in ensuring that an overview is maintained. There must be no significant omissions, despite excuses, etc. The role of the Policy Champion is essential in this part of the process in ensuring compliance.

d) *Maintenance of Metadata.* Once the Metadata for an organisation have been compiled it is essential that they will be maintained actively. Otherwise the currency, and thus use, of the Metadata will degrade with time. Maintenance is required on several levels and over long periods and these each need to be considered. Even with investment in technically sophisticated search tools, such systems will find little user acceptance if the data are incomplete or not up-to-date. Hence, following initial Metadata compilation, the subsequent Metadata maintenance is of major importance. The role of the Metadata Steward is essential in ensuring that maintenance is consistently carried out over a long period.

4.10. Metadata Tools for geospatial data.

There are a considerable amount of metadata management and collection tools available. These include tools for entering and editing metadata and utilities for pre-processing, extracting, post processing, and validating metadata. For the case of Ecuador where no spatial metadata standard has been defined and no specific tool is applied, the use of free available conversion tools is recommended. Appendix 3 summarizes most of the known metadata tools used for documenting geospatial data and serving geospatial metadata. Most of these tools were designed to help complete Content Standards for Digital Geospatial Metadata (CSDGM).

Concluding remarks

In this chapter, the different architectures for clearinghouse were identified and evaluated and then the architecture for the National Clearinghouse is proposed in basis of this analysis. The architecture selected is the hybrid system; it is implemented using a multi-tier software architecture that includes a client tier, a middleware or gateway tier and a server tier. Its main components are the Web Client, clearinghouse Gateway and Clearinghouse nodes. Given the importance of metadata standard and metadata implementation for the clearinghouse, a metadata content standard is suggested to apply in the implementation of the National Clearinghouse as well as issues of metadata management are addressed to facilitate the implementation of metadata.

5. Conceptual Design of Ecuadorian Geospatial Data Clearinghouse

5.1. Introduction

In the previous chapter the architecture for a national clearinghouse for Ecuador was proposed. In this chapter both the conceptual design of the Ecuadorian clearinghouse as well as an approach for the implementation are presented. The latter includes a proposal for performance criteria for the evaluation of the development of the clearinghouse. Based on such criteria a development plan can be implemented, monitored and controlled.

5.2. The proposed Ecuadorian National Clearinghouse

The general conceptual architecture for the National clearinghouse is depicted in figure 5-1.
It composed of three main components: Web Clients, Clearinghouse Gateway and clearinghouse Nodes, the interconnection between components is through Internet. Although not yet fully accessible and operational in all organizations, the choice to use Internet as a basic architecture seems obvious. It is expected that most future geoinformation applications and services will be based on web-related software and technology, and it has been proved to enable a future relation with the commercial and e-commerce based sector. The growth of location based services applications using XML, and investigations of GML, are only some first examples of this.

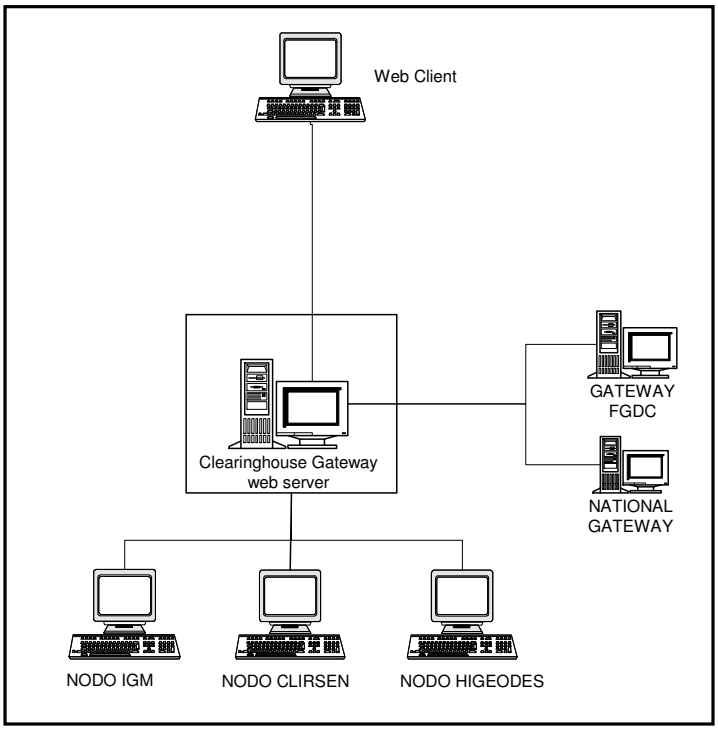


Figure 5-1 Conceptual diagram of National Clearinghouse

5.2.1. Web client

To search the clearinghouse a user goes to the clearinghouse website using their web client normally a web browser and access the page with the search form.
The Web browser enables (authorized / non-authorized) users to connect to the clearinghouse gateway search interface and to specify the criteria to query the distributed metadata. To secure some form of protection it is possible to use an authentication procedure before accessing the data. There are various of such procedures available and operational in the market. Although data in an initial stage may be freely accessible, experiences show that once payments become necessary, authentication using public and private keys may become indispensable. Prior to this, a system of registration may be possible, as further explained hereafter.

5.2.2. Clearinghouse Gateway

Clearinghouse gateway typically includes a web server, a search interface, a metadata client and a registry of distributed metadata servers as is depicted in figure 5-2

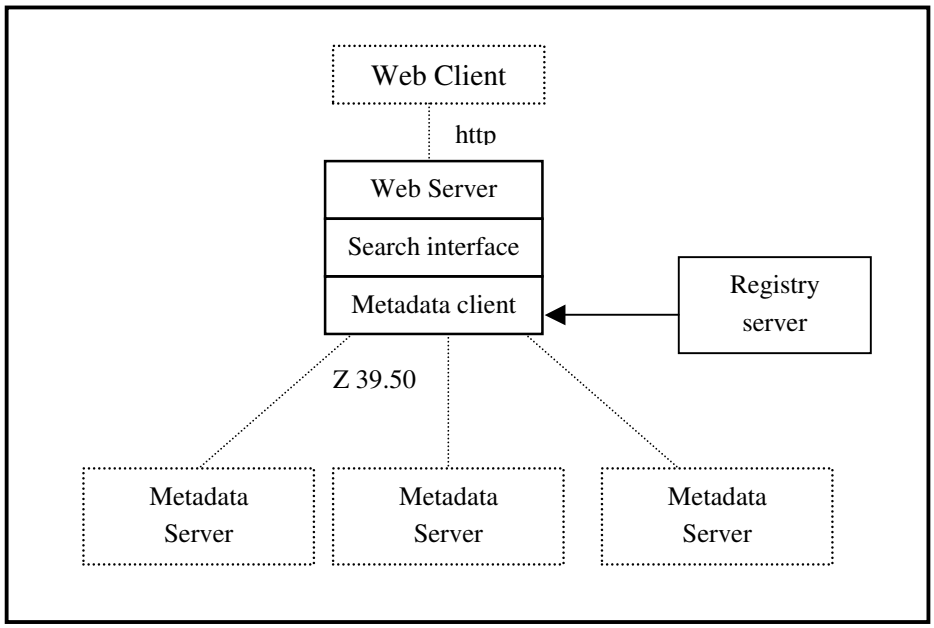


Figure 5-2 Configuration of clearinghouse gateway

The web server is responsible for all communications between web client and clearinghouse gateway through the hypertext transfer protocol (HTTP).
The search interface collects the query parameters defined by a user and sends the query to the metadata client in standard format. The metadata client is responsible for the distributed search and retrieval though a common communication protocol such as Z39.50.
The clearinghouse gateway functions as a mediator between data providers and data users. It provides a single point of access for both consumers and suppliers of data and has two main functions: maintenance of the server registry and it provides distributed search and retrieval capability to users.

5.2.2.1 Search interface

When a user selects the query service, a search interface will be displayed for the user to define his query criteria by entering or selecting search parameters. The query is then decomposed and reformatted into a standard form and distributed to all servers identified by the users through the metadata client.

The search results are presented to the user in certain format such as HTML or text, which allows the user to view them with the web browser. With the link embedded in the metadata, a user can send an order form to the data provider for datasets or can request datasets online.

In a client/server system, the client can request a service form the server through Graphic User Interface (GUI). In the case of the clearinghouse gateway, the metadata client module functions as the server of the search interface. Usually most GUIs for Internet based applications are running on top of web browsers.

There are basically two types of search interface for a clearinghouse. One is a html based search interface; the other is Java based search interface. The html form can be used to collect user query components, which can be send to the metadata client through the common gateway interface (CGI) via HTTP POST method. Java applets accompanying an HTML documents or directly embedded in it, running on the client side offer a means to extend the search interface in an interactive way. The main functions of the search interface include:

- Providing query forms for users to select or enter search parameters,
- Sending query parameters to the metadata client,
- Presenting the search results to the user to browse through or view,
- Allowing the user to request for metadata from metadata servers,
- Allowing the user to send order information or to request datasets from clearinghouse nodes.

5.2.2.2 Registration of distributed metadata server

When a user accesses the clearinghouse gateway web site, a web page will be displayed to provide a means of selecting a specific service. If a data provider selects a service to add or to update the registration of his metadata server, a user interface will be displayed to allow him to enter or to modify the metadata server attributes. A user name and password are required, because only the clearinghouse node administrator has the authenticated rights to do that. The information then is stored in the server registry. A Clearinghouse registry or catalog of the metadata server is a database about all clearinghouse nodes participating in the clearinghouse activity. The nature of distributed servers requires that the knowledge of the existence and properties of any given node participating in a community should be known to the community. In support of GSDI concepts, the need for a dynamic directory of clearinghouse servers is important.

5.2.3. Clearinghouse nodes

A clearinghouse node consists of metadata server, metadata management system, an API between metadata server and metadata management system, data store and data services as is depicted in Figure 5-3

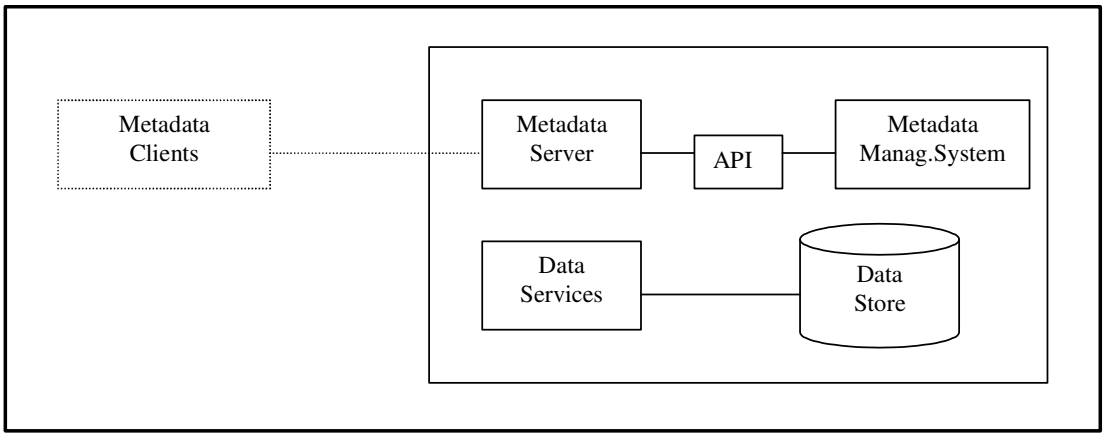


Figure 5-3 Configuration of a clearinghouse node

The main functions of a clearinghouse node are maintaining geospatial data and metadata, responding to the metadata search from the clearinghouse gateway, providing geodata services to facilitate access, ordering, delivering and sharing of data sets.

5.2.3.1 Metadata server.

The metadata server provides the interface between the clearinghouse gateway request and the local metadata management system. The metadata management system is external to the metadata server. The metadata server provides a neutral form of access from a client to a server-side API. Within the metadata server there are mappings to data and functions in the metadata management system. This permits different implementations of databases or document collection that are viewable as the same from the user's perspective. Each metadata server can be linked to one or more clearinghouse gateways if available. The metadata server accesses the metadata through an API. For instance, if the metadata are managed by RDBMS, that API could be Open Database Connectivity (ODBC).

5.2.3.2 Metadata management system

Inside each clearinghouse node, organisations will collect and manage metadata using data management systems according to their organisational requirements. There can be different ways for an organisation to store the metadata, however it is important that these data management systems can provide metadata that can be indexed and searched from the respective metadata indexes. Metadata index provides optimization of search for a given metadata object class. The metadata indexes are linked with the metadata server.

5.2.3.3 Data store.

This is the geospatial data maintained in a clearinghouse node. A data store holds one or more data sets. The definition of a dataset can be adjusted to meet a given organization's requirements but it generally correspond to the smallest identifiable data product for which metadata are collected.

5.2.3.4 Data services.

Each organisation can decide which geodata services to be provided inside a clearinghouse node. Geodata can be online or offline. Some organisations may decide that geodata services are outside the scope of the clearinghouse and provide no geodata services. The OpenGIS Abstract specification

Topic 12: Open GIS service architecture provides a framework of services required for the development and execution of geospatial oriented applications. (OGC,1999)

In clearinghouse, four types of services may be defined:

1. A data access Service extracts data from a data store. It minimally offers extraction of a copy of a dataset, but typically selection of a subset of dataset. Examples are selection of the portion corresponding to a geographic sub region, extraction of a named file from a collection, etc.
2. A geoprocessing service operates on data supplied or nominated by a user to generate a derived dataset. Data 'nominated' by the user is data to be supplied by a data access service or by another geoprocessing services. Data 'supplied' by a user is data originating from the user. Geoprocessing service operations include transformation, analysis, model-based prediction, optimisation and so on. The most common example is to convert the existing geospatial data set format into a standard or specific format based on the user's request.
3. Portrayal service operates on data from a data access service, data derived by a geoprocessing service or data supplied by a user to generate a data set in a suitable form for the production of a visualisation by the user's application. One of these kinds of applications is web mapping. Web mapping services are used to assist users in geospatial search system, showing geographic context and extent of relevant data against base map reference data. The Internet is used to connect a user with a server, and often the client runs the application within a browser. The online map building could happen based on the following sequence of steps (Green and Bossomaier, 2002):
    - Selection or specification of details of map by user (limits, border, etc.)
    - User's browser ("client") needs to transmit these details to the server
    - Interpretation of request by server
    - Access of server to the relevant data
    - Building of map by the server and turning it to an image (e.g. GIF fomat)
    - Building of an HTML document by the server and embed the above image in it
    - Server return the above document and image to the client
    - Browser displays the document and image for the user
4. Ancillary services provide a user with support for identifying and using the other service types. These may include E-commerce services for ordering and charging, security service and 'value adding' service. A prominent growth is expected in location-based services. It is estimated that with a connection to telecom facilities 71% will offer location-based services[1], which will somehow require basic up-to-date geospatial information. It must be said, however that the security and transaction controls are critical for the online transaction in any network-based architecture. For example, when a user access to certain geodata service, the user may be asked to enter his 'user name' and 'password' as registered in the service, the security service is invoked to check the user's authority to the service. Only authorized user has accessibility to the geodata service.

[1] http://www3.amsinc.com/CMC/newsroom.nsf/pr/BWAD-4MUL3A

5.3. Implementation approach

Initially, there are 3 organisations considered in the implementation of the national clearinghouse. These organisations are IGM, CLIRSEN and HIGEODES and have been participating actively in activities concerning with the implementation of the clearinghouse in the country. In the future, more organizations can integrate the system. The maturity model developed by RAVI in the Netherlands for the implementation of the clearinghouse is suggested to apply for evaluating the maturity of an organisation for participation in the clearinghouse. This model ranks organisations on a scale of five, ranging from 1(NGDI not relevant) to 5 (very mature organisation)

The ranking of an organisation was determined by the following criteria: (Bregt A. 2001)

1. Organisation Position in the field of geoinformation.
   - Provider of geoinformation
   - Demander of geoinformation
2. Technical infrastructure within the organisation (GIS and Internet)
3. Geoinformation infrastructure (local metadata information system)

This maturity model proved to be a practical and simple model to evaluate organisations on their possible participation in the NGDI. Based on results of the maturity evaluation, practical advice might be given to improve the internal information infrastructure of each organisation.

The nature of the clearinghouse is dynamic because the technology is changing very fast, then the implementation of the Ecuadorian Clearinghouse must be conceived in phases:

Phases	Activities
Catalog services Prototype	1. Creation of metadata within organizations. 2. Development of the user interface for the National clearinghouse 3. Creation of clearinghouse nodes of different organizations hosting the metadata 4. Establishment of the national gateway to administrate the different nodes of the NGDI.
Evaluation phase	Evaluate the performance of the clearinghouse in the first phase. It might be done by means of surveys or questionnaires on-line and usability studies. New improvements can be done in base of this evaluation
Access to data via interoperability	Once the discovery service is optimized, new geodata services such as Web mapping services and others can be added to enhance the performance of the clearinghouse.

Table 5-1 Phases to implement the National Clearinghouse

In this research only issues for geospatial data discovery were covered, however research need to be done in aspects related to geospatial data visualization (web mapping) to increase the potentialities of the proposed architecture.

5.4. Evaluation of the National Clearinghouse

Once the national clearinghouse will be implemented, is recommend conduct evaluations in order to identify the problems facing the users of the clearinghouses.

This evaluation might be accomplished by means of questionnaire or survey on-line and usability studies.

The main reason to perform usability evaluations in clearinghouse is to assess the effectiveness of the Clearinghouse's human-computer interface and identify the primary barriers to usability between the Clearinghouse interface and the final users (NACSE, 2001).

One important step to execute this type of evaluation is defining the criteria to perform such evaluation.

A list of possible selection criteria has been developed. These have been organized into 3 main categories: content criteria, form criteria and process criteria, which reflect the main areas to be considered in the evaluation of the National Clearinghouse.

The following table contains:

- The criteria for the evaluation,
- Questions that can help with the evaluation of clearinghouse against these criteria,
- Practical hints and tips that can be used to help in the evaluation.

5.4.1. Content Criteria: Evaluating the information.

The Content criteria are based on the information that clearinghouse contain.

Categories	Criteria	Question	Hints/tips
Content criteria: evaluating the information	Validity	Do the resources fulfill the stated purpose? Do I get I want? Is the content of the resource verifiable?	Are references given? Is there any information missing? Is the information up to date?
	Substantiveness	Is the information substantive? Is there value-added information?	Does the resource contain more than contact details?
	Accuracy	Is the information accurate?	Are you able to check the accuracy of the information?
	Comprehensiveness	What is the depth of the information? To what level of detail does the resources go? Is some of the information incomplete? Is everything you expect to find there?	Does the index or contents page imply comprehensive coverage? Is the metadata readable? Is the metadata understandable?
	Composition and organisation	Is the information composed well? Is the information clearly organized?	Does it include thesauri? Is there a good structure? Is the information arranged logically and consistently? Is the resource organized by the needs of the users?

Table 5-2 Criteria for evaluating the information provided by the clearinghouse

5.4.2. Form criteria: Evaluating the medium

Form criteria are based on the presentation and organisation of the information.
The design features will affect how easy users find it to navigate and use the resource.

Categories	Criteria	Question	Hints/tips
Form criteria: Evaluating the medium	Ease of Navigation	Is it easy to navigate the resource? Is it easy to browse the resource? Is it easy to search the resource?	Does it take more than three 'clicks' (three links) to get the metadata/data? Are all the links clearly labeled? Do maps support ease navigation? Are graphics/maps clearly labeled and identified? Is keyword searching possible? How effectively can information/metadata be retrieved?
	Provision of user support	Are there instructions? Is there on-line help?	Is there any on-line help? Is contextual help available? Are training material provided?
	Appropriate use of technology	How appropriate is the format?	Is appropriate interactivity available?
	Aesthetics	Has consideration been given to the appearance of the site? Does the resource follow good design principles?	Does it look and feel friendly? Are the size, colors of the maps appropriate?

Table 5-3 Criteria for evaluating the medium

5.4.3. Process criteria: Evaluating the system.

Process criteria are based on the processes and systems that exist to support the information resource. The system that lies between the information provision and the information retrieval will affect the quality of access, form and content. Some evaluation of the system is necessary to discern the quality of a resource over time.

Categories	Criteria	Question	Hints/tips
Process criteria: Evaluating the system.	Information integrity (Work of the data provider)	Is the information current and up to date? Is the information durable in nature? Is there adequate maintenance of the information content?	If the site contains data or information that is time-sensitive, how current is this data? How current is the data included in each update? Is there a statement about the frequency of update? Has the data been updated recently?
	System integrity	Is the technical performance of the resource acceptable? Is the system stable? Are adequate measures taken to maintain the integrity of the system?	Is the search speed satisfactory? Is the resource currently accessible? Is the connection to the site providing the information reliable and stable? Are the links reasonably stable?

Table 5-4 Criteria for evaluating the system

Each of these criteria will be ranked on a scale of 1 to 5:

1. Very weak support
2. Weak support
3. Moderate support
4. Strong support
5. Very strong support.

Then, in the basis of this evaluation, the clearinghouse can be improved to better fulfil the user requirements.

5.5. Concluding remarks.

In this chapter the conceptual design of the Ecuadorian clearinghouse was presented. Its components and the interaction between them were examined in detail to get a better understanding about its functioning.

An approach for the implementation of the clearinghouse is presented. Considering the nature of the clearinghouse, the implementation is proposed in phases. The first phase of the implementation is the establishment of catalog services. To fulfill this phase, a list of activities has been identified.

For the evaluation of the National Clearinghouse, a list of possible selection criteria has been identified: content criteria, form criteria and process criteria, which reflect the main areas to be considered in the evaluation of the clearinghouse.

Based on such criteria a development plan can be implemented, monitored and controlled.

6. Institutional and Organisational Issues of NSDI

6.1. Introduction.

The architecture for the national clearinghouse was proposed in chapter 5, however the establishment of the geospatial data clearinghouse, as a part of the NSDI, comprise not only the technical aspects to put it running but also institutional and organisational issues that need to be addressed in advance to assure an appropriate environment for successful implementation.

At present, despite the new technology of geographical information is developing rapidly, the main obstacle for data access, sharing, and dissemination are institutional issues rather than technical problems(Pinto J & Nedovic-Budic Z, 2001). Generally, most of research's have been addressed in technical terms with its "soft" or organizational side mostly neglected.

Experiences around the world have demonstrated that to set up a SDI, the establishment of the machinery for cooperation and coordination and its instruments become an essential aspect (Masser I, 2002).

In this chapter, the institutional issues for the establishment of the NSDI are addressed as well as the Organisational implications for agencies that want to implement a clearinghouse node.

6.2. Institutional components

There are six main institutional aspects that need to be considered in the context of the NSDI:

Social/cultural issues*:* The Social acceptability of GIS within a SDI context should be answered from an understanding of both the culture of the society and the interaction between the incoming technology and the recipient society (De Man E & Van den Toorn, 2002) .

It is important to identify how people involved will react with the introduction of geospatial data technologies and how feasible it is to implement it.

Political issues*:* The international experience makes clear that the political support is important for establishing the co-operation required. The mechanism for sharing data between relevant organisations is the basis for which the NSDI will function. Political commitment needs to be obtained on this point.

Managerial issues*:* The managerial issues involved include the authority, staff levels, management of resources, human resources development, leadership, strategies for private sector involvement, and other management and system support issues.

Legal issues*:* The development of an effective NSDI requires a legal framework. This framework should facilitate the distribution and use of geospatial information. To ensure the success of the system and continued sharing of information, legal issues need to be addressed and developed before the implementation stage. Legal issues that merit attention are: Copyright, intellectual property protection, liability to ensure the suitability and quality of the data in the NSDI and protection of personal privacy information.

Such a legal framework is needed to guarantee investment in the quality information required for successful data sharing.

Educational issues*:* The development of NSDI can only take place with the support of a strong knowledge and education infrastructure.

Financial issues*:* The development of a NSDI requires investments, finding ways for resources for implementation, and working out the operational costs. It is thought that the costs needed to be borne by the beneficiaries of the system: the users and the data producers. In addition a defined policy for pricing the information is needed in order to ensure no monopoly of information

6.3. Critical Success Factors (CSF) Analysis for the implementation of the NGDI

The critical success factors analysis is an example of soft system development methodology (Paresi C, 2000). The critical success factors method focuses first on the factors that are critical to achieve the stated goals and objectives. It then looks at the activities that are necessary to support the achievement of the critical success factors.

Defining a critical success factors matrix could be a useful mechanism to identify the requirements and its priorities to ensure success of the development of the Ecuadorian geospatial data Infrastructure and the Clearinghouse.

The following factors were identified important and crucial for the development of the National geo-spatial Data Infrastructure:

- Long-term Strategic vision and framework,
- High level Political support,
- Financial support,
- Availability of an appropriate Information and communication infrastructure
- Institutional commitment
- Data standardisation,
- Financing and pricing policy
- Capacity Building
- System maintenance and sustainability.

Long-term Strategic vision and framework*:*

A practical step to take in the development of a national SDI is the development of a vision detailing a desired future and a clear sense of how SDI components could serve in the near future and help to re-alize it. This also involves setting clear priorities and defining a strategy or policy to accomplish the vision.

A vision of the future could help to streamline future activities towards a mutual objective. A common and shared vision about spatial data collaboration and co-operation may fundamentally change the landscape for the nation wide exchange of data and information.

High-level Political support*:* Experiences abroad have demonstrated that any SDI initiative can be successful without support from the highest National level. Therefore it is important to involve or-ganisations and persons with decision power and credibility.

Financial support: To establish the NSDI, requires huge amounts of money both for its implementa-tion and for its maintenance. A proportion of the initial costs have to come from the government; it is therefore high recommended to ensure participation and support of the Central government. A way to persuade government or other ‘funders’ would be to have something to show already (for example, a

clearinghouse system) rather than a concept document alone. This does not have to involve huge costs since some clearinghouse components are available free over the Internet.

Availability of an appropriate Information and Communication Infrastructure*:* The communication network is the backbone of the NGDI. The prime consideration of the physical network is bandwidth, as geospatial data is usually of large volume. Today, optical fibre technology provides the best bandwidth option.

Institutional Commitment*:* Inter-organizational cooperation is essential for the development of the NSDI. Data sharing and exchange can efficiently take place only when concerned organizations accept to cooperate. Cooperation entails cost sharing of the system, sharing of ideas thus good assessment of the system.

Data standardization. Standardization is one of the most important building blocks of the NSDI. An extensive set of standards is required to support GDI implementation. Some of those are needed to cater for the aspects that are associated to geospatial data clearinghouse. There should be standards for the data exchange, data quality (accuracy), currency, accessibility, precision, etc.

Financing and pricing policy: It is a decisive factor for getting financial resources to support the NSDI development and the way of marketing its products. It is difficult to assess the scale of fees for charging the NSDI products as participating organizations have different reasons to give different prices for the same product, on the other side, users of data are of two types, from the participating organizations themselves and external users.

There should be agreement from the participating organizations under the control of the National coordinating body for establishing the fees of their products.

Capacity building: the lack of staff with the necessary geographic information management skills is a big problem especially in developing countries. Capacity building initiatives need to be developed in parallel to the processes of NSDI implementation. National organizations with support of international organizations are encouraged to organize workshops and training to raise awareness and knowledge about spatial information management. This will be a significant contribution to capacity building.

System flexibility and maintainability*:* A Clearinghouse should be developed in an incremental way, i.e. a phased approach. This suggests that the architecture of clearinghouse should be flexible and extendible. It should follow Open system principles(GSDI, 2001), which allows interoperability of components. The architecture should be strongly modular, to accommodate progressive implementation as well as to accommodate multiple choices of solutions by custodians and other participants

6.3.1. Activities supporting the Critical Success Factors

From experiences gained of other SDI and clearinghouses development abroad, the following activities can be judged relevant to support the CSFs:

- Establishment of a National Coordinating Body,
- Development of Strategies, plans and policies,
- Awareness creation and Exchanges of best practices,
- Promulgate legislation
- Execution of standards,
- Execution of data security
- Organizational structure, marketing, costs and funding
- Upgrading staff at managerial and operational levels

Establishment of National Council for Geoinformatics*:*

The first activity that should precede the establishment of the NGDI is the creation of the National Council for Geoinformatics at high level, which ensures the integration, coordination, and continuity of the activities of the concerned organizations. This Council must have legal mandate for designing and implementing SDI concepts, coordinating the development of standards and protocols, building and sustaining core data sets and providing guidelines for the establishment and good functioning of the NSDI.

The principal task of this body will be to facilitate the evolution of NSDI through the efforts of all stakeholders. Therefore it is important to avoid creating top-heavy co-ordination structures that could be inefficient and not financially sustainable in the long run. More efforts must be concentrating on developing initiatives that promote interagency collaboration and data sharing between stakeholders(Masser I, 2002).

In the aspect related to clearinghouse activities, it is recommended to create a Clearinghouse Committee and a clearinghouse-working group to handle the daily and permanent functioning of the system.

Development of Strategies, plans and policies:

The National Council will be concerned with setting up of policy priorities within the planning framework and oversee policy implementation programmes.

Development of strategies for new programmes to improve the existing systems, assigning responsibilities to the task forces which care of technical issues like standards; access and use policy; organizations structure, marketing, cost and revenue structure; system integrity; communication network; hardware/software requirements; etc.

Plans should be developed and implemented for the dissemination of information on SDI activities under way, including the information about the SDI components, available technical best practices, and the promotion of the use of existing technologies and standards to support the development of a SDI. For example by establishing WWW pages on the Internet or using printed media or CD-ROM where Internet connections are limited.

Awareness Creation and exchanges of best practice:

Lessons in awareness creation about SDI can be drawn upon from various countries (Lachman et al., 2001). A list of activities includes:

- Outreach through support for SDI from high-profile individuals.
- Promotion of SDI principles through presentations.
- Education through workshops, training courses and material.
- Provide “train-the-trainer” technical workshops to explain the origins, purpose, and strategies for implementation of the SDI standards.
- Use pilot projects to demonstrate the value of spatial data and a SDI to improve decision making in communities.
- Establish networks of communication to enable participants to exchange experiences with SDI implementation.
- Facilitate information sharing through newsletters, web pages, and publications, regularly inform interested parties of SDI-sponsored activities and initiatives.
- Provide a forum for debate, analysis and the identification of issues relevant to SDI development.

- Help interested parties or groups to use the spatial data clearinghouse to locate sources of data, training and expertise.
- Offer interested parties the opportunity to participate in Working Groups and Committees, as appropriate.
- Awareness creation of SDI components should be considered down to the lowest level and with strong management support and leadership.

Promulgate Legislation*:*
The geospatial information that will be presented through the Internet should have legislation, since part of it is free and another will be marketed and redistributed. Developing a bill to legislate information of Geospatial data in Ecuador through Internet is task of the National council of Geoinformatics. This legal base should address legal, technical and economic responsibilities and define among others aspects like patent, loyalty, restrictions of use of the information, production costs and free distribution.(Ruano M, 2002)

Execution of standards:
Any data exchange mechanism cannot succeed if national standards for the exchange of data are missing. A well-designed set of standards will promote interoperability, portability and maintainability.
Users can take an active role in encouraging and accelerating the standards process, first by becoming informed about standards issues that will impact them and their organisations, and then by using formal avenues to incorporate standards into system design and development activities. Education and information can be facilitated through participation in professional organisations, special training seminars on specific standard issues and regular reading of key publications.

Organizational structure, marketing, costs and funding*:*
There is a need for establishing strategies for funding the institutional development of the NSDI and ensuring a maintenance plan of the system. Developing measures for cost recovery and fee structures are also needed to evaluate the cost-benefits of the system.

Upgrading staff at managerial and operational levels*:*
This activity encompasses training programmes for policy and decision makers. Data producers need to be trained to use the metadata standard and the tools to create it. Trained human resources are needed for maintaining, upgrading, and using the system. There should be a short and long term training programs for managers, system administrators, and system operators, both at the infrastructure and organizational level.

6.3.2. Critical success factors Matrix

A critical success factor matrix is developed in terms of the activities (actions) that support several factors. These activities will be most contributing to enable reaching the stated goal and have to be given high priority. Based on the factors and activities identified in previous section, the matrix can be defined.

Proposed activities to support the establishment of the NGDI	Critical Success factors										
	Long-term strategic vision and framework	High level Political Support	Financial Support	Availability of an appropriate IC infrastructure	Institutional commitment	Data standardisation	Financing and pricing policy	System maintenance and sustainability	Capacity building	Action weight	Ranking
Establishment of a National Coordinating Body	X	X	X		X	X			X	6	2
Development of strategies, plan and policies	X		X	X	X	X	X	X	X	8	1
Awareness creation and exchanges of best practices	X	X	X		X				X	5	3
Promulgate legislation	X	X					X			3	7
Execution of standards					X	X		X		3	6
Organisational structure, marketing, cost and funding	X		X		X		X			4	4
Upgrading staff at managerial and operational level	X				X				X	3	5

Table 6-1 Critical success factor matrix

The weight of all factors is assumed to be of equal importance as one unit (1). The activities that are needed to achieve these factors are weighted according to the numbers of factors achieved by each action. It is important to perform this evaluation as detailed as possible to be sure of its success.

6.4. Organisational implications for clearinghouse implementation.

6.4.1. Metadata of organisations

A national clearinghouse can only operate on the basis of metadata services within organisations (Bregt. A, 2000). As was identified in survey (Section 3.4.8), no one organisation has a metadata information system implemented, this fact become a big limitation for organisations wanting to participate in the clearinghouse.

Organizations that have been successful in implementation of a metadata have addressed the following needs:

1) **Adopt an operational plan**: from a planning perspective, priorities need to be addressed to training staff and management, data set inventory and prioritization, adopting procedures and best practices.
2) **Establish Procedures**: To define what level of granularity to collect metadata, and what level of detail to collect metadata.
3) **Train people**: identify needed skills for personnel and set aside time for training. Both managers and staff should have an awareness of the importance and benefits of metadata
4) **Assess technology infrastructure**: identify collection tools compatible with existing IT structure and that supports procedures for creation, maintenance and distribution of metadata.
5) **Identify suitable metadata repository**: the place where the metadata will reside should be based on consideration of internal access, external access and maintenance.

To Establish a Clearinghouse Node, organisations will require among other the following activities(Racca D, 1997):

- An understanding of the FGDC Content Standards for Digital Geospatial Metadata
- A study of Z39.50 server technology, http server technology and various metadata preparation and validation tools on several computing platforms.
- Installing servers to run the suite of related software and to store data.
- Developing a Clearinghouse Web page
- Modifying and debugging a Web-to-Z39.50 gateway
- A file system strategy for how the software and data would be stored
- An adequate time for creating metadata, checking metadata for conformance to the standard, preparing data, creating browse graphics, and establishing links so that users could immediately download the data.
- A period of time where the Clearinghouse software can be tested, and put into a production mode

All these activities related to implementation of metadata and clearinghouse node imply changes in the organisation like reorganizing work processes. Personnel will need to be trained in the use of this new technology, new personnel must be recruited and the existing computational department should be reorganized and extended to accomplish these requirements.

6.5. The costs of NSDI

An initial approach for the cost of implementing the NSDI was estimated in previous research done by Mr. Rodolfo Salazar. These cost were projected using the reference values obtained in studies made in United States and United Kingdom (Rhind). The cost estimated for the implementation of the National SDI is about USD $ 357'500, 000. However to get a real overview of costs for implementing a NSDI is quite difficult, in this moment only the rough cost estimation is available. The most important aspect to considerer is the way of how to get that funding; of course more detailed estimations must be available then

6.6. The funding

According with (Rhind D, 2001) there are at least four funding models to create and maintain a NSDI:

- Funding by central or local government using appropriate funds derived from taxation and paid out for defined services or activities;
- Funding though payments made by costumer, collected by the private sector;
- Funding through payments made by costumer, collected by the public sector, and
- Funding on the basis of sponsorship, advertising or other indirect methods.

This model has been used in developed countries with relative success; however SDI implementation in developing countries differs from that of developed countries mainly because of the differences in the legislative and regulatory systems; the lack of political and economic security; the culture and usually highly centralized infrastructure system (Giff G & Coleman D, 2002). Therefore, the models identified by Rhind are applicable in their current form in developing countries.

An in-depth analysis of the situation in every country is needed, and drawing on the lessons learnt in the application of the models in developed countries it will be possible to modify the models to suite the right environments of every country.
In studies carried out by Giff and Coleman, a range of potential funding models for SDI implementation and maintenance in developing countries is suggested:

- Funding from Government budget
- Funding through International Donor Agencies
- A Government and International Donor Agencies partnership
- International Donor Agencies and Private Sector (local and international) partnership
- Government Private Sector partnerships
- The creation of a Government, Donor Agencies and Private Sector partnership
- The creation of a donor pool. That is, a partnership amongst different donor agencies with each agency responsible for different aspects of the SDI. This donor pool should be organized in such a way that it will ensure there is sufficient funds to sustain the SDI until it becomes self-sufficient or other methods of funding are secured.
- Non-monetary Private Sector contributions (e.g. data collection, database management)
- Matching ratios with the Private Sector (local and international) based on tax incentives

Given the current economic situation in Ecuador coupled with the constraints of most donor agencies the best possible model would be the creation of a pool of funds to be access for SDI financing when necessary.

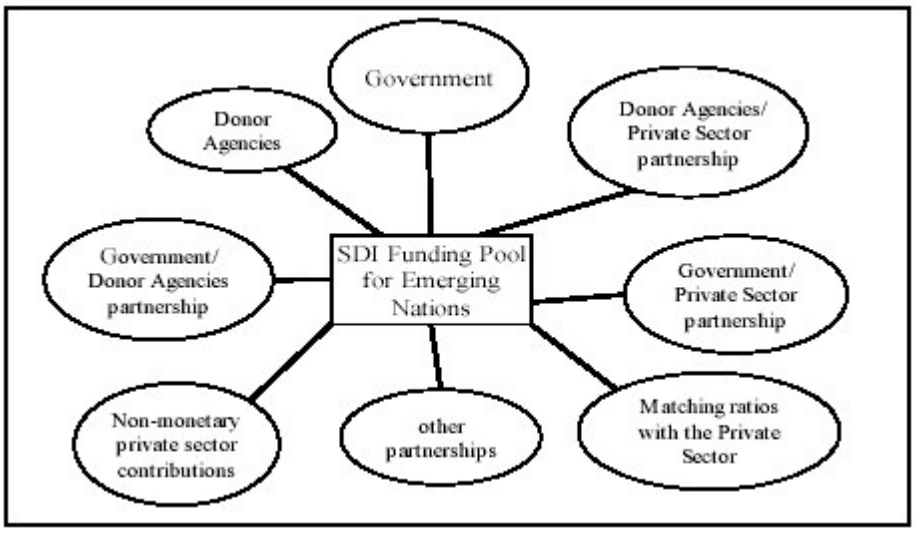


Figure 6-1 SDI Funding pools for emerging Nations (Giff and Coleman, 2002)

Practical experiences has showing that having a clearinghouse in place could be more persuasive to potential 'funders' to give the funds needed to implement the SDI. As promotion of the clearinghouse occurs more funding will become available.

6.7. Concluding remarks

The execution of the NGDI and the clearinghouse implies institutional and organisational issues that need to be addressed to prepare the environment for the successful implementation. The clearinghouse cannot be treated in isolation because it or will be a part of the NGDI.

For the establishment of the clearinghouse, organisations have to make strong efforts to accomplish this aim, they need to re-organize workflow, develop plans for the establisment of the metadata in such a way that it does not affect its normal activities.

One of the most critical constraints is the lack of funding and personnel with the sufficient knowledge to manage the introduction of this new technology.

Support of the central government is needed at least to cover the cost of implementing clearinghouse nodes in the organisations involved in this project. As was identified in this chapter, the creation of a funding pool can be a solution to get the funding to start the project.

All those activities need finally to be controlled and leaded by the National Council of Geoinformatics, the establisment of this body is quite important for the establisment of the NSDI and the National clearinghouse.

7. Conclusions and Recommendations

7.1. Conclusions

Spatial Data Infrastructures have been implemented in developed countries and it is widely believed that also developing countries can benefit by the implementation of National SDI.
Hence, Initiatives at Global, regional and local levels have been promoted to support this kind of activities. In Ecuador, the initial efforts to develop the NSDI are promoted by IGM, CLIRSEN and HIGEODES. However, the lack of economic and technologic resources as well as the lack of research in this matter represents serious constraints.

The main objective of this thesis was to propose the design for the National clearinghouse in a conceptual way. The clearinghouse is just on step towards the development of the NSDI, therefore for its implementation is extremely important to study and understand the whole mechanism.
This goal has been achieved by literature review about SDI and its related activities around the world.
The following task to fulfill was to evaluate the existing situation in Ecuador in terms of SDI.
A questionnaire was carried out to identify the current Ecuadorian geospatial market mechanism, its regulations, needs and restrictions. Additionally a workshop was carried out to introduce the concepts of SDI within the Ecuadorian geospatial community and specifically those related to clearinghouse. These two events provided valuable information about the existing situation that is analyzed in chapter 3. The most important result of these events is that participants became aware of the importance of the establishment of the NSDI.
The concepts of Clearinghouse in Ecuador are still in embryo. The current situation of Ecuador in terms of ICT development and availability of Internet services is low. As a result the geospatial data market on the Internet is almost inexistent.
However, the Central Government is making efforts to improve this situation. There are some actions already implemented to facilitate the development of the e-government in Ecuador.
The different architectures for clearinghouse were identified and evaluated and then the architecture for the National Clearinghouse was proposed in base of this analysis. Its different components were examined in detail to get a better understanding about its functioning.
The clearinghouse architecture is based on the World Wide Web and consists of three main components: Web Client (client tier), clearinghouse gateway (middleware tier) and clearinghouse nodes (server tier). This architecture can offer efficient search capabilities to users, and capabilities to monitor all the datasets within the whole clearinghouse system while provide more flexibility and freedom to data providers.
The implementation of the clearinghouse requires the establishment of standard for the description of the data (metadata). The FGDC metadata standard is suggested to use in the implementation of the National Clearinghouse. This standard provides the user with a detailed description of the data and flexibility to providers to tailor it according to its needs. This standard can be modified for specific data types by employing an endorsed "profile" or "extension", which is simply an addition or a simpli-

fication to the standard. Additional advantage is that metadata conversion tools used for documenting geospatial data are free over the Internet.

The issues of standardisation cover the central position in an attempt to implement the NSDI and the National Clearinghouse. Standardization is not an easy job. It is tedious and time-consuming task.

The implementation of a metadata in Ecuador requires a solid infrastructure based on policy, guidelines and strong organisational decision to cooperate towards a common objective.

The nature of the clearinghouse is dynamic because the technology is changing very fast, then the implementation of the Ecuadorian Clearinghouse must be conceived in phases.

In the first phase has been considered the implementation of catalog services, the main focus of this research, and then an evaluation phase is proposed. To perform that evaluation, a list of possible criteria has been developed. These criteria have been organized into 3 main categories: content criteria, form criteria and process criteria, which reflect the main areas to be considered in the evaluation of the clearinghouse when the prototype will be running in the future. Improvements to the system can be done in basis of the evaluation performed.

The next phase is the implementation of geodata services such as web mapping and others to enhance the performance of the system.

A successful implementation of the National Clearinghouse and the NSDI requires funds; therefore support of the central government is needed at least to cover the cost for implementing clearinghouse nodes in the organisations. The creation of a funding pool can be a solution to get funding and keep the system running

The development of the clearinghouse is a continuum process and it is evolving rapidly.

Clearinghouses will be redesigned as the basis for One-Stop Portal to locate, access, or download geospatial data. The trend is towards integrating data access, visualization (Web Mapping) and geoprocessing services into the data discovery of clearinghouse. The future clearinghouse will facilitate the discovery of data services and use of geospatial information rather than pure data discovery and downloading, in that way is working Open GIS Consortium.

The integration of catalog and Web mapping services in the Clearinghouse is one illustration of the potential capabilities made possible by standardization.

The development of the National Spatial Data Infrastructure and clearinghouse are very complex issues and involves many aspects as were identified in this research.

This research can be seen as a start point and a learning process and the result of this research are expected to contribute for the future development of the National Spatial Data Infrastructure and the National clearinghouse.

7.2. Recommendations and further research

The establishment of the National Council of Geoinformatics become a priority to norm and regulates geospatial data activities in Ecuador. The National Council must have legal mandate for designing and implementing SDI concepts, coordinating the development of policies on privacy, copyright, liability, pricing, security and standards as well as providing guidelines for the establishment and good functioning of the NSDI.

This National Council must be supported at higher level of Government with participation of all organisations concerned with geospatial information in the country.

It is recommended to establish formal working groups around well-defined objectives, strategies, plans and actions. These working groups would be made up of interested parties and experts to deal with specific aspects of NSDI.

In the aspect related to clearinghouse activities, it is suggested to create a clearinghouse Committee and a clearinghouse-working group to handle the daily and permanent functioning of the system.

A Clearinghouse Committee must be established comprising representatives of governmental organisations, private agencies and academia. In relation to metadata, the clearinghouse committee members jointly prioritize the documentation and collection of framework data. The Committee will determine priorities and approve work schedules for the clearinghouse work group.

The Clearinghouse Working group will investigate; test and implement technical developments that would help the clearinghouse effectively deliver geographic metadata and data over the Internet.

Before starting up the National clearinghouse, awareness about the necessity of developing standards must be awakened at each level of the Ecuadorian geospatial community.

Due to a rapid growth of geospatial data in Ecuador, it is practically impossible to document all information. Therefore for a successful implementation of the clearinghouse the efforts must be focused on a core data set collection and around clearly defined goals and objectives. The definition of the framework data for the NSDI is a high priority.

Organisation considered in the implementation of the clearinghouse are responsibles to upgrade their staff and ICT to fit the requirements that imply put running a clearinghouse node.

It is suggested implementing clearinghouse using existing hardware. A survey needs to be conducted to identify existing hardware in every organisation. The preference will be to implement the clearinghouse using the same type of hardware available in the organisation. Requirements analysis needs to be performed to identify the specific hardware configuration. Hardware should be upgraded on as-needed basis to identified requirements.

A list of criteria has been identified in this research, based on such criteria; a development plan can be implemented, monitored and controlled.

The backbone of the clearinghouse is the internet connectivity, then the National Government should become aware about the establishment of a efficient communication network.

The ability to discover, evaluates, and visualize available spatial data requires the interaction of discovery services and Web map services. The standardization of these software interfaces by the OpenGIS Consortium facilitates the construction of many compatible servers, which allow users to discover and display geographic information. Therefore is important to encourage National organisations that new acquisition of GIS Software will be in conformity with OGC specification to facilitate the integration of data in the future.

Issues for geospatial data discovery were covered in this thesis, however research need to be done in aspects related to geospatial data visualization (web mapping) to increase the potentialities of the proposed architecture. It can be considered as a new research problem.

In this research, given the time constraints only 12 organisation were considered in the survey, however further analysis of user requirements at local level must be considered.

The success of the National clearinghouse will depends on the willingness of organisations to document and release geospatial data. Continued education and promotion of metadata will help increase the quality and quantity of spatial data within the national Clearinghouse.

In Ecuador, the first steps to build the NSDI had been promoted by IGM. However the essence of the SDI concept is that there is no master architect but it should be a net of partnerships and relationship evolving purposefully. So that It is ideal to set-up clear priorities and involves users and producers of geoinformation in Ecuador.

References and Bibliography

Aimin G, 2000. A client - server clearinghouse architecture with spatial data downloading capability, ITC MSc Thesis, Enschede, 127 pp.

Antenucci et al., 1991. Geographic Information System. A guide to the technology. Van Nostrand Reinhold, New York, 293 pp.

Bertola I, 1998. The Uruguayan Clearinghouse. Ministry of Public Works and Transportation www site: http://www.clearinghouse.com.uy/ accessed on 14-november-2002.

Bishr and Radwan, 2000. GDI Architectures. In: R.G.a.J. McLaughlin (Editor), Geospatial Data Infrastructure. Oxford, pp. 147-147.

Blake et al, 2001. Geospatial data Visualisation-Web Mapping, GSDI Cookbook, Cape Town, South Africa, pp. 62-73.

Borrero S, 2001. Permanent Committee on Spatial Data Infrastructure for the Americas, PC-IDEA, Tsukuba, Japan.

Bregt. A, 2000. The Dutch Clearinghouse for geospatial information: Cornerstone of the National Geospatial Data Infrastructure. In: R.G.a.J. McLaughlin (Editor), Geospatial Data Infrastructure. Concepts, cases and good practice. Oxford, pp. 262-267.

Callaos N, 1999. The World Communication and Information Report 1999-2000, UNESCO, Paris.
Cardenas F, 1998. "Towards the development of National GIS programme in Ecuador." MSc Thesis, ITC, Enschede.

Conatel, 2000. Consejo Nacional de Telecomunicaciones. Strategic Plan 2000-2004

De Man E and Van den Toorn, W., 2002. Culture and the adoption and use of GIS within organisations. International Journal of Applied Earth Observation and Geoinformation(12): 1-13.

FGDC, 1998. Content Standard for Digital Geospatial Metadata, Federal Geographic Data Committee, Virginia-USA.

Gelbman R and Mathys T, 1995. Making metadata part of your Daily Diet. Proceedings of the 1999 Urban and Regional Information System Association(URISA) annual conference.

Giff G & Coleman D, 2002. Spatial Data Infrastructure Funding Models: A necessity for the success of SDIs in Emerging Countries, FIG XXII International Congress, Washington, D.C. USA.

GISFORM, 2001. ETeMII White Paper, European Territorial Management Information Infrastructure, Parma.

Green T and Bossomaier T, 2002. On line GIS and Spatial Metadata. Taylor and Francis, London. pp 198-201.

Groot R, 2002. Advancing the geospatial data infrastructure concept. No master architect, ITC lecture notes, Enschede.

Groot R. and McLaughlin J, 2000. Geospatial Data Infrastructure. Concepts, cases and good practice. Oxford University Press, New York, 286 pp.

GSDI, 2001a. Geospatial Data Catalogue: Making data discoverable. In: Doug Nebert (Editor), The SDI Cookbook Developing Spatial Data Infrastructures, South Africa. 43-73.

GSDI, 2001. The SDI Cookbook Developing spatial data infrastructures: the SDI cookbook, 1, Cape Town, South Africa, 151 pp.

Harvey F, 2000. Development of an Interface for better use of metadata. Quality means more than standards, GIM international, pp. 77-79.

IGGI, 2001. The Principles of Good Metadata Management, Department for Transport, Local Government and the Regions, London.

IGM, 2001. Instituto Geografico Militar. Strategic Plan

Indian SDI, 2001. National Spatial Data Infrastructure: Strategy and action plan, New Delhi, pp. 32.
Kim J, 1999. Metadata for geo-spatial data sharing: A comparative analysis. Annals of Regional Science, 2: 171-181.

Kirkman et al, 2002. Global Information Technology Report 2001 - 2002: Readiness for the Networked World, New York, 384 pp.

Lachman et al., 2001. Lessons for the Global Spatial Data Infrastructure: International Case Study Analysis, RAND Science and Technology Policy Institute.

Masser I, 2002. Reflections on the Indian National Geospatial Data Infrastructure. GIS development www site: http://gisdevelopment.net/policy/gii/gii0009pf.htm accessed on February 7- 2003.

NACSE, 2001. Usability Evaluation Procedures. Northwest Alliance for Computational Science and Engineering www site: http://www.nacse.org/mhs/review/index.html accessed on February 18 2003.

Nebert D, 2000. Geospatial Data Clearinghouse. Data discovery and access www site: http://snig.igeo.pt/potugues/Forum/Revista/n5/html/usgeospatial_ingles_final.htm accessed on December 14 2002
Nebert D, 2001. Discovery Services for Geospatial Data. USGS www site http://www.fgdc.gov/clearinghouse/sdi/nebert2.ppt. accessed on January 16 2003

OGC, 1998. Open GIS Guide. OpenGIS Consortium www site: http://www.opengis.org/techno/guide/guide1.htm accessed on January 23 2003.

Ozsu et al., 1990. Principles of distributed database systems. Prentice Hall, 666 pp.

Paresi C, 2000. Information System Development Methodologies, Techniques and Tools, ITC Reader, Enschede.

Pinto J and Nedovic-Budic Z, 2001. Organizational (soft) GIS interoperability: lessons from the U.S. GIM International, 3(3): 290-297.

Racca D, 1997. Implementation of a geospatial Data clearinghouse for Delaware, University of Delaware, Delaware www site: http://www.rdms.udel.edu/fgdc/gateway/implement.pdf accessed on January 22 2003

Radwan et al., 1997. Guidelines for the development of a geospatial clearing house in a heterogeneous environment, JointEuropean and exhibition onGeographical information '97, Vienna, pp. pp. 277-287.

Reed C, 2001. OpenGIS interfaces and Spatial Data infrastructure, SDI, cookbook, Cape Town, South Africa, pp. 62-69.

Rhind D, 2001. Funding an NGDI. In: G. McLaughlin (Editor), Geospatial Data Infrastructure. Concepts, cases and good practice. Oxford University Press, New York.

Rocca S, 1999. Clearinghouse. A Way to provide access to digital spatial data through metadata. Centre for geoinformation. Wageningen www site: http://cgi.girs.wageningen-ur.nl/cgi/education/courses/k075219/results1999/008.htm accessed in February 6 2003.

Ruano M, 2002. Legislation for Geographic Information Systems in Internet, GIS ECUADOR 2002, Quito-Ecuador.

Salazar. R, 2001. Business Process to design a Cadastral Infrastructure as a part of a land Administration System in Ecuador. MSc. Thesis, ITC, Enschede, 85 pp.

SEDAC, 2002. Content Standard for digital Geospatial Metadata(CSDGM) overview. Socioeconomic data and application center. www site: http://sedac.ciesin.org/metadata/overview.html accessed on January 24 2003

UNDP, 2001. Information and Communication Technologies for Human Development, United Nations Development Program, Quito-Ecuador.

UTICE, 2000. Policies and Standards for Information Technologies, UTICE, Quito, Ecuador.

Van Oosterom P. Lemmen C, 2002. GEO-ICT Technology Push versus Market Pull, GIM-International, pp. 12-15.

Van Oosterom P. Lemmen C, 2002a. Impact analysis of Recent Geo-ICT development of Cadastral systems, FIG XXII International Congress, Washington-USA, pp. 20.

Workshop " Clearinghouse implementation as an instrument for Geospatial Information Management in Ecuador" October 2002 Quito-Ecuador.

Appendix 1

The Networked Readiness index

NRI Rank	Country	NRI Rank	Country	NRI Rank	Country
1	United States	26	Spain	51	Mauritius
2	Iceland	27	Portugal	52	Peru
3	Finland	28	ChzecRepublic	53	Bulgaria
4	Sweden	29	Slovenia	54	India
5	Norway	30	Hungary	55	El Salvador
6	Netherlands	31	Greece	56	Jamaica
7	Denmark	32	Argentina	57	Colombia
8	Singapore	33	Slovak Republic	58	Philippines
9	Austria	34	Chile	59	Indonesia
10	United Kingdom	35	Poland	60	Egypt
11	New Zealand	36	Malaysia	61	Russian federation
12	Canada	37	Uruguay	62	Sri Lanka
13	Hong Kong (SAR)	38	Brasil	63	Paraguay
14	Australia	39	Latvia	64	China
15	Taiwan	40	South Africa	65	Romania
16	Switzerland	41	Turkey	66	Ukraine
17	Germany	42	Lithuania	67	Bolivia
18	Belgium	43	Thailand	68	Guatemala
19	Ireland	44	Mexico	69	Nicaragua
20	Korea	45	Costa Rica	70	Zimbabwe
21	Japan	46	Trinidad y Tobago	71	Ecuador
22	Israel	47	Dominican Republic	72	Honduras
23	Estonia	48	Panama	73	Bangladesh
24	France	49	Jordan	74	Vietnam
25	Italy	50	Venezuela	75	Nigeria

Key factors	U.S.A.	Colombia	Venezuela	Peru	Ecuador	Uruguay	Chile
Population	275,000,000	42,300,000	24,200,000	25,700,000	12,600.000	3,337,000	15,200,000
GDP per capita	US$ 33,886	US$ 5,923	US$ 5,677	US$ 4,797	US$ 3,068	US$ 8,904	US$ 9,187
Main telephone lines per 100 inhabitants	69.97	16.91	10.78	6.37	10	27.84	22.12
Internet host per 10.000 inhabitants	2928.32	11.06	6.68	4.17	0.18	162.02	49.11
Piracy rate	24.00%	53.00%	58.00%	61%	65%	66.00%	49.00%
Percent of PCs connected to internet	50.04%	2.90%	1.47%	1.03%	0.77%	7.69%	5.75%
Internet users per 100 inhabitants	59.75	2.07	3.93	1.59	1.42	11.09	11.55
Average monthly cost for 20 hours of internet access.	US$ 19.58	US$ 14.00	US$ 25.34	NA	US$ 20.61	US$ 13.38	US$ 17.88

Factors	U.S.A.	Colombia	Venezuela	Peru	Ecuador	Uruguay	Chile
Network access	**3**	**51**	**46**	**48**	**62**	**38**	**31**
- Information infrastructure	4	59	40	47	62	38	27
- Hardware, software and support.	1	43	51	48	61	37	35
Network policy	**5**	**52**	**53**	**61**	**69**	**38**	**26**
- Business and economic environment	6	63	65	60	72	34	31
- ICT Policy	3	41	40	62	66	42	21
Networked Society	**8**	**59**	**55**	**58**	**63**	**47**	**32**
- Networked learning	2	55	52	55	65	45	28
- ICT opportunities	1	62	54	64	67	60	20
- Social capital	20	61	58	55	57	36	47
Networked economy	**5**	**59**	**57**	**59**	**68**	**41**	**36**
- e-commerce	1	60	50	62	72	48	35
- e-government	9	49	59	50	65	42	24
- General infrastructure	4	69	62	65	66	33	49
NETWORKED READINESS INDEX	**1**	**57**	**50**	**52**	**71**	**37**	**34**

Appendix 2

Understanding agreement

ACUERDO DE VOLUNTADES

Los abajo firmantes, representantes de los diversos organismos productores y usuarios de información geoespacial, reunidos al fin de una Jornada de seminario taller: LA IMPLEMENTACION DEL CLEARINGHOUSE COMO INSTRUMENTO DE GESTIÓN DE LA INFORMACIÓN GEOESPACIAL.

Considerando,

Que el Estado y Gobierno del Ecuador, por medio de sus instituciones que manejan, generan y administran información geoespacial, debe proveer servicios eficientes y coordinados para que estos sirvan de soporte a las actividades económicas y sociales que requiere el desarrollo sostenido del País.

Que es necesario impulsar el establecimiento de una estrategia para el manejo de una infraestructura de datos geoespaciales, que comprendan los mecanismos de implementación que sean necesarios para evitar duplicación de esfuerzos para lo cual deberán aunar criterios de elaboración y utilización eficiente de información geoespacial.

Que la implementación de sistemas descentralizado de nodos Clearinghouse, constituirá una herramienta útil, para un mejor acceso a la información geoespacial que redundará en un manejo eficiente de la información y en la ayuda de toma de decisiones en diversos ámbitos.

Por tanto, **Acuerdan**, suscribir el presente acuerdo de voluntades en los siguientes términos:

PRIMERO

Afirmar su interés en impulsar la creación de un Consejo Nacional de Geoinformación que permita impulsar la producción ordenada de la información espacial, formular políticas nacionales de geoinformación, promover la utilización de información geoespacial, facilitar el acceso y uso de esta información, proponer la normativa necesaria para reglamentar la producción, almacenamiento, distribución, comercialización, derechos de autor, mediante la implementación de una infraestructura Ecuatoriana de Datos Geoespaciales.

SEGUNDO

Manifestar su acuerdo de participar en próximos talleres sobre el tema, organizados por instituciones como ODEPLAN, COSENA, IGM, como entes encargados de los sistemas de Planificación y Seguridad Nacional, respectivamente.

TERCERO

Promocionar el establecimiento de un Sistema Nacional Descentralizado de Nodos Clearinghouse, que genere información estratégica importante para el país, con un primer énfasis en el tema de prevención y mitigación de Amenazas y Riesgos, impulsando también

DIRECCION JURIDICA

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impulsando también la catalogación de información por parte de otros actores y en otras temáticas, bajo estándares aceptados regional e internacionalmente y generando políticas que transparenten la disponibilidad de la información.

CUARTO

Iniciar las actividades concretas, tendientes a la formulación de un proyecto nacional en un plazo de 45 días.

Las instituciones abajo firmantes, acuerdan solicitar al PNUD y otros organismos multilaterales y de asistencia técnica, sus buenos oficios para apoyar las presentes iniciativas.

Quito, 3 de octubre de 2002

ALFREDO BARRIO
MIN. AMBIENTE

FUNDACYT

D. CIVIL

GUSTAVO GARCIA D
INAMHI.

Fidel Alcocer López
NETURA

COPOE

HBS. APS.

ICAIREN

HIGEDDES-EPN

Consejo nacional de recursos hídricos
CNRH.

MAG-DINAREN.
Hernán Velásquez.

I. G. M.

Programa de las Naciones Unidas para el Desarrollo

Dpto de Ciencias del Agua
Escuela Politécnica Nacional

UNDP. Testigo de honor.

EDC. TESTIGO DE HONOR

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Appendix 3

Metadata Editors & Suites		
Tool Name	**Function**	**Platform/OS/GIS**
tkme	Multi-lingual CSDGM (1998) metadata creation tool	MS-Windows 95, 98, NT, 2000. Linux and Solaris 7 SPARC require Tcl/Tk library installation. C source code available.
ArcCatalog	Intelligent CSDGM (1998) metadata creation tool for Arc/Info and ArcView	MS-Windows NT/2000 with Arc/Info 8+ or with ArcView 8.1+
Spatial Metadata Managment System (SMMS) 3.2	Intelligent CSDGM (1998) metadata creation tool	MS-Windows 95, 98, NT, 2000. Version for GeoMedia requires GeoMedia.
FGDCMETA (AML) 1.2	Intelligent CSDGM metadata extractor tool for Arc/Info	UNIX or NT Arc/Info when < version 8.0
xtme	Multi-lingual CSDGM (1998) metadata creation tool	UNIX with XR5
Corpsmet95 1.3	CSDGM metadata creation tool	MS-Windows 95, NT
DataLogr 2.11c	CSDGM metadata creation tool	MS-Windows (32 bit versions)
Data Tracker™ GIS	Intelligent CSDGM metadata creation tool with automated data inventory capabilities	MS-Windows 95, 98, NT
GEOSCOPE 2.0	Metadata Creation Tool (Canada)	MS-Windows NT
M³Cat	Multilingual CSDGM, GILS, NBII and international metadata standard metadata creation tool	Server: Microsoft Windows NT Server with the IIS 4.0 module. Client: NT WorkStation with Peer Web Services installed
METADATA (AML)	Intelligent CSDGM metadata extraction tool	ArcInfo for UNIX or MS-Windows
MetaStar Data Entry	CSDGM, DIF, GILS, Dublin Core metadata tool	MS-Windows 95, NT

Metadata Utilities		
Tool Name	**Function**	**Platform/OS/GIS**
mp	Multi-lingual utility to check compliance of metadata with CSDGM (1998) and produce output in formatted text, HTML, SGML, XML or DIF form	Solaris 7 SPARC, Linux, MS-Windows 95, 98, NT, 2000. C source code available.
DBFmeta	Intelligent CSDGM (1998) metadata extraction tool for attributes of .dbf files	Solaris 7 SPARC, Linux, MS-Windows 95, 98, NT, 2000
cns (Chew and Spit)	Multi-lingual CSDGM (1998) metadata format preprocessor for mp	Solaris 7 SPARC, Linux, MS-Windows 95, 98, NT, 2000
err2html	Utility to reformat mp's error report into more comprehensible form	Solaris 7 SPARC, Linux, MS-Windows 95, 98, NT, 2000
Theme Metadata (AVX)	HTML metadata display extension for ArcView	ArcView that supports extensions (3+, but < 8.1), and Web Browser
Theme Locator Tool	Finds ArcInfo coverages, shape files, and CAD drawing files on filesystems	ArcView
Metadata Servers		
Tool Name	**Function**	**Platform/OS/GIS**
Isite	Z39.50 compliant metadata server (NSDI node supporting)	Binaries available for Linux, Solaris, OSF/1, MS-Windows NT and 2000. C++ source code available to be compiled on other platforms
GeoConnect Geodata Management Server	Metadata access manager, metadata search interface, Z39.50 compliant metadata server (NSDI node supporting). Hosting available.	ASP web server, SQL Server 7.0 or Oracle 8.x

Appendix 4
Survey of Spatial Data infrastructure and users needs in Ecuador

Background and Purpose of this Survey

Many national governments throughout the world are involved in developing spatial data infrastructures that will better facilitate the availability and access to spatial data for all levels of government, the private sector, the non-profit sector, academia and citizens in general.
In Ecuador, The Military Geographic Institute (IGM) is trying to take the initiative to establish and work together with the main organisations that produce geoinformation in the country towards the establishment of the National Spatial Data Infrastructure (NSDI) in Ecuador.
One of the Key components of NSDI is the national clearinghouse that allows the users get to Know what geographic data exist, the condition of data and instruction for accessing data.
The goal of this survey is to gather information on the nature and characteristics of the main national spatial data, institutional frameworks, standards and policies currently available in some organisations in the country. The information collected may be used to assess the need for the establishment of the National Spatial data Infrastructure and the national clearinghouse.

This survey should take no more than 30 minutes of your valuable time.
If you have any doubt about completing this survey, please contact Cap. Ing. Xavier Molina (IGM-Geographic Division)
email: xaviermolina69@hotmail.com; molinasimbana@itc.nl or telephone (5932)9390261-2805359

1. Definitions

National Spatial data Infrastructure (NSDI). - Is defined as the technologies, policies, and people necessary to promote sharing of geospatial data throughout all levels of government, the private and non-profit sectors, and the academic community.
Spatial data. Data defined spatially (in location) by four dimensions (geometry and time) related to the earth.
Metadata.- standardized data about spatial data sets that is used to document and catalogue the spatial data sets. Metadata describe the content, quality, condition, and other characteristics of spatial data sets.
Clearinghouse.- a distributed network of data producers and users that is used for discovery and access to standardized metadata and geospatial data. It might typically use the Internet, internationally accepted protocols and standard methods that enable spatial data discovery and access in ways not currently available through standard web engines.
Data Standards - standards for data content, classification and management that are available for the entire community of spatial data producers and users.
Core Data - common base sets of data with broad geographic coverage meeting specified standards that are important to a broad variety of users. Other themes of data are built upon or referenced to these framework data sets. These data sets might typically be available to all users through the networked clearinghouse with few or no restrictions.
Remote Sensing: It's the instrumentation, techniques and methods to observe the Earth's surface at a distance and to interpret the image or numerical values obtained in order to acquire meaningful on particular objects on Earth.

Name of Organisation ……..

Type of Organisations: ( ) Governmental ( ) NGO ( ) Private ( ) Research ( ) Others

Name of Respondent Supplying Information:…….
Title/function: …….
Mailing Address:……. ……..
E-mail Address:……..
Telephone Number**:** ……..
Fax Number: …….

Please answer the following questions by ticking/ answering the appropriate response.

1) What is the mission of its organisation?
……
……
2) What are the primary types, categories of spatial data (digital or analogue) and the source that you consider core or fundamental to fulfil requirements of your organisation?

( ) Topographic maps.
Source:…… Format: ( ) Digital ( ) Analogue

( ) Administrative boundaries (E.g. Provincial and cantonal jurisdiction boundaries)
Source:…… Format: ( ) Digital ( ) Analogue

( ) Cadastral data
Source:…… Format: ( ) Digital ( ) Analogue

( )Vegetation data
Source:…… Format: ( ) Digital ( ) Analogue

( ) Soil data
Source:…… Format: ( ) Digital ( ) Analogue

( ) Geological data
Source:…… Format: ( ) Digital ( ) Analogue

( ) Population maps
Source:…… Format: ( ) Digital ( ) Analogue

( ) Aerial photography
Source:…… Format: ( ) Digital ( ) Analogue

( ) Satellite images
Source:…… Format: ( ) Digital ( ) Analogue

( ) Others:……..
Source:…… Format: ( ) Digital ( ) Analogue

3) Are there data/information up to date to fulfill with the objectives and requirements of its organisation?

( ) YES ( ) NO

4) Which core geographic data/information produce your organisation?
Point out for every type of data: name of data sets, scale, publication date, format (digital/analogue). Use the following table as guide:

Name of data sets	Scale	Publication date	Format	
			Digital	Analogue
Ex: Topographic map	1:50.000	1987	x	x

5) How often your organisation updates its data?
……
……
……..
6) Are there initiatives to produce or update data in a coordinated way?

( ) YES ( ) NO

If your answer is YES, please explain what kinds of initiative are doing.
……
……
7) Do you know what data/information is available in other organisations?
( ) YES ( ) NO

If your answer is YES, please explain How do you Know about the availability of this information.
……
……
Access Mechanism:
8) Which of these services are you using to get spatial data /information with other organisations?
( ) E-mail
( ) World wide web-internet
( ) On line file transfer programs (ftp)
( )Others:……
……

9) Which mean would you prefer to access to digital/spatial data information?
( ) Download from a public Web page
( ) Via a National Network (clearinghouse)
( ) Access through a commercial network
( ) CD –ROM

( )Others:……
……

10) Which problems/obstacles do you foresee to access/share data?
( ) Lack of Information and Communication Technology.
( ) Lack of hardware/software.
( ) Financial Problems
( ) Lack of Data Quality (Lack of positional and attribute accuracy, poor source of the information)
( ) Lack of Copyright Policy
( ) Others:…….
…….

Data Collection and coordination.

11) Does your organisation have an active or proposed initiative for developing a national/local spatial data infrastructure (or its equivalent according with the definition included in the first part of this survey)?

( ) YES ( ) NO

If your answer is YES, please explain the objective of that initiative.
……
……
……

12) What parties must be involved in collecting data for the NSDI and how this data collection should be coordinated?
……
……
……

Participation and involvement

13) Your organisation is interested in helping the development of the National Spatial Data Infrastructure?

( ) YES ( ) NO

If your answer is YES, please explain how or what actions your organisation would be able to do to promote this activity.
……
……
……

Pricing.

14) Do you have data pricing policy?

( ) YES ( ) NO

If your answer is YES, what is the basis or method for determining the price of data that your organisation produces?…….
…….
…….

Privacy (If applicable):

15) Do you have policies or mechanism to protect the privacy of individual citizens relative to data that is accessed through your organisation?

( ) YES ( ) NO

Policy Issues.

16) Do your organisation have policy for development/use of spatial data standard.

( ) YES ( ) NO

17) Is your organisation creating metadata for geographic data?

( ) YES ( ) NO

If your answer is YES, please indicate which metadata Standard are using?

……

……

Research:

18) Have funds been specifically budgeted and spent on research projects to advance NSDI concepts?

( ) Yes ( ) No

If YES, please describe the types of projects that have been funded.

……

……

User needs

19) What type of information requires its organisation to fulfil with its mission?

( ) Satellites images
( ) Databases
( ) Cartography
( ) Aerial Photograph
( ) Orthophotos
( ) Cadastral Maps
( ) Others……..

20) What are the scales that fit its needs?

( ) 1:1.000.000
( ) 1:500.000
( ) 1:250.000
( ) 1:50.000
( ) 1:20.000
( ) 1:10.000
( ) 1:5.000
( ) 1:2.000
( ) 1:1.000
( ) Others…….

21) What are its requirements in terms of accuracy?

( ) millimetres
( ) centimetres
( ) decimetres
( ) Between 1m and 10 m
( ) Between 10 m and 20 m
( ) Between 20 m and 50 m
( ) Over 50 m.

THANK YOU FOR YOUR TIME AND EFFORT IN COMPLETING THIS SURVEY!