MASTER IN GEOSPATIAL TECHNOLOGIES

DEVELOPMENT OF REGIONAL SPATIAL DATA INFRASTRUCTURE (SDI) (CASE STUDY IN HEART OF BORNEO)

By

Dwi Septi Cahyawati

THESIS

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Dwi Septi Cahyawati

Supervisors:

Dr. Sven Schade (Institute for Environment and Sustainability, European Commission - Joint Research Centre, Italy)

Co-supervisors:

Prof. Dr. Werner Kuhn (Institute for Geoinformatics, University of Muenster)

Prof. Dr. Pedro Cabral (New University of Lisbon, Portugal)

Consortium partners:

Westfälische Wilhelms-Universität Münster, Institute for Geoinformatics, Germany

Universitat Jaume I, Castellón, Dept. Lenguajes y Sistemas Informaticos, Spain,

Universidade Nova de Lisboa , Instituto Superior de Estatística e Gestão de Informação Lisboa,Portugal

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ABSTRACT

The Heart of Borneo (HoB) initiative was declared on 12 February 2007 in Bali, with purpose to collaborate conservation activities in Borneo Island among Brunei Darussalam, Indonesia and Malaysia. The initiative will join 23 National Parks from three different countries. Concerning the fragmented geographic information from heterogeneous sources, there is a necessity to establish a better management of geographic information among three countries in Borneo Island. The establishment of a Spatial Data Infrastructure (SDI) is one possible solution. In fact, Brunei Darussalam, Indonesia and Malaysia have already developed National Spatial Data Infrastructures (NSDI). The current status of NSDIs is critical for the development of a regional conservation SDI for HoB, but the information for current status of NSDI developments is not available. In this research, the current status of NSDI developments is examined by adopting Reference Model for Open Distributed Processing (RM-ODP). The analysis continues with the identification of required components for developing a regional conservation SDI in HoB. The state of play analysis for the European SDI (INSPIRE) is adopted to investigate available and missing components. On this basis, recommendations for the regional SDI are provided. A prototypical geoportal for regional SDI in HoB is implemented by utilizing GeoNetwork software.

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ABBREVIATION

APSDI: Asia-Pacific Spatial Data Infrastructure.

Bakosurtanal: Badan Koordinasi Survey dan Pemetaan Nasional.

BSDI: Brunei Spatial Data Infrastructure.

FGDC: Federal Geographic Data Committee.

GMES: Global Monitoring for Environment and Security.

INSPIRE: Infrastructure for Spatial Data Information in the European Community.

IPR: Intellectual Property Rights.

ISDI: Indonesian Spatial Data Infrastructure.

ISO: International Organization for Standardization.

MaCGDI: Malaysian Center for Geospatial Data Infrastructure.

MyGDI: Malaysian Geospatial Data Infrastructure.

NSDI: National Spatial Data Infrastructure.

PCGIAP: Permanent Committee On GIS Infrastructure For Asia And The Pacific.

RM-ODP: Reference Model Open Distributed Processing.

SDI: Spatial Data Infrastructure.

WCS: Web Coverages Service

WFS: Web Feature Service

WMS: Web Map Service

WWF: World Wildlife Fund.

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CHAPTER 1 . INTRODUCTION

Geographic information (GI) is critical to promote economic development, improve our stewardship of natural resources, and protect the environment (Clinton 1994). GI is widely used in many fields and contributes substantially to the well of human beings. It is often used in public administration (such as cadastre), where it contributes to urban, regional and national planning, it is used to improve the efficiency of transportation of people and freight (GI Panel 2000). Van Loenen et al. (2009) linked GI to other information, for example; health care information, telecommunications, financial information and traffic information. Meanwhile Longley et al. (2005) addressed GI as geographic data, which is special and important.

Many countries in the world produce and maintain their GI, since such data is vital to make sound decisions at the local, regional, and global levels (Nebert 2004). As the importance of GI for the complex utilizations in economic, social and environments has been arisen, but the cost to produce individual data is very high, the needs to share and distribute the data in particular ways is becoming considered. One of the ways of sharing the data is by developing Spatial Data Infrastructure (SDI) (Nebert 2004). It is noted that SDI is an evolving concept about facilitation and coordination of the exchange and sharing of GI between stakeholders (data providers, value adders and data users) from different jurisdictional levels (Rajabifard and Williamson 2004).

In Europe for example, the initiative for spatial data infrastructure, is called the Infrastructure for Spatial Information in Europe (INSPIRE). The directive establishing the legal framework for setting up and operating an Infrastructure for Spatial Information in Europe (European Commission 2007) is based on spatial information infrastructure in European Union member states (Onsrud 2007). The development of INSPIRE aims to support policies or activities related to the environment. It is underpinned to deal with many border regions in Europe, and transnational projects (Masser 2007).

This thesis aims at an SDI case study for the Heart of Borneo (HoB). The nature and complexity of conservations in Borneo Island leads the decision makers to do

collaboration and accurate decision making. The experience of INSPIRE will become the reference point for gathering possibilities of establishing the regional conservation SDI in HoB. The chapter at hand emphasizes the introductory part from this thesis, which can be followed from motivation, the problem statement, objectives, methodology and expected outcomes and the thesis outline at the last.

1.1 Motivation

Nowadays, SDI becomes a topic for developing countries, such as Darussalam, Indonesia and Malaysia. In the developing countries, GI are produced in expensive ways, often overlapped each other and provided in low accuracy. If the data are available, then it is a common that the data are not accessible. The national institutions often create GI for their official needs which sometimes have already created by another institution. It is therefore highlighted in Nebert (2004), many national, regional, and international programs and projects are working to improve access to available GI, promote its reuse, and ensure that additional investment in spatial information collection and management results in an ever-growing, readily available and useable pool of spatial information. With this objective in mind, many countries are developing SDI to manage and use their GI assets more efficiently (Crompvoets et al. 2007).

The Borneo Island conservation project can give an example in which SDI may prove useful scenario for collaborating GI. There are serious land issues in Borneo Island regarding the wildlife protections against the land expansion for the human life needs. One of the major problems is how to establish wildlife protection sites. The fact that the area has already fragmented into many regions and belongs to different countries with different regulations, become a consideration. There is a need to adjoin protected areas that involve a degree of co-operation across one or more boundaries between (or within) countries (Sandwith et al. 2001). As the understanding of establishing the collaboration has arisen, so has the attention to the GI related to the HoB area (HoB Declaration 2007). The idea to establish the transboundary partnership became the focus in the exploratory workshop of HoB Initiatives among the three nations in Borneo's island, Brunei Darussalam, Indonesia and Malaysia on 5-6 April 2005 in Brunei Darussalam (WWF 2005).

The importance of GI in transboundary partnership is addressed as Spatial Development Initiatives as stated in Mayoral-Philips (2002), in addition to conservation-based transboundary areas, Spatial Development Initiatives have been aggressively promoted to unlock economic potential in specific spatial locations through the crowding of public sector expenditure and private sector investment. Thus, understanding the goal in Spatial Development Initiatives to Spatial Data Infrastructure (SDI), both gain the similar purposes. In elaborating the different GI, a regional SDI will be founded from the national SDI from each nation. The regional SDI in HoB is an initiative intended to create an environment as an infrastructure that a wide variety of users who require a regional coverage, will be able to access and retrieve a complete and consistent data sets in an easiest and secure way. Its roots are in the regional governments and their cooperation (Rajabifard et al. 1999).

1.2 Problem Statement

The collaboration agreement in HoB has been founded, but there is still problem, especially in the GI sharing implementation. The area is fragmented into three nations, and so is the geographical information. Regardless the 220.000 km^2 huge areas to protect and to conserve, it is therefore a must to share the GI to develop a strategic conservation planning among three different nations.

Recognizing the importance to share the geographical information across the nations, a framework to develop a regional SDI to hold conservation activities in Borneo has to be considered. The fact that the national GI are structured and fragmented according to each policies and regulations is becoming understandable since each nation in HoB has different stage in developing their National Spatial Data Infrastructure (NSDI). To assess the NSDI development, the study related to different components established in each NSDI is becoming necessary to identify the missing SDI components. Moreover, assessing the NSDI status will give a starting point to look for possibility of sharing the geographic information. The development of a regional SDI of HoB would be an example of how to overcome the problem of sharing GI across the boundaries.

It is still unclear if the findings of INSPIRE can be projected to development countries in general and the HoB case in particular. Conservation provides one thematic example, where such a projection can be tested. At European level, development of a regional conservation SDI is ongoing within the Nature-SDIPlus project[1]. Nature-SDIPlus is one of SDI project which adopted INSPIRE initiatives. In this project, the interdisciplinary team of domain specialists and data modellers focus on interoperability and exploitability of distributed GI data sets in nature conservation (Nature-SDIplus Promotional Material 2008).

1.3 Objectives of The Thesis

In order to address the outlined problems, the thesis has three objectives:

1. To assess the current status of Spatial Data Infrastructure (SDI) development in Brunei Darussalam, Indonesia and Malaysia.
2. To evaluate the regional HoB SDI status and identify required developments using INSPIRE architecture as comparison standard and guidance.
3. To look for the possibility of GI visualization from different nations in one single application and identify the key issue in integrating GI among HoB nations.

Documenting and confirming the current SDI achievement in the three involved nations provides actual information of SDI development. We believe that the missing component in developing SDI can be assessed through adoption of INSPIRE State of Play Analysis, while the development within NSDI can be examined by adopting Technology Watch.

The development of regional SDI in HoB will benefit many sectors, from data providers to data users. Since the establishment of HoB initiative is intended to collaborate conservation activities within this area, the users which benefit regional SDI in HoB are probably coming from environmentalists, natural/national park managers, local communities and governments for planning and development.

[1] http://www.nature-sdi.eu/. Last accessed January 2010.

1.4 Methodology and Expected Outcomes

This research adopts case study approach, which GI come from each nation in the area of interest. The development of SDI in each nations will be summarized in order to perform the current status of SDI services. Summarizing the recent SDI status will provide information of possibility to develop a sharing application among nations across the boundaries.

The INSPIRE initiative will become the comparative experiences in developing a regional SDI. The SDI status and development will be evaluated according to INSPIRE as an arising project for spatial data infrastructure in Europe. The architecture of INSPIRE will be used as a technical schema to investigate the architecture in each NSDI. The comparative study will be conducted in order to seek for the missing component in each involved NSDI according to INSPIRE specifications for SDI development.

After assessing the status of NSDIs, the visualization of GI for conservation purposes will be developed. This will result in a prototype of interactive web mapping which can be integrated into particular conservation geoportal. According to the vision of establishing European geoportal in Bernard et al. (2004), geoportal will facilitate links and coherence with many institutional servers and portals and will provide on-line access to collections of spatial data and services supplied by multiple public and private organisations.

The development of shareable GI visualization will require GI from different nations with its specifications. The GI sample will come from World Wildlife Fund (WWF) as the organiser of HoB actions. The data is specified for the conservation actions, for instances river, forest and natural park data. The expected result in this process is the visualization of the data sets from different nations into one single application, which will indicate the relevancy of the data sets.

We use methodology of Reference Model for Open Distributed Processing (RM-ODP) (ISO/IEC 10746-1:1998) for assessing the development of NSDIs. Then we continue by adapting the methodology of assessing (N)SDI of 32 countries in Europe

(Vandenbroucke 2008), to identify the missing components of SDI in each NSDI. The presented items to be compared are as described in the SDI Cookbook (Nebert et al. 2004). There are five components which form together an SDI : legal framework and funding, reference data and core thematic data, metadata, access and other services, and standards which will be assessed, then the description of the 'ideal SDI' in the CookBook will be taken as a sort of baseline. We utilize convergence management to withdraw the recommendations and issues developed during the case study analysis.

The proposed research steps are illustrated in Figure 1.1. The research can be grouped into four steps, literature reviews, case study development, case study analysis and expected outcomes. Overall, the research is divided into six chapters that can be described briefly in the thesis outline.

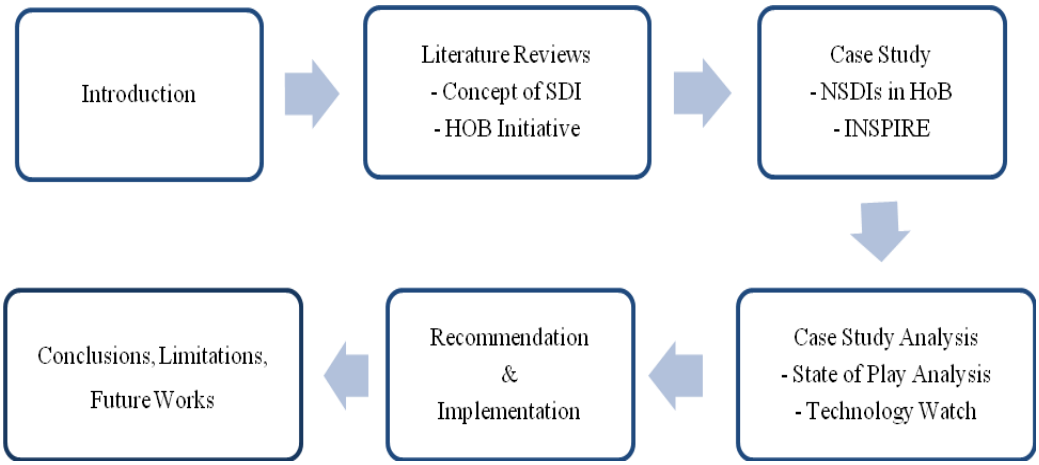

Figure 1.1 Strategy for Pursuing The Objectives

1.5 Thesis Outline

The thesis outline is organized into six chapters. Chapter 1 of this thesis covers the general research introduction, introducing the importance of SDI, discussing the need to establish regional SDI in HoB regions. Then, the chapter discusses the research objectives, methodology and the thesis outline.

In chapter 2, the background and review of literatures are covered. In the first part we introduce HoB and the initiative maintained in this area. The next part we describe more about SDI. We discuss the nature, concept and experience of SDI development in some. Furthermore, the implementation of SDI in Brunei Darussalam, Indonesia and Malaysia also discussed. Then the thesis also brings the INSPIRE initiative in the next part of chapter 2. It discusses a brief introduction of INSPIRE initiative and its implementation within European countries, moreover the Nature-SDIplus is used as the example of the INSPIRE implementation for conservation purposes in protected areas.

Chapter 3 includes the strategy for state of play analysis the SDI in INSPIRE and the NSDI in HoB nations. In this chapter we introduce the INSPIRE architecture, followed by the comparative study of INSPIRE and NSDIs state of play, whereas the SDI components as stated in the SDI CookBook (Nebert 2004) is used as the comparative components.

In chapter 4, we present the case study of conservation SDI in HoB region. The chapter examines the comparative study of national SDI in each nation particularly in HoB initiative, comparing to INSPIRE specification as the more developed practice in SDI implementations which experienced the implementation of SDI in conservation purposes. In this chapter, the Nature-SDIplus is considered as the representative of INSPIRE implementation.. Then, the chapter continues with the implementation of regional SDI in HoB by performing a prototype of Geoportal generated from GeoNetwork opensource and data set sample from institutions within HoB initiative.

We discuss the case study research in chapter 5, bringing the result conducted during the research and providing general recommendations for developing GI in HoB region. Then, the chapter continues with a scenario of regional SDI in HoB trough stepwise approaches as the scenario for the thesis project

In chapter 6, we describe the conclusions and limitations during the project. In advance, the future research also included in this chapter.

CHAPTER 2 . BACKGROUND

Geographic information (GI) plays an increasingly important role, both nationally and internationally, it is decisive in the environmental monitoring and management essential to the survival of future generations (Bernhadsen 1992). The importance of GI to support decision-making and management of these growing national, regional and global issues was cited as critical at the 1992 Rio Summit (Nebert 2004). The importance of GI in conservation initiative also reflected in HoB Workshop held in Brunei Darussalam in April 2005 (WWF 2005). To provide background of developing regional SDI in HoB, we resemble the literature reviews of Borneo, SDI and conservation activities in this chapter.

2.1 Borneo

Borneo Island becomes the study area in this research. It is the third largest island in the world (after Greenland and New Guinea) and the largest land mass in the Sundaic Region, more than five times the size of Java (Mc Kinnon et al. 1996). It refers to Kalimantan for Indonesian and East Malaysia for the part which is belonging to Malaysia. The rest of the island belongs to Brunei Darussalam. The view of Borneo Island in Google Map is shown in Figure 2.1 below.

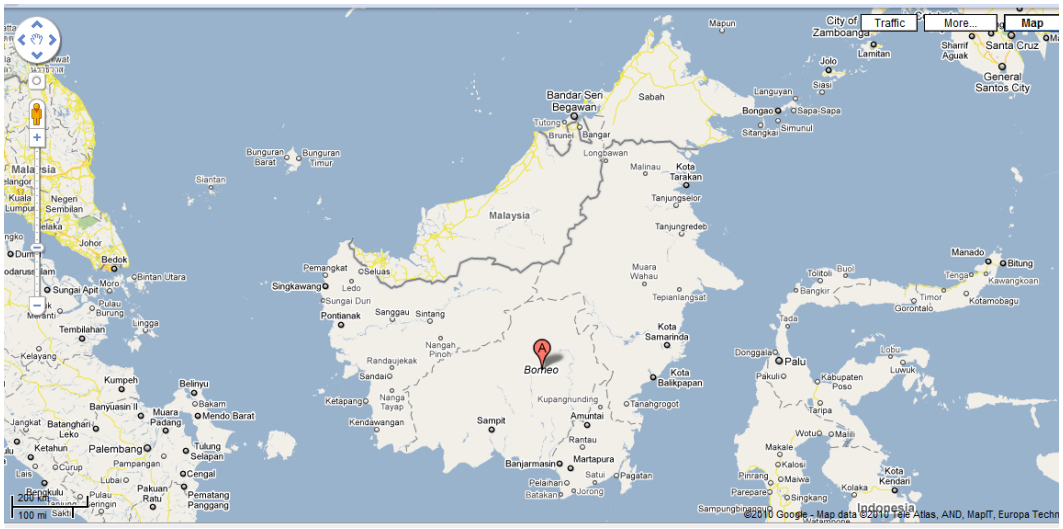

Figure 2.1 Borneo Island in Google Map View[2]

[2] ttp://maps.google.com/maps?hl=en&source=hp&q=google%20map&um=1&ie=UTF-8&sa=N&tab=wl. Last accessed 12 January 2010.

2.1.1 Geography of Borneo

Borneo is an island located in South East Asia Region, it covers an area of approximately 746,305 square kilometers (sq km) (Nijman 2005). It is ringed by the islands of Sumatra to the west, Java to the south, Sulawesi to the east and the Philippines to the north (Rautner et al. 2005). Borneo's territory is divided between three nations. In the northwest the independent sultanate of Brunei Darussalam (usually abbreviated to Brunei) covers less than 6,000 square kilometres (about twice the size of Luxembourg). Brunei itself is divided in half by the largest state of Malaysia, Sarawak (covering 124,500 square kilometres), which is located along the northwest coast of the island. Sabah is the second Malaysian state (72,000 square kilometres) and covers the northeastern tip of Borneo. However, the largest part of Borneo covers more than 500,000 square kilometres belongs to Indonesia and it is called Kalimantan (Persoon and Osseweijer 2008). The Indonesian part of Borneo is more than twice as large as the Malaysian territory and nearly one hundred times the area of Brunei. The provinces of Kalimantan make up just over 28% of Indonesia (Rautner et al. 2005).

2.1.2 Why Borneo is Important

The biological diversity of Kalimantan is one of the highest in the world but it is under pressures and threats due to population increase and economic development (WWF 2005). It is noted in Pio (2005), Lambir Hills National Park, in Sarawak (Malaysian Borneo), has the highest documented tree diversity in the world - 1,175 species in a 52-hectare (ha) plot. Borneo is also rich in endemic species: the 6,000 endemic plant species include 155 dipterocarp tree species – rainforest giants which produce valuable timber and aromatic oils and resins, and provide habitats and food for a vast range of plants and animals. Other endemic inhabitants of Borneo include 160 fish, 100 amphibians, 47 lizards, 44 mammals, 41 snakes and 39 birds.

As a big island, Borneo has a network of large rivers constitutes the main routes for communication and transport. The three longest rivers in Indonesia are located on Borneo: the Kapuas (1,143 km) flows to the west coast, the Barito (900 km) flows

south and the Mahakam (775 km) of which the estuary is on the east coast (Persoon and Osseweijer 2008).

2.1.3 Threats to Borneo

Borneo is a land of immense value, for its role as a 'world lung' and its wealth of ecological, biological and scientific resources. This land is at considerable risk of inappropriate or careless exploitation, as attention to its conservation is divided by political boundaries and varying conservation practices and commitments (WWF 2005). The part of the HoB within Brunei's boundaries is an already well-protected area, the Ulu Temburong National Park, and the Government has decided to expand its area. In Malaysia, some parts of the HoB designated area already have a protected status; others were initially to be converted into oil palm plantations after a process of logging and land clearance. The land-use plan for these parts will have to be changed by the Government. Indonesia, with by far the largest part of the Heart of Borneo within its boundaries, is facing the most serious challenges: the scale of illegal logging and the mining potential are high, while it also houses the largest population living within the boundaries of the projected area (Persoon and Osseweijer 2008).

Besides the illegal logging, the conversion of forest to oil palm plantations can be considered one of the biggest threats to the remaining forests on Borneo. In Malaysian Borneo, the average annual growth rate of oil palm areas was nearly 8% between 1998 and 2003 and over 1.6 million ha of oil palms now exist in Sabah and Sarawak. In Kalimantan the area used by palm plantations grew by 11.5 % to nearly a million ha in 2003 (Rautner et al. 2005).

2.1.4 Heart of Borneo Initiative

The Heart of Borneo (HoB) Initiative has been evolved since the first time the initiation stated. The WWF campaign for the HoB, which was launched in 2004, is one of the major conservation initiative taken to protect large areas with high biodiversity. The proposed area covers about 220,000 square kilometers in Indonesia, the Malaysian states of Sarawak and Sabah, and a small part of Brunei (Persoon and Osseweijer 2008).

The governance from three nations and also some institutions and NGO involving in HoB then attended an exploratory workshop in Brunei Darussalam which was held in 5-6 April 2005. Three nations and the workshop presented the benefits of large-scale conservation thinking, reviewed issues facing the uplands of Borneo, and promoted the need for effective transboundary partnership with the aim of developing a conservation vision and action plan to promote a future declaration of the Heart of Borneo (Proceeding HoB 2005). In December 2006, an official declaration by the heads of State was made during the Asean Summit in Manila, which paved the way to the signing of the 'Declaration on the Heart of Borneo Initiative: Tree countries, one conservation vision' in Bali, in February 2007 (Persoon and Osseweijer 2008).

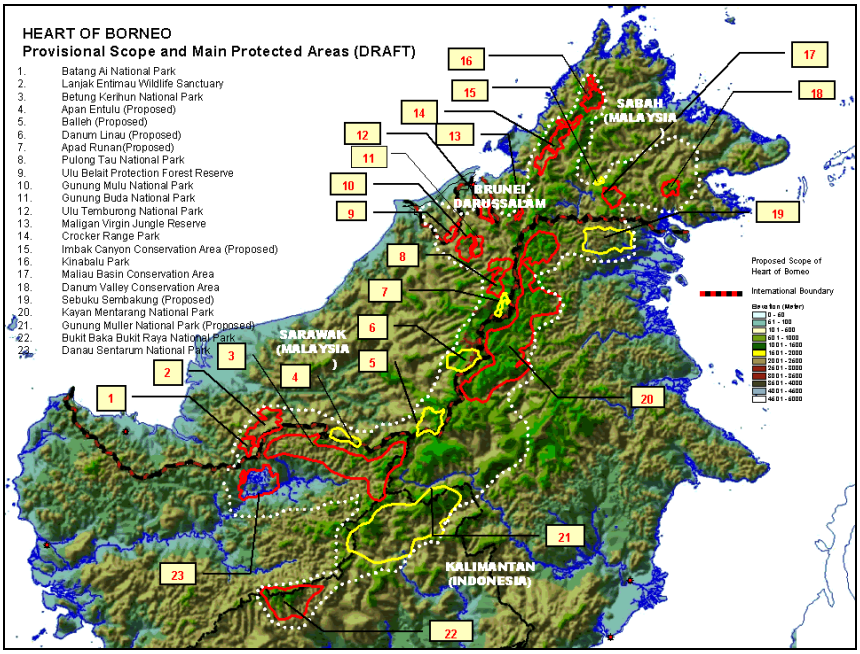

Figure 2.2 The Proposed Area for HoB Initiative (WWF 2005)

The HoB project is a huge transboundary initiative to conserve one of the last remaining frontier forests on the entire island of Borneo, by involving Borneo's three governments (Malaysia, Indonesia and Brunei Darussalam) and several non-governmental organizations (Rautner et al. 2005).

2.2 Managing Geographic Information

The development of Spatial Data Infrastructures (SDI) has been developed currently as recorded in Nebert et al (2004). Many countries believe that they can benefit both economically and environmentally from better management of their spatial data assets by taking a perspective that starts at local level and proceeds through state, national and regional levels to global level (Rajabifard and Williamson 2001).

2.2.1 Geographic Information

The Geographic Information (GI), also known as geo-spatial data, is the information that describes phenomena associated directly or indirectly with a location with respect to the Earth surface. Nowadays, there are available large amounts of GI that have been gathered (for decades) with different purposes by different institutions and companies (Nogueras-Iso et al. 2005).

GI is also used in decisions (GI Panel 2000). The accurate GI can help the decision maker to create a strategic decision which sometimes is very critical. As the example of earthquake or another disaster happened, then rapid decision is needed for evacuation and rehabilitation. And to support the governance, accurate GI is strongly involved.

As the importance of GI became considerations, there are also some obstacles in utilizing GI. The GI or geographic data as stated in Rajabifard and Williamson (2001) is expensive and time consuming to produce. Highlighted in (Rajabifard and Williamson 2001, Nogueras-Iso et al. 2005), the apparent lack of reusable resources may be motivated by the following circumstances:

- Most organizations need more data than they can afford.
- Some organizations, despite being public institutions, are reticent to distribute high-quality information.
- Data collected by different organizations are often incompatible.
- In most cases, there is a lack of knowledge about what data is currently available.

- The poor quality and poor documentation of data that is available through the WWW.
- Another issue related with the use of Internet is the increasing complexity of discovery and information retrieval services.

Considering the particular circumstances, it is necessary to integrate a number of data sets that may have been produced by different agencies within different nations for specific purposes, to their own specifications and priorities, and with little regard to the needs of other users (Rajabifard and Williamson 2001). The initiative to collect and store the geographic information in order to be able to distribute and reuse has been arising in the year of 1994, after The Executive Order of The President 1994 was signed by President Clinton (Masser 2005).

2.2.2 Spatial Data Infrastructure

The term "Spatial Data Infrastructure" (SDI) is often used to denote the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data. The SDI provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia and by citizens in general (Nebert 2004). According to the definition by The Federal Geographic Data Committee (1997), SDI is an umbrella of policies, standards, and procedures under which organizations and technologies interact to foster more efficient use, management, and production of geospatial data. This definition was applied to the national SDI in the United States.

Another definition from Rajabifard and Williamson (2004), Spatial Data Infrastructure (SDI) is a dynamic, hierarchy and multi-disciplinary concept that include institutional, policy, technical, standards and human resources dimensions. Furthermore, it also includes that SDI is an evolving concept about facilitation and coordination of the exchange and sharing of spatial data between stakeholders (data providers, value-adders and data users) from different jurisdictional levels.

The initiatives of NSDI have been growing in many countries. Realizing the importance to settle the foundation for the sustainable development, many countries start to maintain their infrastructure on geographical data. The step to start establishing spatial data infrastructure is a long term project and needs a lot of efforts and collaboration through all the institutions.

The purpose of SDI as stated in Groot (1997) is to save time, effort and money in accessing spatial data and using it responsibly, and to avoid unnecessary duplication in the harmonization and standardization of required data sets by promoting the sharing of available data. The process of SDI development and implementation consists of four main components (Masser 2007). The four components are the institutional arrangements that are required for delivering geographic information, tasks related to the creation and maintenance of fundamental data sets, procedures for making GI accessible, and ways of facilitating the development of strategic technology and applications (Masser 2007).

One of the ways to make GI accessible for public is by implementing a geoportal. A Geoportal in an SDI framework is a gateway to spatial data, metadata, users and tools which are interactively connected in order to use spatial data in an efficient and flexible way (Müller and Würriehausen 2009). In Europe, based on Bernard et al. (2004), the vision of the EU Geoportal is to allow users to discover, understand, view, access, and query geographic information of their choice from the local level to the global level, for a variety of uses, such as environmental policy development and impact assessment, land use planning, natural disasters preparedness, monitoring, and response.

2.2.3 Regional Spatial Data Infrastructure

The current complexity of communications between the various countries and regional bodies in any region is very high (Rajabifard and Williamson 2004). Increasingly, these countries are finding it necessary to cooperate with other countries to develop regional multinational SDI to assist in decision-making that has an important across national boundaries (Rajabifard et al. 1999). One of the needs for a regional SDI reflected in Rajabifard and Williamson (2004) is for accessing accurate

and consistent regional databases to make right decisions and to implement and resulting regional initiatives in order to organize economic activities in such a way as to maximize regional and individual country benefit. This is well understood that establishing the regional SDI focusing in conservation in HoB will gain environmental, economic and social benefits for each member.

The first two regions which have started to develop SDIs at a regional level are the Asia-Pacific and the European region. These two Regional SDI initiatives are the Asia-Pacific SDI (APSDI) and the European Geographic Information Infrastructure (EGII) which are coordinated by the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) and the European Umbrella Organization for Geographic Information (EUROGI) respectively (Rajabifard and Williamson 2001).

2.2.4 INSPIRE

The development of INSPIRE (Infrastructure for Spatial Information in Europe) initiative has been a complex process involving many groups of people since its exception in September 2001 (Masser 2005). In 2001, the European Commission launched the INSPIRE initiative. It was based on the observation that the accessibility, interoperability and affordability of spatial data and information systems were limited (Vandenbroucke 2008).

The INSPIRE initiative aimed to solve the barriers that inhibit the widespread use of spatial information to support environmental and other policies in Europe (Smits 2002). Those barriers are technical and also organizational:

- Gaps in spatial data availability at national and European level; at the same time duplication of data collection efforts, even within organizations,
- Non-harmonized spatial data which makes them difficult to combine and to integrate in applications;
- Lack of documentation and metadata, or data about the data, which makes it difficult for potential users to assess whether the data are “fit for use”;

- Data are difficult to find and not easy to access, with often many and complex procedures and agreements to be established before access is given or before data are obtained;
- Data are often expensive;
- Barriers (in the form of conditions) for sharing and (re-)using the data.

The major objective of INSPIRE is to make harmonized spatial data readily available to support environmental policies that have a direct or indirect impact on the environment (Vandenbroucke 2008). Highlighted by Masser (2007), the development of an SDI in Europe would be based according to the INSPIRE Principles, which are:

- Data should be collected once and maintained at the level where this can be done most effectively.
- It should be possible to combine seamlessly spatial data from different sources and share it between many users and applications.
- Spatial data should be collected at one level of government and shared between all levels.
- Spatial data needed for good governance should be available on conditions that are not restricting its extensive use.
- It should be easy to discover which spatial data is available, to evaluate its fitness for purpose, and to know which conditions apply for its use.

The core of the architecture of INSPIRE are the INSPIRE Service Types: Discovery, View, Download, Transform and Invoke as reflected in Figure 2.3. INSPIRE Services are accessed via the rights management layer and may be accessed by applications and geoportals via the INSPIRE services bus (INSPIRE NSA 2008).

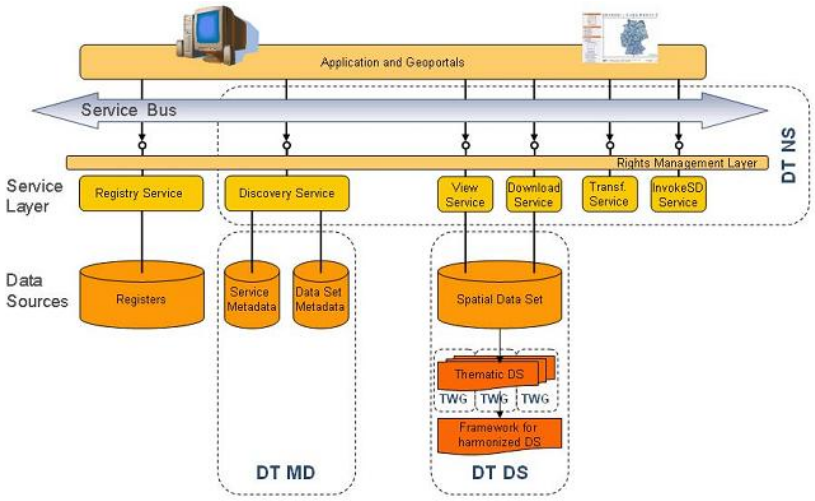

Figure 2.3 INSPIRE Architecture (INSPIRE 2008)

2.2.5 Conservation Spatial Data Infrastructure

The terms of transboundary conservation or conservation across national boundaries has attracted growing attention recently. Because national boundaries are often the outcome of very complex historical processes involving battles between traditional rulers or empires or political agreements between colonial powers, which rarely coincided with ecological realities or desirabilities, efforts to protect nature have usually remained confined to the limits set by the official, national boundaries (Persoon and Osseweijer 2008).

In Africa, one of the projects on transboundary conservations is called as Transboundary Protected Area. Transboundary Protected Area (TBPA) according to Sandwith et al. (2001) is an area of land and/or sea that straddles one or more boundaries between states, sub-national units such as provinces and regions, autonomous areas and/or areas beyond the limits of national sovereignty or jurisdiction, whose constituent parts are especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed co-operatively through legal or other effective means.

Moreover, transboundary conservation is not only about conservation, but also about bringing people together, building constructive dialogue across boundaries, promoting

understanding trust and friendship, even in longstanding politically disputed areas of this region. Transboundary conservation is a concept the world needs, a contribution to long-term conflict resolution, a contribution to a culture of peace (Hill 2005). The importance of GI in transboundary partnership is addressed as Spatial Development Initiatives as stated in Mayoral-Philips (2002), in addition to conservation-based transboundary areas, Spatial Development Initiatives have been aggressively promoted to unlock economic potential in specific spatial locations through the crowding of public sector expenditure and private sector investment. Thus, understanding the goal in Spatial Development Initiatives to Spatial Data Infrastructure (SDI), both will gain the similar purposes.

Nature-SDIplus

An example of SDI which concerns in supporting conservation goals is Nature-SDIplus in Europe. The establishment of Natura 2000 and the new transboundary EU approach for protected sites management has enforced the link between nature conservation and geo-information. This has generated the need for interoperable and accessible EU harmonized data sets (Nature-SDIplus Promotional Material 2008). The link is also addressed by the INSPIRE Directive which pursues an EU Spatial Data Infrastructure to support environmental policies. The research within the FP7 project "Nature-SDI plus" links to spatial data infrastructures (SDI) as one of the primary fields of research at the GIScience Research Unit. The focus of the research is on interoperability and exploitability of distributed spatial data sets in nature conservation (Nature-SDIplus Promotional Material 2008).

Nature-SDIplus Network aims, through state-of-the-art methodologies and best practice examples, to improve harmonization of national data sets and make them more accessible and exploitable. The main objective of Nature-SDI plus Network is to: involve new stakeholders; share data and best practices; improve and stimulate exploitation and the re-use of information on nature conservation. The project will analyze the usability and accessibility of data. (Nature-SDIplus Promotional Material 2008).

CHAPTER 3 . METHODOLOGY
FOR SDI CASE STUDY ANALYSIS

In this thesis, case study analysis is used to answer research objectives. Case study analysis can be adopted to document and analyze implementation process. The method is appropriate if the researchers want to define research topic broadly, to cover contextual or complex conditions and to rely on multiple sources of evidence (Yin 2003).

The case study area is involving NSDI implementations in each nation of HoB. The area covers the development and implementation of NSDI which documented in the paper or publication or other documentations available through internet. We consider documentation will be ranged from 1993- when the first initiation of developing NSDI started as mentioned (Masser 2005) - up to today.

Based on the documentations, the recent status of NSDIs will be compared by adopting the methodology released by GEOSS, INSPIRE and GMES, an Action in Support (GIGAS) called Methodology for technology watch and comparative analysis of information and data management systems (GIGAS 2009). The methodology was developed to analyze and compare different information and data management system for improving and advancing on the interoperability of the architectures which are underpinning INSPIRE, GMES and GEOSS. The decision for applying the methodology based on the functionalities of GIGAS approach as highlighted by Klien et al. (2009) that GIGAS makes use of a formal and structured approach to identify and analyze commonalities and interoperability gaps in architectures, standards and governance issues. Furthermore, the methodology also can be implemented for analyzing and comparing different system to identify elements for convergence, technology and interoperability gaps and areas for improvement purposes. In the following, this methodology is applied to the three involved NSDI. Then, the analysis continues by adopting questions for assessing component of ideal SDI from INSPIRE-state of play analysis (Vanderbroucke 2008) as guidance applied to NSDI in Brunei Darussalam, Indonesia and Malaysia.

3.1 Methodology Overview

There are two approaches used in this research. The objective of assessing NSDI achievement in each country is examined by using methodology for technology watch. Meanwhile, the identification of required development in regional HoB SDI is executed by identification of available and missing components of ideal SDI within NSDI. The overview of two different approaches for the research is carried out in this sub section.

3.1.1 Methodology for Technology Watch

Methodology for technology watch and comparative analysis of information and data management system derived from Reference Model for Open Distributed Processing (RM-ODP) (ISO/IEC 10746-1:1998). Several benefits can be gained from the methodology for technology watch and comparative analysis of information and data management system, which are addressed in empowering each community with a neutral tool for comparison and convergence, allowing a critical analysis to be performed by the initiative owners both at management and technical level so that decision makers can be involved in the process and provide an identification of interoperability gaps, areas of possible convergence (GIGAS 2009).

The first step of the methodology for technology watch and comparative analysis of information and data management system is the *Identification of Convergence Objectives*. Such objectives are formed from the collection of requirements used to identify the interoperability opportunities among the systems. The step aims to make the activities scope and target clarified and narrowed down. Then the target systems will be examined with *Technology Watch* for their requirements, standards, services, architecture, models, processes and the consensus mechanisms with the same elements to the other systems. The process itself based on the RM-ODP, which reviews the objects in five different viewpoints (ISO/IEC 10746-1:1998). The five viewpoints are:

- **Enterprise viewpoint**. In this viewpoint, the analysis is focused on the purpose, scope and policies in each NSDI under study. The role of enterprise activities is addressed as the key activities which determine the foundation for the NSDI. The

term of enterprises in this case study area are referring to the NSDI initiators and providers in each country.

- **Information viewpoint.** This viewpoint discusses the interest to any data or metadata which are relevant for the parallel view in the different initiatives. It summarizes the modeling approach for the architecture information of the system under study. In the analysis of the case study, the metadata standard for the GI has been considered as the important part of the NSDI achievements. In this regard, the existence of data or metadata standard will be reviewed.

- **Service viewpoint**. The Service Viewpoint reviews the approach of the Interface and Services Types, also how the services are specified. In the case study, the viewpoint is adopted to assess the online services of the NSDI which is usually performed as web portal.

- **Engineering viewpoint.** The Engineering viewpoint takes into account the mechanisms and functions require for supporting interactions among resources (services) in the system under study. This viewpoint puts more interests on the architecture of the systems under study, and

- **Technology viewpoint.** Technology viewpoint defines the run time environment and the status of the standardization process.

The process continues to a *Comparative Analysis* which focuses in the solutions, requirements, architecture, models, processes and consensus mechanisms of among the systems, gives result in summaries and recommendations of the case study objects. The last step, *Convergence Management* is the phase of outreach and possibly shaping. With this step, the recommendation for case study result will be conducted. As mentioned that the results of the analysis mainly are recommendations wherein the issues of public, the target systems and stakeholders are addressed (GIGAS 2009). The workflow of the analysis process is viewed in Figure 3.1.

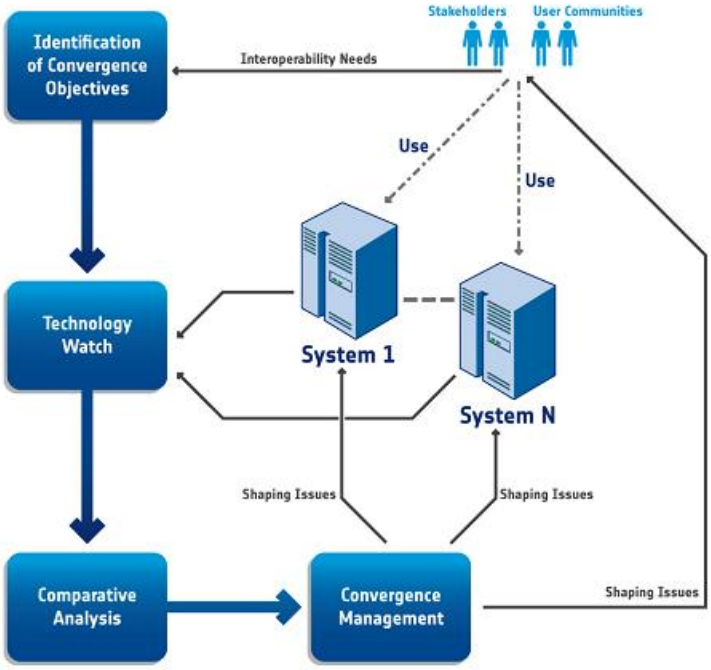

Figure 3.1 Technology Watch Overview (GIGAS 2009)

Figure 3.1 shows the process of methodology for technology watch and comparative analysis of information and data management system. As the existence of regional SDI will give benefits for different stakeholders and user communities, then stakeholders and user communities are addressed to examine the building blocks of NSDI development. Stakeholders consist of government through its departments and local government, while the user communities stand for Non Governmental Organization (NGO) such as WWF, TNC, BIRDLIFE, etc, academia and local communities. These users will get the benefit from regional SDI development and can involve also as data providers. Systems 1 to system N are the NSDIs and regional SDI in HoB. The shaping issues focus in management issues for relating NSDIs, regional SDI and users which will be discussed in Chapter 4 and 5.

3.1.2 INSPIRE State of Play Analysis

Vandenbroucke (2008) has applied INSPIRE State of Play Analysis to assess the status of NSDI in 32 countries in Europe. The analysis was done by identifying the available and missing components of ideal SDI in each NSDI. Although the development of NSDI in Europe has been maintained in some countries, but the component of SDI in particular country is sometimes not complete. This possibly

happen due to the fact that from the very beginning, it was recognized that INSPIRE should build upon the existing components of the emerging SDI at national (NSDI) and sub-national level (Vandenbroucke 2008). The diversity of SDI initiative in Europe made the necessity to assess the established SDI within Europe. For the methodology of assessing SDI, it was decided to collect and structure information on the five components of the GSDI Cookbook and take description of the 'ideal SDI' in the Cookbook as a sort of baseline (Vandenbroucke 2008).

The analysis was conducted by applying a desktop study in a step-by-step way. The reason behind this was the hope that the richness and variety of the NSDI development could be captured better than doing this with a rather static survey (Vandenbroucke 2008). The five generic components of ideal SDI notated by Nebert (2004) is considered as the building blocks of the SDI under study (Vandenbroucke 2008).

Applying the methodology to case study in this research, the reference of ideal SDI is still refers to Nebert notion of ideal SDI in GSDI Cookbook (Nebert 2004). The decision for adopting Nebert notion as ideal SDI is because Nebert provided guidance for establishing SDI which can be used in any level of SDI initiative.

3.2 Ideal Spatial Data Infrastructure Overview

In order to compare NSDIs development, a globally accepted framework for SDI establishment has to be carried out. The framework will be used to identify comparative components that will be compared among NSDIs. Nebert (2004) mentioned an ideal conceptual framework of SDI development in SDI CookBook to give the guidance for the stakeholder to establish SDI, to assess the implementation of available SDI or to compare the existing SDIs. The core components which form together an SDI explained in the SDI CookBook are legal framework and funding, reference data and core thematic data, metadata, access and other services, and standards which as reviewed below:

- **Legal framework and funding**: Development of legal framework and funding is the key to ensure the development of an SDI. This will refine the stakeholder

participations, both producers and users for rights and duties in utilizing the services. Continuous funding is necessary for establishing an SDI which serves and provides reliable information. Around the world, some nations build their NSDI driven by the national or federal government initiatives (Nebert 2004).

- **Reference Data and Core Thematic Data:** The concepts of reference data and core thematic data have different perspectives, as stated in the SDI CookBook. However, core data then defined as a set of GI that is necessary for optimal use of most GIS applications i.e. that is a sufficient reference for most geo-located data. Each data can be provided by different provider within an SDI. It is being concerned to make sure the data are shareable.

- **Metadata:** One of the options to ensure the share ability among systems is by using the metadata. Metadata is defined as a key ingredient in supporting the discovery, evaluation, and application of GI beyond the originating organization or project (Nebert 2004). With the availability of metadata, the SDI services are searchable in terms of the information can be discovered and accessed by user. Furthermore, metadata can be benefit to avoid duplications in establishing the data sets. However, to make consistency among metadata, there are some standards established, for instance ISO 19115 which is known as the international standard for metadata.

- **Access and Other Services:** SDI can facilitate the access of the geographic information in local, national, regional or global level. Many of SDI initiatives implement a web portal as a gate point to view, to access and to use the GI available in the systems. The data sets is becoming discoverable through web service, making use the catalogue services or clearinghouses that established to provide access for user. The internet technology has been evolving, so has the web mapping technology. The availability of the web mapping services within SDI is considered as one of the requirement in developing SDI.

- **Standards:** Many countries are establishing and maintaining SDI in the national level. By the time, the regional development in particular region also needs the support of consistent geographic information. The similar interests bond the countries in particular region to develop the regional SDI, for instance the INSPIRE in Europe and PCGIAP in Asia Pacific region. In this regards, the

standards to ensure the access among countries or regions are needed. One that has been mentioned above is ISO 19115 for metadata standard. Implementation of the international standards will make sure the harmonization of the data sets and also the services within SDIs.

3.3 Chapter Conclusion

This chapter explains the applied methodologies in this research. Based on the methodology reviewed above, the case study areas consist of Brunei Darussalam, Indonesian and Malaysia. Each NSDI will be analyzed further in such structural way. In order to put guideline for comparative analysis, the building blocks for which components of NSDI assessed are decided to adopt the experience of INSPIRE state of play analysis which has conducted in 2007 (Vandenbroucke 2008). In the next chapter, the implementation of the methodology in this chapter for assessing NSDIs development will be further discussed.

CHAPTER 4 . CASE STUDY ANALYSIS

As part of the work, the analysis of the NSDI status is conducted. It aims to assure the foundations for the development of regional SDI in HoB. It is mentioned in the previous chapter, the methodology for assessing the status of NSDI is referring to methodology for technology watch and comparative analysis of information and data management systems. We identify the convergence objectives for establishing the regional SDI in HoB by using Nebert's notion of an ideal SDI. This step enables a gap analysis with respect to the state of play of the NSDIs. Then, the analysis continues with technology watch and comparative study for each NSDI. This chapter addresses the first objective of the thesis - to assess the current status of Spatial Data Infrastructure (SDI) development in each nation. Subsequently, it is followed by discussion for the second objective - to evaluate the regional SDI status and identify required developments using INSPIRE architecture as comparison standard and guidance - simultaneously.

4.1 Identification of Convergence Objectives

We aim to identify the key working area and targets of the HoB activities. This step concerns the stakeholders and user communities roles, in order to develop the system which is suitable to their needs. This is done by collecting the parameters for comparing the achievement of particular NSDI. The selected parameters should represent ideal SDI components, for instance, as stated by Nebert (2004).

In the previous chapter, the development of ideal SDI covers several components, legal framework and funding, reference data and core thematic data, metadata, access and other services, and standards. These basic components are divided into several more building blocks which determine the development of SDI. The division of the building blocks is adopted from Vandenbroucke (2008), with some exceptions regarding the availability of the NSDI data in the study area. The following building blocks are considered in our work (the first part reflects the distinctions from presented in the previous chapter, while the second part corresponds to Vandenbroucke's categorization):

I. Organizational Issues: Level of SDI, Degree of Inter-operationality, Coordination, Participants

II. Legal Issues and Framework: Legal framework, Policy of access to public sector information, Intellectual Property Rights, Restricted access, Data licensing, Funding and pricing policy

III. Reference Data and Core Thematic Data: Quality of reference data & core thematic data, Geodetic reference systems and projections, Interoperability Language and culture

IV. Metadata for the SDI: Availability of metadata, Metadata catalogue availability and standard, Metadata implementation

V. Access and other services for the data and metadata: Discovery Services. View Services, Download Services

VI. Standards: Standards

Vandenbroucke provides sets of questions for each item of his categorization (Vandenbroucke 2008). These questions to NSDIs will be used to guide the NSDI comparative study in a later part of this section. Questions have been used for assessing the status of NSDIs in 32 countries with heterogeneous achievements in Europe (Vandenbroucke 2008). Concerning the similarity of case study to the SDI State of Play Analysis in Europe, related questions are adopted to HoB case study. To examine the question, we complete the detailed technology watch first, in order to provide brief information about current status of NSDIs. The result of the comparative study is presented in Table 4.6 in this chapter.

4.2 Technology Watch

In this section, the identified parameters from the previous work are reviewed according to five viewpoints of the Reference Model Open Distributed Processing (RM-ODP), which also refer to ISO/IEC 10746-1 (GIGAS 2009). As explained in the Chapter 3, technology watch reviews the objects in five different viewpoints: enterprise viewpoint, information viewpoint, computational viewpoint, engineering viewpoint and technology viewpoint. Each NSDI is analyzed and summarized its characteristic and achievements according to each viewpoint.

4.2.1 Enterprise Viewpoint

The Brunei Darussalam SDI was based on national collaboration and initiated by the national government. At this moment, there is no information available about the year the activities started. The technology aims to harmonize the Sultanate's GI bases and makes them available and accessible through internet (Brunei 2008). Brunei also concerns in data integration as the priority in the projects. At this moment, the development of NSDI is carried out by the Survey Department and the Land Department. However, in the future, the private company or public can involve in the NSDI implementations (BSDI 2008).

NSDI in Indonesia was established by the initiation of Indonesian SDI (ISDI) in 2000. Bakosurtanal is the national institution which responsible for the development of the ISDI. Bakosurtanal has responsibility to provide the national clearinghouse for ISDI. As the Network Node, Bakosurtanal is also responsible for implementing the acquisition, maintenance, update, exchange of certain GI. The development of ISDI focuses on five aspects; institutional aspects, legal aspects, fundamental data sets aspects, technology research and development, and human resources aspects. The private companies and public are encouraged to involve in the project. The technical framework for developing ISDI was presented in the PCGIAP meeting (Bakosurtanal 2002) in Brunei on April 2002, which as shows in Figure 4.1.

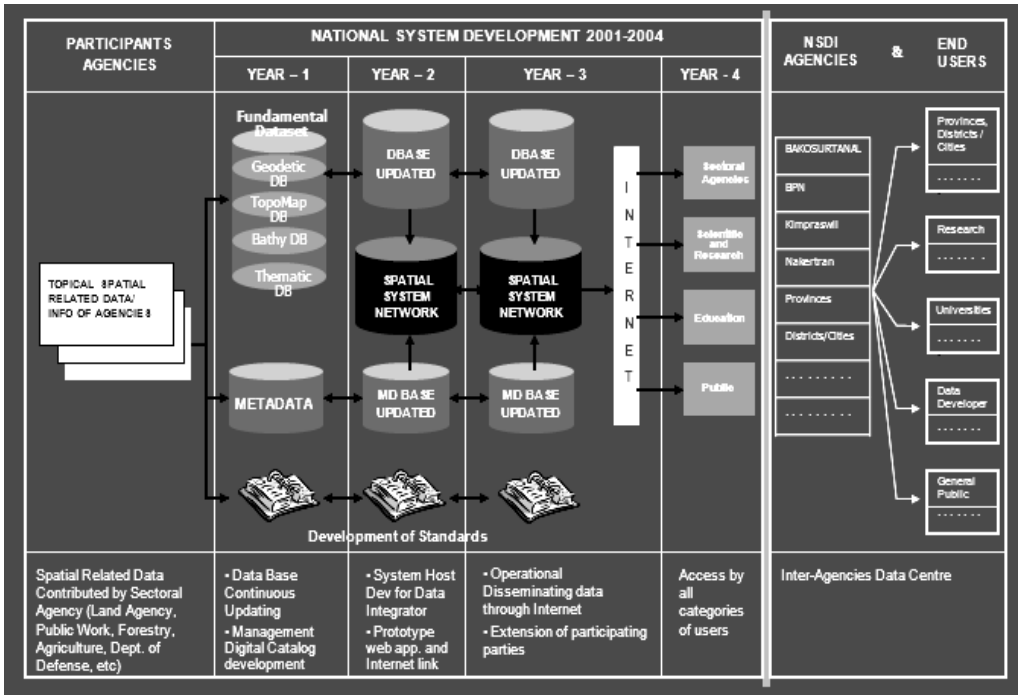

Figure 4.1 The Technical Framework of Development ISDI in 2001-2004 (Bakosurtanal 2002).

In Malaysia, the initiation of NSDI has been settled down with the development of National Infrastructure for Land Information System (NaLIS) by a directive from the Government's Secretary General in 1997. A Coordinating Committee (NCC) at the national level was formed to role the central policy and decision making body for the development and operation of NaLIS (Nordin 2002). In 2002, the Malaysian Centre for Geospatial Data Infrastructure (MaCGDI) was developed and aimed to promote the development and implementation of Malaysian Geospatial Data Infrastructure (MyGDI) (MaCGDI 2007). MyGDI fosters different users and data providers to benefit GI further as shows in Figure 4.2

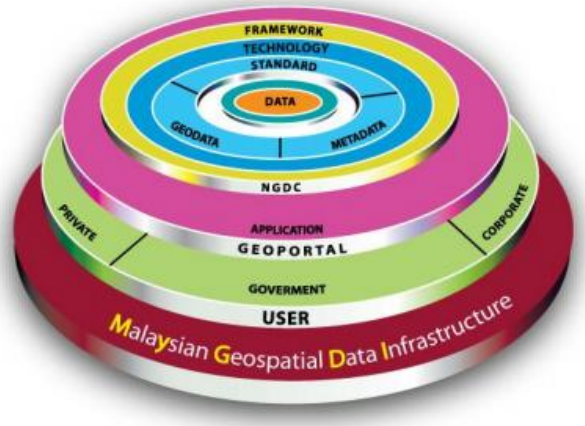

Figure 4.2. MyGDI Business Model (MaCGDI 2007)

Table 4.1 provides the summary of the enterprise viewpoint of SDI developments among three countries.

Table 4.1 Summary of Enterprise Viewpoint

Country (NSDI)	**Main Initiator**	**Level of Directive**	**Focus of Development**
Brunei Darussalam (BSDI)	Survey Department	National level	• Reduce data duplication • Data integration
Indonesia (ISDI)	Bakosurtanal	National level	• Institutional aspects • Legal aspects • Fundamental data sets aspects • Technology research and development, and • Human resources aspects.
Malaysia (MyGDI)	NaLIS, then in 2002 changed into MaGDI	National Level	• National Clearinghouse • Metadata Standards

4.2.2 Information Viewpoint

The institution in charge for producing GI in Brunei is the Survey Department. The core data sets which produced are cadastral, roads, rivers at scale of 1:2,500 and most data are available in the digital form (PCGIAPb 2006). However, there is no available information that can be use as the reference for the use of compliance data or metadata standards in the BSDI.

Indonesia through Bakosurtanal develops the metadata which follow the national standard for the GI. In the absence of the national standards, then the standard will temporarily follow the standard or specification of Network Node, and will be assessed for maximum three years. The Network Node consists of departments or ministries, Provincial Local Governments, and Districts/City Local governments. As the member of APSDI, Bakosurtanal also sets the node to the regional spatial data sets. In compliance to global SDI, Indonesia decided to adopt the Federal Geographic Data Committee metadata standard called 'Content Standard for Digital Geospatial Metadata', FGDC-STD-001-1998 as the national content standard of metadata (Puntodewo and Nataprawira 2007).

GI in Malaysia are certified and described according to the Malaysian Standard for Features and Attributes Codes (MS 1759). In compliance to the international standard, the metadata standard is also developed based on ISO/TC211.

In short review from the information viewpoint, BSDI has no information for the data and metadata standard used, ISDI follows FGDC-STD-001-1998 as standard for metadata, and MyGDI uses MS 1759 and ISO/TC211 for metadata standard. The summary of this viewpoint is presented in table below (Table 4.2).

Table 4.2. Summary of Information Viewpoint

Country (NSDI)	Metadata Standard	Additional Information
Brunei Darussalam (BSDI)	Unknown	-
Indonesia (ISDI)	FGDC-STD-001-1998	Adopted for National Standard

Malaysia (MyGDI)	MS 1759 and ISO/TC211	Adopted for National Standard

4.2.3 Service Viewpoint

Brunei launched the e-map in 2007, aimed to provide online services for the clients and employees. The e-Map is a collaboration work among Ministry of Development, Departments of Survey, Land and Town and Country Planning. The e-Map project will cover the implementation of e-Map portal, e-LIS portal, e-PPT portal, e-Planning portal and e-Land portal. e-Map portal is used as an entry point to access the GI. An e-LIS application is aimed to support the Land Information System within Survey Department, and e-PPT portal is used to support the process of land subdivision and consolidation. An e-Planning portal provides support for the business process within the Town and Country Planning Department. Furthermore, the Land Department provides the business process supports by establishing the e-Land portal (BSDI 2008). The Framework of e-Map in BSDI is showed in Figure 4.3.

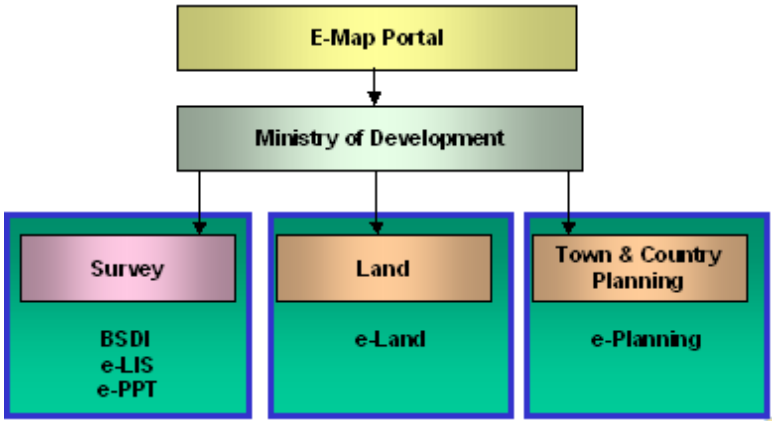

Figure 4.3 e-Map Framework (BSDI 2008[3])

The applications are integrated into BSDI to enable the GI harmonization in Brunei. At this moment, all the applications are still under preparation in the e-Map website.

Bakosurtanal settled the web-portal as the gate point to view and download the GI through internet. Investigation to the website summarized some of the service capabilities are available, for example for viewing the interactive map of road

[3] http://bsdi.gov.bn. Last accessed 5th January 2010.

network (limited to an island) as performed in the Figure 4. Download service is also available for the shape file of provinces in the scale 1:1000.000. One of the functionalities, deployed by Bakosurtanal in the website, is the road network map which covers some islands in Indonesia (Figure 4.4).

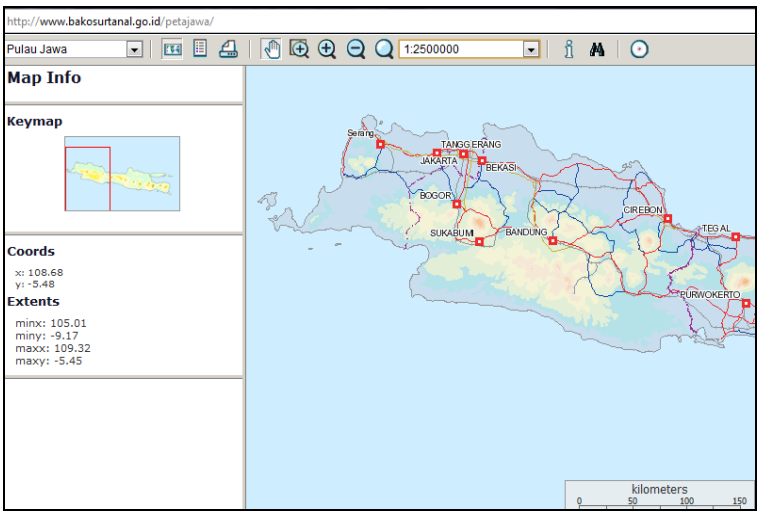

Figure 4.4 The Interactive Map of Road Network

The information of recent natural disasters is also available and can be downloaded from the website. The experience of several natural disasters in this country which happened in short time range leads the government of Indonesia to provide a quick and accessible online map to provide the actual and up to date information for the mitigation purposes. Further, it was necessary to deploy the emergency quick response map which was implemented during the mitigation of West Sumatra earthquake in September 2009.

Malaysia provides the online services for the GI through Malaysia Geoportal. To be able to access the information, a user registration is applied. Malaysia Geoportal is composed from Metadata Catalog, GIS applications, and NGDC/SGDC. NGDC has the responsibility to develop a portal for supporting access and encourage greater collaboration and coordination in utilizing GI among all levels in government. The available data categorize into 12 feature categories associated to MS1759. The search service also uses MS1759 Search Engine specification which provides the users the particular codes to be applied into the GI. MyGDI metadata standard is formatted by

following ISO/TC211 about standard in Geographical Information (MyGDI 2009). Overview of MyGDI services which involve heterogeneous data providers and users is reflected in Figure 4.5.

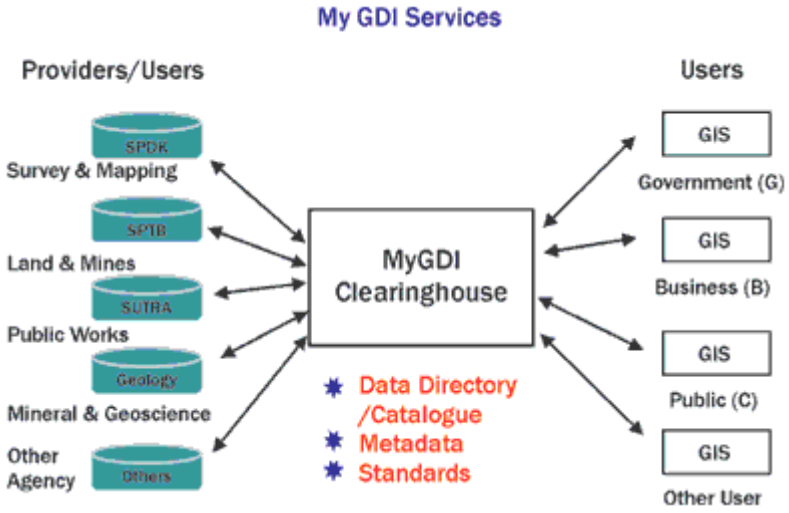

Figure 4.5 MyGDI Services (Ahmad 2004)

MyGDI addresses many users with different purposes to explore the geographic information with some privileges. User has to register in order to utilize the services of geoportal. To satisfy and to make it more convenient, varies of products and services are available through MyGDI geoportal, which include:

- MyGDI Metadata Catalogue or Data Explorer,
- Geoinformation for Executive,
- Geographical Names Database (MyGeoname),
- Feature and Attribute Code (MS 1759),
- Malaysian Land Integrated Information Services (MyLIIS),
- Geoinformation for Natural Resources and Environment,
- Unique Parcel Identifier (UPI), and
- Map Viewer.

The user interface for Data Explorer as presented in Figure 4.6, allows user to discover, view and access GI through the website. The interface gives easiness to find the GI by selecting keywords and possibility for data with time different.

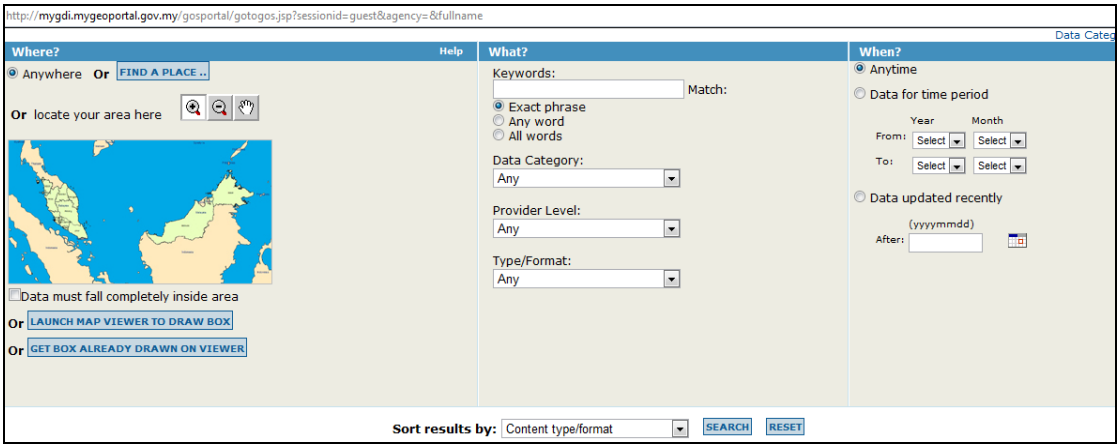

Figure 4.6 The Interface of Data Explorer in MyGDI GeoPortal (MyGDI 2008)

In this viewpoint, the architecture of the NSDI the service viewpoint can be summarized as listed in the table below (Table 4.3).

Table 4.3 Summary of Service Viewpoint

Country (NSDI)	Online Map	Language	Download Services	Integrated Services to Other Institutions/Systems
Brunei Darussalam (BSDI)	Under implementation	Melayu, English	Under implementation	Yes
Indonesia (ISDI)	Yes	Indonesian, English	Yes	Yes
Malaysia (MyGDI)	Yes	Melayu, English	Yes	Yes

4.2.4 Engineering Viewpoint

This viewpoint examines the architecture of systems under study. In the case study area, the viewpoint is adopted to study architecture services of NSDI. Unfortunately, the technical documentation of this viewpoint has not yet available or accessible for BSDI. It is possible due to the fact that BSDI is under implementation processes which lack of achievements were documented in this stage.

According to Syafi'i (2006), the integration of GI is very important and SDI can facilitate the data integration by implementing a set of standards, rules and technologies. ISDI through Bakosurtanal has established some GI integration projects and maintained in database management system, with the main objectives:

- The integration of Indonesian topographic map series of scale 1 to 25.000, 50.000 and 250.000 (published by Bakosurtanal). Each map series is stored in different schema of database.
- The integration of Indonesian coastal map of 1 to 50.000 scale (published by Bakosurtanal) that contain both land and marine information of the coastal area.

The spatial database used to maintain GI is Oracle 9i with Spatial Data Option that has the following characteristics (Syafi'i 2006):

- Seamless, the spatial is stored continuously throughout Indonesia (not on map sheet basis).
- Multi-purposes, the same data can be used for different purposes.
- Multi-users, the same data can be accessed by different user concurrently.
- Interoperable, the data stored in the database can be accessed using different GIS software and applications.

The architecture of spatial database in ISDI is presented in Figure 4.7 below.

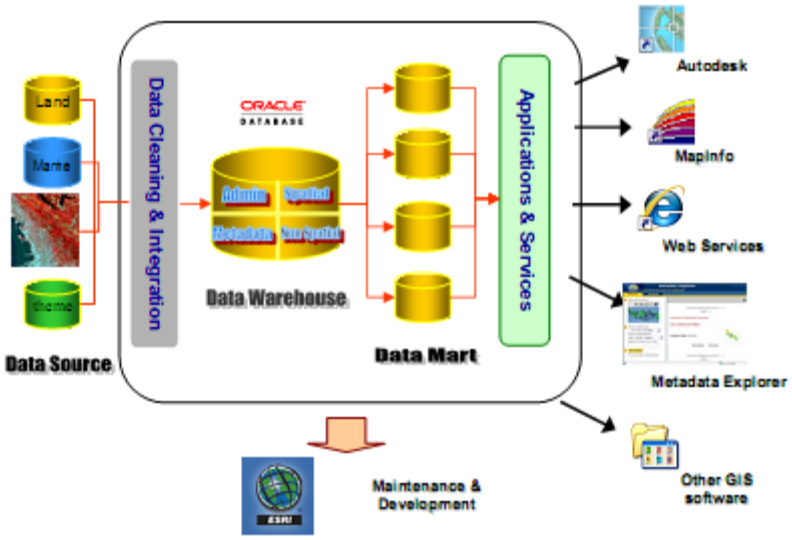

Figure 4.7 GI Warehouse Architecture (Syafi'I 2006)

The Web Service architecture of MyGDI provides three fundamental operations: publish, find and bind. The data oriented service has been built in MyGDI (Figure 4.8) which addressed the issues of data and user needs. However, the inclusion of service oriented is concerned to develop in the future to enable technology for GIS decision making in communities (Figure 4.9).

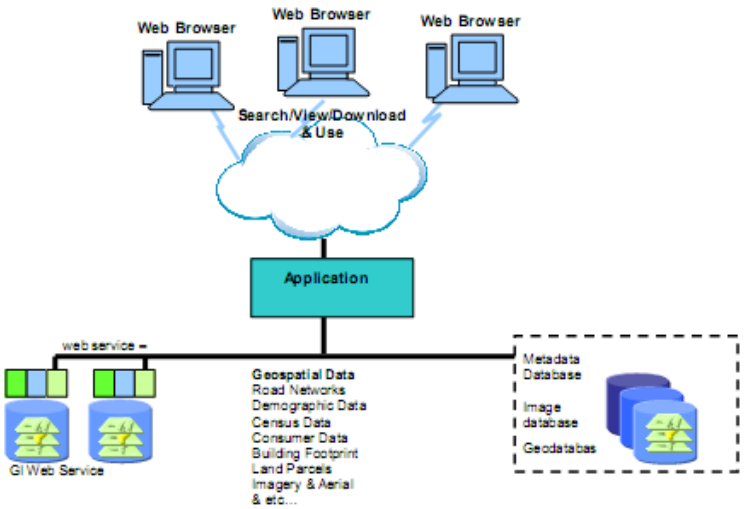

Figure 4.8 Data Oriented Service in MyGDI (© MyGDI 2008)

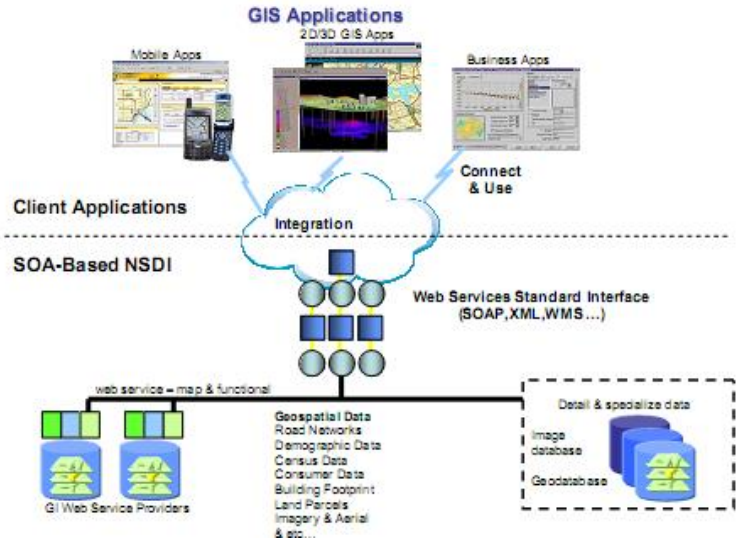

Figure 4.9 Service Oriented of Web Service in MyGDI (© MyGDI 2008)

The enhancement of data oriented service to service oriented service aims to enlarge the types of services that can be provided through web services. The types of services according to MyGDI (2008) are:

- Services that are provided and for use by government,
- Services that are mainly provided by government and used by government and business (G2G and G2B),
- Services provided by business entities and used mainly by other businesses, and
- Services provided by business entities and used by the other business entities as well as the consumer at large.

From the engineering viewpoint, the architecture of NSDIs have different focuses. At this moment, the engineering viewpoint in BSDI is not reviewed yet. Within ISDI, the focus of information viewpoint is to integrate GI. Furthermore, MyGDI is concerning in developing service oriented web services to fulfill the user needs. In this viewpoint, it shows that each country has different focus in establishing its NSDI. The documentation of BSDI in engineering viewpoint is not published broadly, resulting unknown architecture of BSDI. Meanwhile, ISDI and MyGDI have developed NSDI's clearinghouse which can be accessed in this research. However, the focus of NSDI development within some range of time is different. Table 4.4 is giving short summary of engineering viewpoint among NSDIs.

Table 4.4 Summary of Engineering Viewpoint

Country (NSDI)	Clearinghouse	Architecture Overview	Focus Development
Brunei Darussalam (BSDI)	Unknown	Unknown	Unknown
Indonesia (ISDI)	Yes	Yes	GI integration
Malaysia (MyGDI)	Yes	Yes	Service oriented web services

4.2.5 Technology Viewpoint

Limited documentation is becoming the barrier to review the technology viewpoint in each NSDI. Therefore, it is possible since the NSDI itself is still under process of development. Noted in PCGIAP country report of Brunei, in 2006, there was no clearinghouse or portal for sharing of GI implemented. The sharing of GI is via intranet that links 3 departments (survey, land and town & country planning departments). Moreover, the current achievement in the technology used for the NSDI is not reviewed. Within BSDI and MyGDI, the documentation of technical parts of the NSDI is limited, and can be considered not available.

In ISDI, a prototype of Indonesian Clearinghouse has been installed in Bakosurtanal website. For this purpose the FGDC metadata standards is adopted as a national metadata standard and a national metadata and data directory server applying Z39.50 protocol has been built (Matindas et al. 2004). The use of Z39.50 protocol for the gateway server is developed to assist the metadata searching globally. This viewpoint can be summarized in the table below (Table 4.5).

Table 4.5 Summary of Technology Viewpoint

Country (NSDI)	Sharing GI Platform	Additional Information
Brunei Darussalam (BSDI)	Intranet	-
Indonesia (ISDI)	Client server protocol – Z39.50	Compliance to ISO standard 23950.
Malaysia (MyGDI)	Unknown	-

4.3 Comparative Analysis

In pursuing the objectives of the research, three NSDIs have been studied and investigated using the building blocks components of SDI and the technology watch. It is obvious that the attention to develop SDI in each country is growing, especially in the government level. Each government tries to gather the GI by developing SDI, providing related policies and frameworks.

In this session, the summary from the technical notes collection of technology watch is formed. The commonalities among NSDI and gaps are identified and collected through the result from the previous notes. Furthermore, the interoperability issue and opportunity are also discussed. As a part of the analysis, the recent status of NSDI is assessed. The comparative table of the parameter under study and its preview in each NSDI are presented below (Table 4.6).

Table 4.6 The Comparative Result of State of Play Analysis (adopted from INSPIRE State of Play 2007).

Parameter	Question	BSDI	ISDI	MyGDI
I. Organizational Issues				
Level of SDI	Does the SDI cover the national level?	Yes	Yes	Yes
Degree of operationality	Have one or more components of SDI reached a significant level of operationality?	Yes	Yes	Yes

Coordination	Is there any officially recognized or de facto coordinating body of SDI i.e. a NMA or a comparable organization (Cadastral or Land Survey Agency)?	Yes	Yes	Yes
	Is the officially recognized or de facto coordinating body for the SDI organization controlled by data users?	Yes	Yes	Yes
	Is An organization of the type 'national GI-association' involved in the coordination of the SDI?	Yes	Yes	Yes
Participants	Are Producers and users of GI participating in the SDI?	Unknown	Yes	Yes
	Are only public sector actors participating in the SDI?	Yes	Yes	Yes
II. Legal Issues and Framework				
Legal framework	Is there is a legal instrument of framework determining the SDI-strategy or -development	Unknown	Yes	Yes
Policy and legislation on access to public sector information (PSI)	Is there any freedom of information (FOI) act which contains specific FOI legislation for the GI sector?	Unknown	Yes	Yes
Legal protection of GI by intellectual property rights	Can GI specifically be protected by copyright?	Unknown	Yes	Yes
Restricted access to GI further to legal protection of privacy	Do the holders of GI specifically concern of privacy laws?	Unknown	Yes	Yes
Data licensing	Is there any framework or policy for sharing GI between public institutions?	Unknown	Yes	Yes
	Are there any simplified and standardized licenses for personal use	Unknown	Yes	Yes
Funding model for the SDI and pricing policy	Is the long term financial security of the SDI-initiative secured?	Yes	Yes	Yes

	Is there is any pricing framework for trading, using and/or commercializing GI?	Yes	Yes	Yes
III. Reference Data and Core Thematic Data				
Geodetic reference systems and projections	Are the geodetic reference system and projection systems standardized, documented and interconvert able?	Unknown	Under progress	Unknown
Quality of reference data & core thematic data	Is there any documented data quality control procedure applied?	Unknown	Unknown	Unknown
Interoperability	Does the initiative concern for interoperability go beyond conversion between different data formats?	Yes	Yes	Yes
Language and culture	Is the national language used as the operational language of the SDI?	Yes	Yes	Yes
	Is English used as secondary language?	Yes	Yes	Yes
IV. Metadata for the SDI				
Availability of metadata	Are metadata produced for a significant fraction of geodata sets in SDI?	Unknown	Under process	Yes
Metadata catalogue availability + standard	Is there one or more standardized metadata catalogues available covering more than one data producing agency?	Unknown	Yes	Yes
Metadata implementation	Is there any coordinating authority for metadata implementation at the level of the SDI?	Unknown	Yes	Yes
V. Access and other services for the data and metadata				
Discovery services	Is there one or more discovery services making it possible to search for the data and services through metadata?	Under process	Under process	Yes

View services	Is there one or more view services available to visualize data?	Under process	Yes	Yes
Download services	Is there one or more on-line download services enabling (parts of) copy of data sets?	Yes	Yes	Yes
VI. Standards				
Standards	Is the SDI-initiative devoting significant attention to standardization issues?	Unknown	Yes	Yes

Some commonalities can be withdrawn from the technology watch and state of play result. Since the initiative of establishing NSDIs arose from the government side, the institutions involved in the developing the NSDIs requirement were dominantly from government. With this condition, the process of developing NSDI will be considered as a sustainable process, since government has the responsibility of funding and fulfilling the requirements. However, each government encourages the private sector to join the process in developing SDI.

There are coordination and collaboration in some institutions or organizations within the NSDI initiatives. For instances, among the Survey Department and the Land Department in BSDI, Bakosurtanal, other departments and local governments in ISDI, MaGDI and state governments in MyGDI. The existence of coordination among institutions within NSDI ensures the awareness of GI availability and reliability. Another benefit from the coordination is the opportunity for the data sets to be accessed and utilized by different users, especially for local government and public sector. The public access to the data sets in the internet is mostly limited. In Brunei, the GI is available by direct access to the data provider. The same activity is also happen in Indonesia, whether in Malaysia, public can access the data with user registration applied.

Considering the standards applied in each NSDI, there is awareness of international data and/or metadata standards. This means the data providers are aware of the

opportunity to set the interoperability services among them. Unfortunately, information for the service and technology used in the NSDI is limited. Exploration of the technology used within NSDI could only be conducted by visiting the geoportal as the entry point of NSDI. The result of the online investigation summarizes that the NSDI provider is considering the online services as part of the SDI which need to be maintained. The development of e-Map in BSDI-which is still under process, the ISDI geoportal and MyGDI geoportal are showing the attention to give the access of GI for the public sector. Some of the data sets are already available, even to access or download will need a particular expenses regarding the policy and pricing regulation.

When we compare the development of regional SDI in HoB to the experience of INSPIRE in developing regional SDI in Europe, in INSPIRE, many member countries are having different stage of SDI development when they joined the initiative. At this moment, the development of NSDI within three countries in HoB is also having different level of achievement. Brunei is facing the common barrier of establishing the NSDI. There is a need to collect the data from the different institutions with the same specification, while the existence of the online platform to provide GI is accepted as one way to give public access to the GI. Further, government needs to establish a fundamental framework, metadata and service standard, also the issue of license and pricing needs to be solved.

As an archipelagic country, Indonesia is having the problem of collecting the data sets. Most of the data are not in the digital form, and have different specification or standard one to another. There is also differentiation of managing the land and coastal data which addressed as one of the problem in the technical issues (Syafi'i 2006). In the future, the data integration and coordination among institutions is still addressed as the main problem.

Malaysia has the form of federal country, and uses the land development and infrastructure as the priority for national development. MyGDI has a good online services and visualization for the GI. The user access for the GI is still limited, and the data integration also becomes an important issue to overcome.

4.4 Implementation Prototype

Within SDI context, the visualization of harmonized data sets is considered as part of establishing SDI service. At this point, the existence of visualization platform, for instance a geoportal, can help user to find the information that they want to access. One of the objectives in this research is to develop a prototype implementation to test the compliance of available spatial data set. As discussed in the previous chapter, comparative study result highlighted the heterogeneity of metadata specification and technical standards used within NSDIs. Then, the visualization of example of data sets from different providers will give best experiences of developing regional SDI among three countries in HoB.

To support the visualization purpose, we decided to develop a prototype of geoportal. According to Tait (2005), a geographic portal is a web site where the discovery of geographic content is a primary focus. Refer to this definition, the proposed geoportal will have the functionality to publish, discover and share the GI from countries within HoB with the particular interest to conservation issues. Related to regional SDI in HoB, the proposed geoportal will be the part of SDI components which as presented by Clodoveu and Alves (2005) in Figure 4.10.

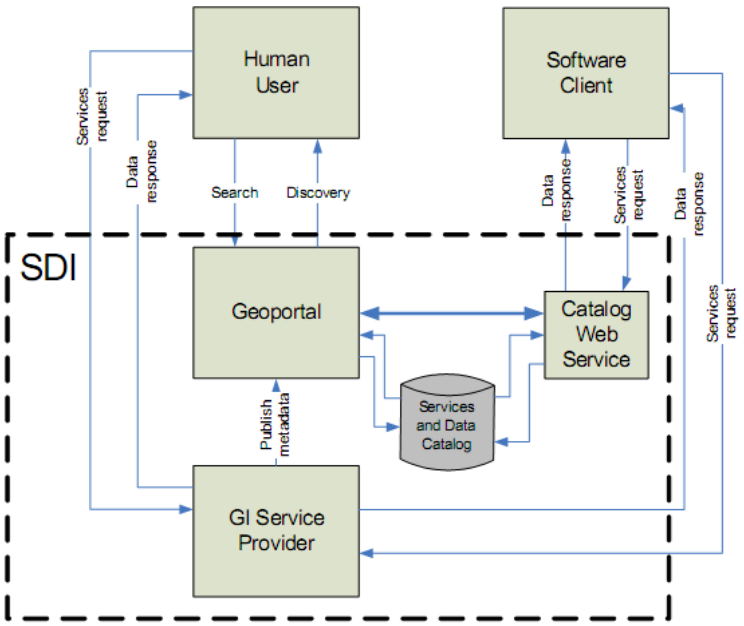

Figure 4.10 Geoportal and SDI (Clodoveu and Alves 2005)

Geoportal will be the entry site to access GI of conservation in HoB through internet connection. By establishing a geoportal, there will be a bridge and meeting point for data providers and data users to benefit SDI services in easiest way.

Therefore, there is a need to analyze the demand of establishing regional SDI for conservation in HoB. Currently, it is difficult for users to access and use the data seamlessly from different domains, for instances, forestry, agriculture, transportation, etc. Another problem is the multilingual aspect, since the SDI will accommodate and assist 23 natural parks in three countries, multilingual issues should be concerned. The definitions and names used in several places can be different one to another due to the multicultural and multilingual issues, even the scientific name is available.

Referring to the experiences of Nature-SDIplus (Nature-SDIplus 2008) in Europe; there are three aspects that should be focused on developing regional conservation SDI:

- The "harmonisation" of spatial data sets. This means the ability of data to be compatible and implies the adoption of common rules in application schemas, co-ordinate reference systems, classification systems, identifier management, etc. from different points of view.
- The "interoperability" of the spatial data sets. This means the ability of the data to be combined and interacted; and implies the adoption of a common framework and network services that enables them to be linked up from one to another.
- The "consistency" between spatial data sets. This means that the representations of different objects which refer to same location, or of the same objects at different scales, or of objects spanning the frontier between different MS, are coherent. In practice it means that data sets coming from different levels of authority or from different countries can be easily used together by any type of user.

With this vision, development of prototype regional SDI in HoB will take into account the necessity to accommodate different data sets and ensure the compliance to international standards in geographic information.

4.4.1 Software and Application

SDI consists of three main parts - database system, catalog system and visualization system (user interface). These components are not created from one unit of software (Grill and Schneider 2009). However, the prototype implementation in this thesis is focused in development of geoportal as part of the visualization system. The decision to implement a geoportal based on the necessity to perform the visualization of different data sets from different data providers related to conservation in HoB. For this purpose, we concern to use to develop a prototype of implementation which accomplishes the international standard in the SDI practices.

The conservation geoportal will provide one stop access for the conservation information which available in maps for further analysis and study. The produced map will assist research, education and moreover, the conservation activities in HoB area. The prototype geoportal is proposed to perform the basic services below:

- Discover and access maps and GI related to conservation online.
- Publish and links to data sets and maps in order to enable sharing possibilities.

The software we are using in the implementation part are GeoNetwork and PostgreSQL. We decide to utilize GeoNetwork open source in the implementation part. It offers a modern architecture, which is at the same time powerful and low cost, based on principles of Free and Open Source Software (FOSS) and International and Open Standards for services and protocols (ISO/TC211, OGC) (Horáková et al. 2007). GeoNetwok was developed by FAO-UN (Food and Agriculture Organization of The United Nations), WFP-UN (World Food Program) and UNEP (United Nations Environment Program) (GeoNetwork 2007) and then distributed as free and open source software. As free and open source software, the users are allowed to benefit from the development results and to contribute to for further enhancement of GeoNetwork software.

GeoNetwork has been developed following the International and Open Standards for services and protocols like ISO-TC211 and Open Geospatial Consortium (OGC) specifications (GeoNetwork 2007). The software is focusing on spatial data, metadata

and interactive map for visualization purpose. GeoNetwork is also designed as server which enables publishing data through internet.

GeoNetwork can be integrated to other softwares which can be integrated to develop an SDI. To maintain the data, we choose PostgreSQL which can handle a large amount of data related to GI. PostgreSQL has advantage for handling GI by performing PostGIS as spatial database extension. GeoNetwork also embeds GeoServer as map server. Users can now not only overlay OGC web map services available on the web, but also create their own map services for other users to browse without having to download additional plugins (GeoNetwork 2007).

4.4.2 Sample Data sets

In order to implement the prototype, some sample of GI are collected. The collection aims to provide a generic approach for the real data sets which are available from different sources with different specifications. In this research, the spatial data sets are available from WWF Indonesia, WWF Malaysia and Betung Kerihun National Park in Indonesia. The spatial data sets from Brunei Darussalam are not assessed due to the availability of the data set.

The content of collected spatial data sets is presented in Table 4.7 below:

Table 4.7 Sample Data Sets Information

Provider	Quantity & Definition	Format & Quality	IPR	Current Use	Existing Metadata	Language	Additional Comments
Betung Kerihun National Park	1 natural park: Wildlife habitat, ecotourism	Digital Data .SHP (shapefile)	Government Domain	Local and national planning	None	Indonesian	Some data without RS
WWF Indonesia	1 natural park, 1 elevation map, 1 administration map	Digital Data .SHP (shapefile) .JPEG	Institution Domain, can be used based on an agreement	Internal, national planning	None	English	

WWF Malaysia	1 natural park	Digital Data .SHP (shapefile)	Institution Domain, can be used based on an agreement	Internal, national planning	None	English	RS used Timbalai 1948

4.4.3 Implementation Results

The decision to benefit GeoNetwork in the implementation of case study is based on the easiness and functionality of this software. Limitations of human resources in the case study area are also being addressed in utilizing simple but powerful software. By capitalizing the strength of GeoNetwork, a prototype implementation has been developed. The basic performance of geoportal has successfully achieved during implementation.

For illustration purposes, we implement a prototype on the local machine. GI from heterogeneous sources are copied to the local file system. The major task of the prototype is to perform the basic operation of geoportal. Ideally, third-party sources should be accessed locally, but the applied software failed connecting.

User Interfaces

We concern user interface as important part of the implementation, since through this, users will interact directly and have impression of its usability. From the case study analysis, we found that similar languages have been used for portal interface among NSDIs, which are Melayu and English. Actually, the national language of the members is different. However, the national language has the same roots and similarities. Realizing these similarities, the implementation accommodates similar languages in the user interface. The user interface for implementation of geoportal is presented in Figure 4.11.

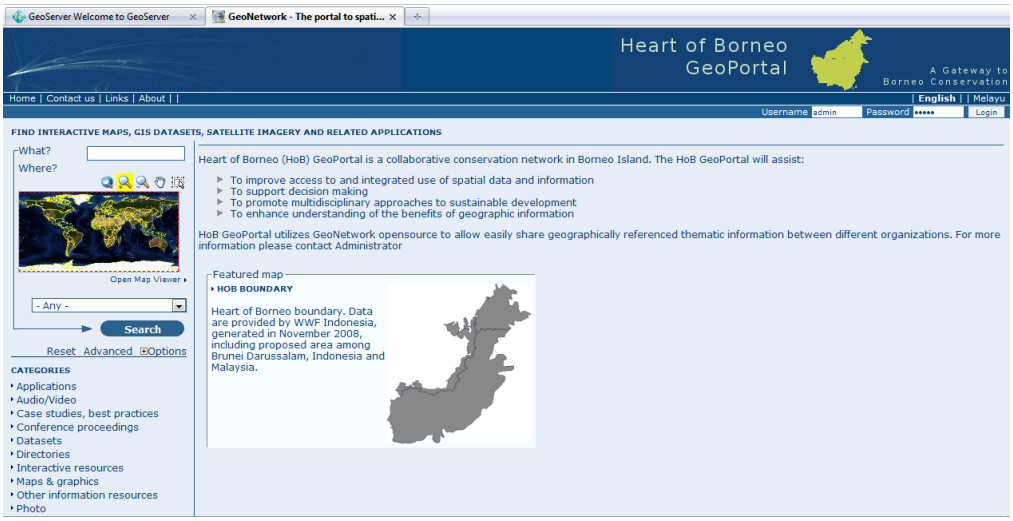

Figure 4.11 Implementation Interface

In order to meet the requirement of friendly interface, the user interface provides English and Melayu as common languages used in the prototype. It will assist heterogeneous users which will benefit the regional SDI.

Basic Operations of GeoPortal Implementation

As mentioned previously, the implementation is still operating locally in the local machine. However, GeoNetwork is designed as server and ready for publishing GI over internet. In the future, the service can be published and accessed through the internet.

In the implementation, we visualize the sample data sets by performing Web Map Service (WMS) locally. We upload the shapefile of data sets through Geoserver. Then the data sets harvested by using WMS ability from GeoNetwork. The visualization of heterogeneous data sets formats is performed in Figure 4.12.

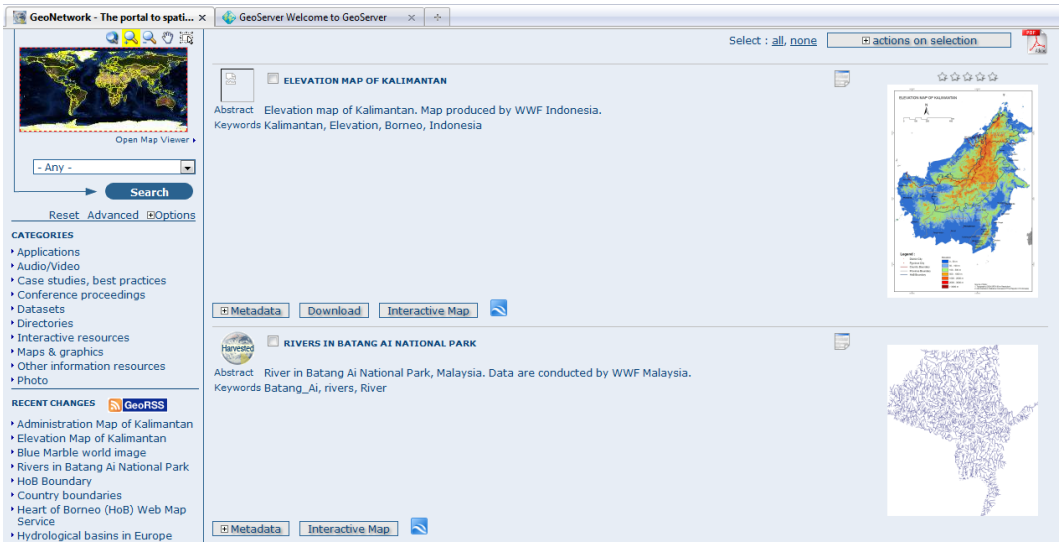

Figure 4.12 Visualization GI from Heterogeneous Sources for HoB SDI

WMS is a human interaction and processing service that allow access to dynamically generated images through a simple interface (GetMap) (Manso and Bernabé, 2005). To perform WMS, we deployed sample data sets from different sources into applied software. One of the data sets has local datum which is not recognized by the software. To overcome this problem, we have to transform the local datum (Timbalai 1948) into accepted datum which is WGS 1948. The task was executed by using ArcGIS software. In the future, additional plugin can be added in the geoportal and will assist to convert the local datum directly to the accepted datum.

Metadata are not implemented within sample data sets as presented in Table 4.7 Sample Data Sets Information. In the implementation, the missing metadata can be deployed by using applied software. The administrator can capitalize the service to add the metadata. However, this task should be finished in data production level.

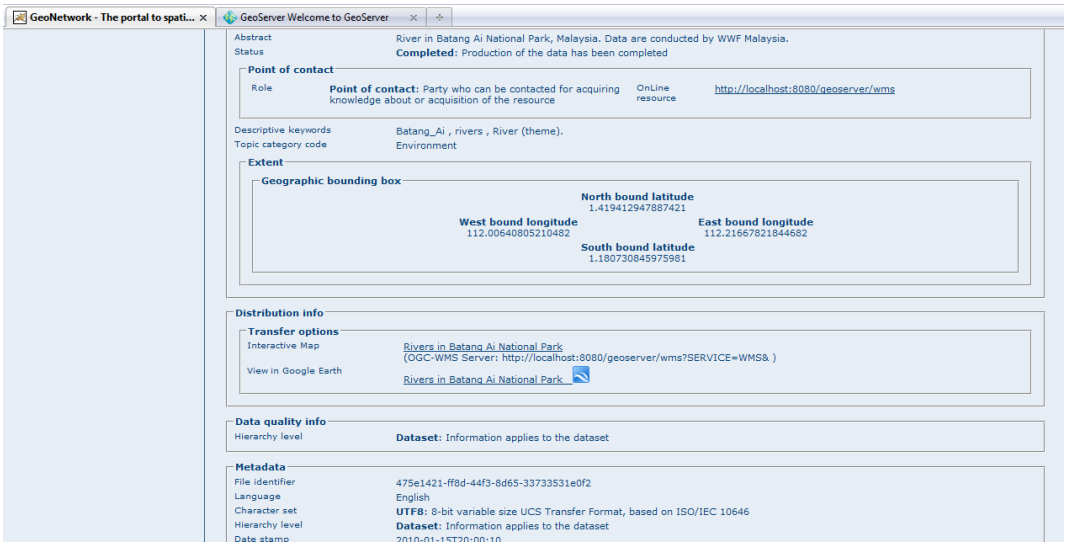

Figure 4.13 Metadata Implementation in GeoPortal.

Figure 4.13 shows the metadata which is added by GeoNetwork, as a consequence for missing or not available metadata in the sample data sets. The metadata added are compliance to ISO 19139 as the standard used in the applied software.

Other services of geoportal such as Web Coverages Service (WCS) and Web Feature Service (WFS) were not successfully implemented due to the failed connection. However, one of the requirements to visualize and make data available in the prototype has been successfully implemented. In the future, the service of the prototype can be enhanced by adding additional functionalities such as WCS and WFS.

4.4.3 Discussion on Implementation

The applied software can visualize basic functionality of geoportal. It will give additional value to the data sets and also provide access to public for further utilization. Then it is considered, the geoportal as the easiest way to share and benefit the usability of GI deployed within regional SDI.

Referring to the missing metadata during implementation, to ensure the effectiveness of regional SDI, it is necessary to put attention for data quality. The quality of available data sets will determine the preparedness of data sets to assist analysis and utilization. Available metadata will assist not only for interoperability among data sets

but also will give easiness to gain information what the available data about. To provide high quality data sets, standardized GI and guidelines of establishing high quality GI will need to improve data preparedness for further utilizations. Therefore, the socialization of producing high quality GI is needed, particularly for GI production.

The simple implementation has shown that by utilizing the applied software and sample GI data sets can facilitate the development of regional SDI in HoB through a structured approach. Some of the benefits of utilizing the geoportal are as follows:

- Enable visualization of data sets from heterogeneous sources and formats,
- Enable access of GI for data providers and data users from different fields with multi purposes,
- Can be used for data validation tools for metadata within GI.

Through this study, the applied software can perform WMS locally as basic service for the proposed SDI. From the sample data sets experience, the institutional arrangements of the GI providers for regional SDI will ensure the data sharing effectively. Obviously, there is a necessity to establish GI privacy, restriction and pricing among data providers. Not only for the availability of data sets but also the possibility for the data to discover, to utilize and to analyze further. Therefore, the development of regional SDI in HoB will facilitate the conservation activities within HoB area by providing related information from geographic perspectives.

4.5 Chapter Conclusion

This chapter describes the status of NSDI development in Brunei Darussalam, Indonesia and Malaysia which are assessed by adopting Technology Watch. The analysis results different stage development in each NSDI. For further analysis, it continues by adopting INSPIRE State of Play Analysis to perform the missing and available components of 'ideal SDI'. The resultant of this step provides information of missing and available components within NSDI and also the required development for establishing regional SDI in HoB. To give visualization of GI within institutions in HoB, GeoNetwork opensource was chosen as the applied software to visualize sample

data sets from several institutions involved. The implementation gives glimpse of GI condition among institutions in HoB initiative.

CHAPTER 5 . RECOMMENDATIONS AND ILLUSTRATION FOR SPATIAL DATA INFRASTRUCTURE IN HEART OF BORNEO

One of many goals in SDI aims to enable the access and sharing GI from different sources. For this purpose, SDI can be accepted as the bridge for multi spatial data sets providers and users. However, to be able to perform the sharing usability, SDI has to build from integrated platforms which assist sharing operation.

Referring to Chapter 4, we discussed the current status of NSDIs and the identification of components developed in NSDIs. The identification result provides the possibility for establishing collaboration work in GI management to support conservation in HoB. The analysis from previous chapter performs different level of NSDIs development and also different specifications used. To achieve a regional conservation goal in HoB, consistent data sets and reliable source of spatial data is required. Therefore, the demand to develop SDI for integrating the GI is obviously high. In this chapter, we discuss the conceptual development of HoB regional SDI and followed by implementation of regional SDI by using sample data sets from different sources. Also, we develop recommendations and stepwise approaches for pursuing regional SDI by mirroring the experience of INSPIRE as regional work in SDI.

5.1 Convergence Management

To pursue the scenario of development regional SDI in HoB, it is important to understand the recent status of each NSDI. From the recent status study, the opportunity to set the node for regional SDI will be figured out and so will the problem of interoperability issues to overcome. The convergence management is used to withdraw the recommendations and issues from the conducted analysis. The recommendation also takes into account the stakeholder's role in the system.

Government is considered as the producer of the GI, especially in the developing country. An institution under government's directive usually is responsible to develop the NSDI, arrange the framework and regulations related to the GI. Then the institution will also responsible for ensuring the compliance of the data sets to

international standards. Regarding the issues of policy and national regulations in regional SDI, it is important to define the comprehensive framework of sharing GI among governments.

To satisfy the second objective, the evaluation of the regional SDI status and identify required developments using INSPIRE architecture as comparison standard and guidance, the current status of already existing regional SDIs will be evaluated. The initiative to establish the awareness of GI integration has been started by PCGIAP (PCGIAPa 1998). Many of the nations in Asia Pacific regions were ready to join in the initiative. Unfortunately, the development of an effective and comprehensive Asia-Pacific Regional Infrastructure (APSDI) is hampered by a lack of support from member nations which results in this initiative remaining only an innovative concept (Rajabifard 2002). It might caused by the economic situations and resources were not sufficient to support the initiative. However, some countries have agreed to settle the node network to connect with regional infrastructure in Asia Pacific, which pursue them to maintain the similar international standards in developing their NSDI.

In case study of HoB, the role of government in each country is crucial to ensure the reliability of the GI, since data are collected from different sources in the field. To support government in conservation works, WWF as the main organization in the HoB initiative may in charge be responsible for setting the GI base in regional SDI of HoB. The GI acquisition can be conducted by each natural park managements as the local data producer, with prerequisite to suit with the national standard of geographical data. The natural parks can be set as the node network for the GI and information regarding the conservation activities in HoB also. Under the coordination with the mapping agencies in each country, the GI sets can be shared through the regional representatives established for the HoB purposes.

The data sets will be collected from about 23 natural parks in HoB, which under supervision of different mapping agencies in different country. Therefore, the standards of the data or metadata should be settled down to ensure the compliance for the regional SDI needs. In this regard, it is important to adopt the common international standard such as ISO 19115 for metadata, ISO 19119 for service

standard and ISO 19139 for an XML encoding of GI metadata. Implementing the international standards which recognized by global community is necessary to ensure and support the compatibility and interoperability of both data and services provided. The task for ensuring data compliance can be performed by the national representative for the HoB project. An overview diagram of the proposed coordination is presented in Figure 5.1.

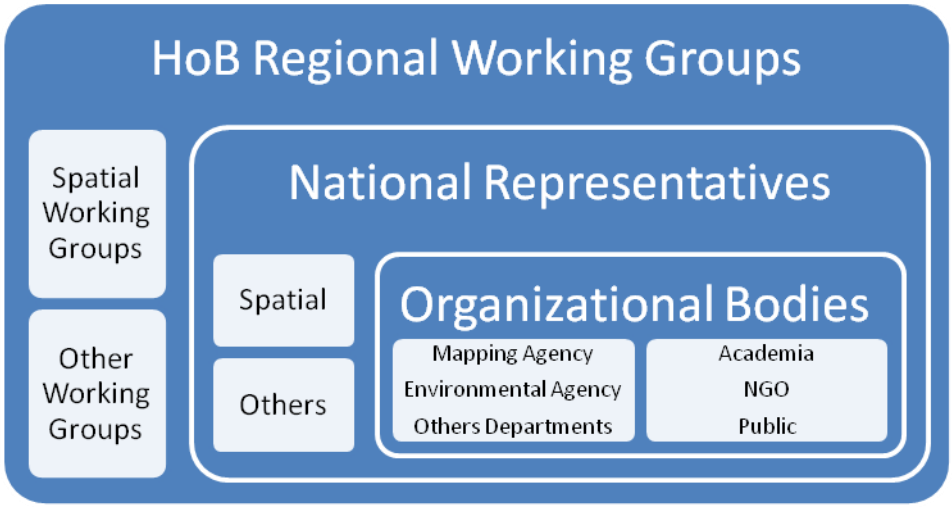

Figure 5.1 The Proposed of Basic Coordination in HoB SDI

Within the *Organizational Bodies*, the institutions have the task to produce the GI which suit the specification needed. The *National Representatives* have the responsibility to establish the node for data sharing and ensure the share ability among the institutions and for top level collaboration. On the top level, the *HoB Regional Working Groups* make sure the fundamental components have been settled, for example, the specification of the GI, the sharing platforms, the policy and licenses for the GI. Defining different scope of coordination can reduce the overlapping responsibility and tasks in the project.

In Organizational Bodies, the government agencies which are considered to involve in the initiative are Mapping Agency, Environmental Agency and other related agencies. While other institutions outside government agencies can also involve in this initiative, for instances: academia (universities, researches, etc.), NGO (local, national, or international NGO, i.e. WWF, The Nature Conservation (TNC), etc) and

public (local communities, individual, etc.). Within National Representatives, there are National Working Groups which focus in the spatial data sets of HoB and other Working Groups which focus in different areas of development in HoB. The Spatial Working Groups in National level is also including NSDI in each country. Similar approaches of Working Groups can be applied in upper level (regional level), which involves the representatives from different countries.

The issue of coordination will arise regarding which institution will start and establish the work of collecting data, managing, harmonizing and distributing GI for regional SDI in HoB. At this time, WWF is becoming the source of HoB information, apart from the government institutions. Then there is possibility that WWF will start the work of establishing and maintaining regional SDI in HoB.

One of the objectives of this thesis is to develop a conceptual framework and strategy of developing a regional SDI for conservation purposes. In order to meet the objective, we will provide the proposed guideline for establishing regional SDI in HoB. Based on the analysis result, further discussion of proposed framework and implementation strategy will be carried out in the next chapter. That chapter will bring the adoption of regional SDI development in INSPIRE for establishing regional SDI in HoB. The chapter will also bring the practice of visualizing data sets from different data providers related to conservation in HoB by utilizing GeoNetwork service.

5.2 Conceptual Development of Spatial Data Infrastructure in Heart of Borneo

Regional SDI in HoB will bond three countries with different achievement of SDI development through a platform of sharing information. By addressing different stage of NSDI development and understanding the lack of architecture information of regional SDI within this region, the conceptual development of regional SDI then can be adopted from the experience of developing regional SDI in INSPIRE, with some simplification added.

Development of regional SDI in HoB is proposed to make harmonized and consistent geographic information available for conservation planning, monitoring and evaluating purposes of data providers. For public user, they can benefit from the

access of geographic information in local, national or regional level. Furthermore, the initiative has aim to achieve the regional development, which particularly as mention below:

- Collect and provide the geographical information which will support the conservation activities in HoB.
- Reduce conservation data duplication and redundancy.
- Conservation data collection will be done and maintained effectively in the level which can ensure the consistency and accuracy.
- Conservation data should be possible to integrate among three countries and to share in particular level, for example managerial level for planning purposes.
- Conservation data from multi sources in HoB can be used by different users and applications.

With these purposes in mind, the regional SDI for conservation in HoB can be implemented. The data come from different institutions, includes local and national government and NGOs. As mentioned in the previous chapter about collaboration data, in the national level, government rules the policies and data specifications. However, data providers within one country can be grouped into one representative under government coordination. It will ensure the consistency of data sets among data providers, since there is supervision body within national representative. Then in the regional level, the data can be shared and combined to support regional planning further, and can be accessed by different users. The proposed diagram of framework in regional SDI in HoB is performed in Figure 5.2.

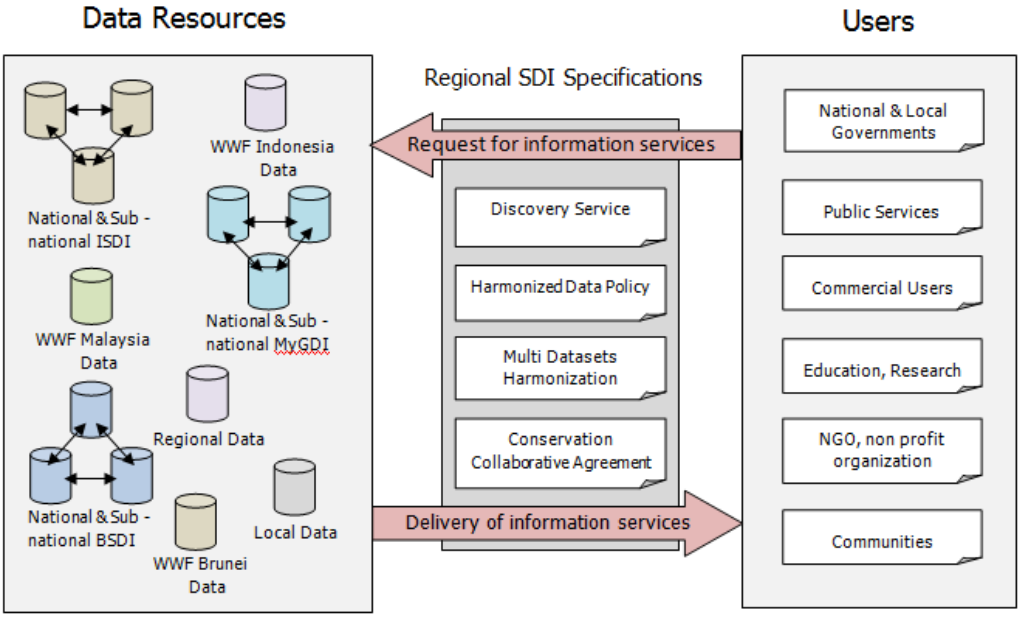

Figure 5.2 The Proposed Vision of HoB SDI (adopted from INSPIRE 2008)

In Figure 5.2, data are coming from different sources, and also users of data are coming from different fields with objective varies. The regional SDI will enable to perform basic services of SDI, for instances discovery services, multi data sets and data policy harmonization and supporting conservation collaborative agreement.

5.2.1 Stepwise Approaches

It is accepted if the development of SDI regardless in which levels it is developed, it will require many efforts and time consuming. In order to support the SDI establishment in the structural way, the stepwise approaches of developing regional SDI is proposed below (adopted with some modifications from INSPIRE Architecture):

- The harmonization of dataset specifications and policies within a NSDI, including the already existed GI. Further collection of GI then must follow the specification to ensure the data harmonization.
- The establishment of node network or country representative for HoB purpose, as part of the NSDI achievement, and can be concerned as a simultaneous work within NSDI development.

- Building the sharing platform which enables the visualization of the data sets from multiple sources, and accomodate the multiculture and multilanguages among the data providers and users.
- The establishment of common services of SDI which provides access to the users for multi purposes and allows the data analysis further. This step will concern the level of sharing data and information for each user groups.

These steps can be developed in parallel time, depends on the availability of multi data sets, readiness of connecting the node network in each NSDI, and the coherent policies related to sharing geographic information in each countries.

5.2.2 Users, Producers and other Stakeholders

At this moment, the HoB initiative is focusing mainly in the conservation activities, to preserve and protect the ecosystem left in HoB area. Regarding the wide scope of initiative, this initiative will involve varies of data users, providers and also stakeholders.

Data Users

The data users will come from various institutions with different purposes, such as:

- Natural parks administrators and governments. The availability of spatial data for these institutions will increase the effectivity and efficiency of planning, management, monitoring and evaluation in HoB area.
- Public Services. Including in this group are public health services, public transportations.
- Commercial Users. For example: travel agents, logging companies, surveyors.
- Education and research. The multi data sets of HoB will useful for supporting the education and research in different levels.
- NGO and other nonprofit organizations.
- Communities, which address the participation of local, national and regional communities.

Data Providers

Mostly data are produced by national mapping agency and the local government with different specifications and accuracies. The local government usually produces the data for internal purposes and does not take into account the data specifications and compliance to the standards.

In HoB case study, since WWF has been involved from the starting stage of the initiation, thus WWF also produces spatial data of HoB for internal uses. Another case, other NGOs and non profits organizations create their own spatial data for their needs. However, the data sets are lack of standard compliances and difficult to perform further analysis.

Therefore, within a regional scope, the data sets will have various formats, e.g. shapefiles, images (JPEG, TIFF, etc), document (pdf), etc. The proposed regional SDI will have the functionality to resemble related information with different formats into information which have meaning, discoverable and assessable for user.

With the abundant of data providers in different way and purposes of creating data, thus it is considered to establish the data harmonization among the data creators. Furthermore, the socialization of developing regional SDI is needed, involving different data creators and users.

Other Stakeholders

The development of regional SDI in HoB will involve other stakeholders especially in the regional level. The PCGIAP and APSDI as the regional organization in geographical are considered joining in this collaboration work. Other conservation organizations in Asia Pacific region or global NGO are also addressed to support the conservation initiative. These organizations can involve as data provider and user of the geographic information from regional SDI. It is also possible that in the future, the regional SDI will become part of global conservation project or another similar initiative.

In respect to the issue of coordination, a good example can be derived from INSPIRE implementation in Europe. A particular institution is in charge for starting the

development, maintaining, harmonizing and distributing GI across the boundaries. In INSPIRE, this institution is named Joint Research Center, which acts as the overall technical co-ordinator of INSPIRE. The JRC ensures the viability and evolution of the technical infrastructure for INSPIRE and guarantees the liaison with European and international research community. JRC also initiates and monitors the work with international standardization bodies for the purposes of INSPIRE and will be responsible for the technical coordination with other relevant international initiatives[4]. Such same approach can be established in the future, so that there will be an institution focused on the development of regional SDI particularly for GI rather than the other issues in HoB. Subsequently, the institution will be performed from variance stakeholders involved in the initiative, for example from governments in three countries and NGOs. The institution, like JRC in INSPIRE, will solve the issues of technical problem and heterogeneous GI from data providers. This collaboration work will give opportunity for managing and controlling the establishment of regional SDI in a structural way by involving all the stakeholders in the management.

5.2.3 Architecture and Standards

In order to perform the SDI services, the proposed SDI in HoB has to have an architecture that enable the interoperable services, which will perform the operation such as to produce and publish, find and deliver, also to use and analyze the geographic information further. The term of architecture points to the models, standards, technologies, specifications, and procedures used to represent, transform and generally accommodate the integration, maintenance and use of information in digital form (INSPIRE 2002).

The architecture of proposed SDI will follow the standards which have been accepted as international standards for SDI. The proposed architecture will enable the regional development by accommodating networks of databases, and linking them through common standards and protocols. The use of common standards and protocols aim to ensure compatibility and interoperability of data and services within SDI. These are the components of regional SDI in supporting the HoB collaboration that needs to be maintained.

[4] http://inspire.jrc.ec.europa.eu/index.cfm/pageid/481

Reference Model

To achieve the regional goal of SDI in HoB, there is a need to provide an architecture model which accommodates interoperable services, and moreover helpful to perform the SDI services. As mentioned in the previous chapter, the architecture of an SDI is included in engineering viewpoint from technology watch. The viewpoint focuses on the mechanism and functions required to support distributed interaction between the elements within proposed SDI.

Concerning the purposes of regional SDI in HoB, the proposed architecture should accommodate many networks of databases existed out of NSDIs. For instance, the natural parks in HoB area are also developing their own database for their internal uses that needs to be linked to regional SDI. The proposed architecture also has to perform the following functionalities:

- Publish data and metadata,
- Find geographic information,
- Context related viewing for geographic information,
- Delivery of geographic information,
- Analyze geographic information,
- Support multi lingual queries and viewing results,
- Support e business and e-government for products and services
- Support the NSDI achievements in integrating spatial data,
- Support the regional development, particularly focusing in conservation activities in HoB.

In order to assist the development of regional SDI, a proposed architecture of SDI in HoB as shows in Figure 5.3, is developed and structured according to the adaptation from INSPIRE architecture (INSPIRE 2002).

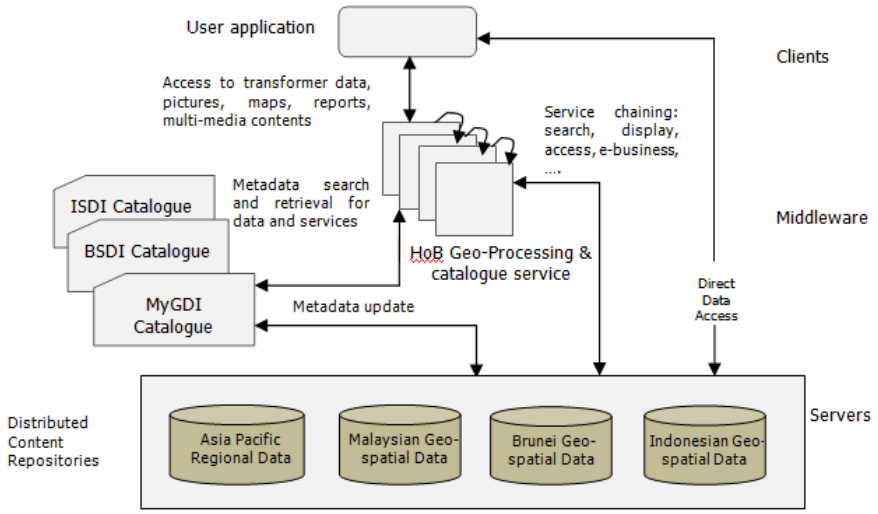

Figure 5.3 The Proposed Architecture Model for SDI in HoB. The components of the architecture supporting regional SDI can come from different geographical areas and from different organizations (adopted from INSPIRE architecture (INSPIRE 2008))

Figure 5.3 brings generic model of any spatial data infrastructure which has been adopted for regional SDI in HoB. The proposed architecture comprises of technical aspects in SDI, which can be grouped into four major components of an SDI. The four major components are:

- User applications. In the case study, the user applications point to any software usually used by user. This includes the tools for query and viewing, managing database, analyzing, etc.
- Geo-processing and catalogue services, which will enable user queries, data extraction, etc.
- Content repositories. The repositories are distributed among different data providers and will provide data.
- Catalogues, which will allow clients and services to search the spatial data in repositories.

Standards

Since the case study result shows different standards have been used within NSDIs. It is therefore necessary to address standard as one of the requirements for developing regional SDI in HoB. By using similar standard, then the compatibility of data and services can be ensured. Metadata structure and technical specification should refer to a standard. Therefore, a standard is developed through a consultative process by the

experts and organizations, which can ensure to assist compliance among users. Consistency in metadata content and style can help users to compare and analyze metadata content quickly. In the absence of consistency, it will be difficult to derive information from metadata in different style of presentations.

Within SDI context, the data sets harmonization is considered as crucial point for ensuring spatial data sharing among stakeholders and users. At national level, national metadata standards can be used to assist data harmonization. However, in the regional level, the harmonization is more complex, since some of the national standardization is not compatible one to another. By adopting accepted international standard, the problem in data harmonization can be reduced.

As mentioned in the previous chapter, there are ISO 19115 and ISO 19139 which produced by ISO. ISO 19115:2003 defines the schema required for describing geographic information and services. It provides information about the identification, the extent, the quality, the spatial and temporal schema, spatial reference, and distribution of digital GI (ISO 2009). ISO/TS 19139:2007 define Geographic MetaData XML (gmd) encoding, as an XML Schema implementation derived from ISO 19115 (ISO 2009).

For service purposes, a client server protocol Z39.50 is suitable to accommodate the need for distributing services. Through Z39.50 protocol, it is easier to use large information in databases by standardizing the procedures and features for searching and retrieving information. This protocol also enables different computer systems -- with different operating systems, hardware, search engines, database management systems -- to interoperate and work together seamlessly[5].

There are some standards apart from ISO which also accepted globally, i.e. the FGDC, Dublin Core and OGC standards. However, the regional SDI in HoB has to adopt standards which internationally accepted. Implementing international standard in the development will give possibilities to link regional SDI to other similar services in the future.

[5] http://www.cni.org/pub/NISO/docs/Z39.50-brochure/50.brochure.part01.html. Last accessed January 2010.

5.2.4 License and Intellectual Property Rights

The issues of license and Intellectual Property Rights (IPR) have to be concerned, moreover because the proposed SDI is involving three different countries with different rules in IPR. The data providers need to pay attention for an agreement of licensing and copyrights among data providers. The data providers should also consider that some data are confidential to share for public. In this case, the agreement of publishing the data through geoportal is needed, particularly in which level of accuracy a data set and what kind of information can be published for public.

5.2.5 Control and Management

As a regional collaboration, the regional SDI in HoB needs full participation from the members. At regional level, a particular body is required to control and manage the operation of SDI in HoB. Referring to Figure 5.1, the basic coordination in establishing regional SDI in HoB, the control and management function can be as part of regional working group's task. The national representatives ensure the GI from each country that they are willing to share, and the regional working groups provides the standards, specifications and collaboration frameworks among institutions and countries. To be more specific, a control body within regional working groups has the main task to control the GI produced by institutions involved in the regional SDI. This particular body should provide the information of GI qualifications for regional SDI.

The control body can be formed as a collaboration of expertise of users and data producers of GI, technical competence, financial resources and policies. This collaboration will drive the specification of GI within regional SDI which accomplishes the required GI for regional needs. Expertise involved in the control body will regularly review implementation of SDI, GI requirement for conservation in HoB and management of regional SDI within local, national and regional level.

5.3 Chapter Conclusion

In this chapter, the thesis provides the conceptual development of regional SDI focusing for conservation activities in HoB. Following INSPIRE experiences; this

chapter is adopting the stepwise approaches to establish regional SDI with some simplification applied with respect to the real condition of HoB. With the support from institutions involved in the initiative and also from governments in Brunei Darussalam, Indonesia and Malaysia, the conceptual development of regional SDI in HoB will become reality. Reliable and consistent GI for HoB conservation activities will be available to the public.

CHAPTER 6 . CONCLUSION AND FUTURE WORK

The Heart of Borneo initiative will provide a better management for conservation in Borneo Island. By establishing a regional SDI in HoB, the problem of fragmented GI among data providers and data users within countries in Borneo will be solved. Furthermore, reliable and consistent geographic information to support HoB initiative will be available.

This thesis aimed at identifying the current status of NSDI in Brunei Darussalam, Indonesia and Malaysia, followed by identifying the required development of regional SDI in HoB. The visualization of GI samples from institution, which are involved in the HoB initiative, was worth to examine. It provided new experience and illustrated GI issues in HoB.

We performed the analyses of the case study as discussed in Chapter 4. The implementation of data sets samples for GI visualization through prototype geo-portal was successfully conducted. Following the results, we developed recommendations for developing regional SDI in HoB in Chapter 5. In this chapter, we take some conclusions related to the thesis objectives and our analyses results.

6.1 Conclusion

Developing a regional SDI becomes one of conservation support in HoB, since the ability for GI visualization and GI distribution through SDI is an important function of SDI. Through this research, we withdraw several conclusions according to the case study analysis.

The first objective in this research is the assessment to the current status of Spatial Data Infrastructure (SDI) development in each nation. The assessment was conducted by adopting Technology Watch and adopting five viewpoints of RM-ODP (ISO/IEC 10746-1:1998) and GIGAS approach. The current status of NSDI in Brunei Darussalam, Indonesia and Malaysia has heterogeneous development, as performed by Technology Watch analysis in Chapter 5.

Despite the complexities of assessing heterogeneous development in different SDI, the Technology Watch can be used for examining the development in a structural way. The method is also very helpful to identify the current status of NSDI which develop based on each particular requirement.

To satisfy the second objectives, the identification of required development for establishing regional SDI in HoB, we examine NSDI missing components by adopting the INSPIRE state of play analysis. The analysis performs different or missing components as described in Table 4.6. Some NSDI have established and maintained components of ideal SDI, whether some components are identified as not implemented within NSDI. In this analysis, adopting the INSPIRE state of play assists in providing the building blocks for pursuing the identification of SDI components in each NSDI.

The implementation part is addressed to examine the third objective, visualization of GI from heterogeneous sources in HoB. The implementation was utilizing GeoNetwork opensource as the applied software for developing prototype of geoportal, aimed for better management of GI from different institutions. Although the prototype is still operating in the local server, the prototype geoportal has successfully implemented GI integration from heterogeneous sources. Another issue withdrawn from this implementation part is the metadata within sample data sets which are not implemented yet.

6.2 Limitations

During the research work, there were some limitations found. The first limitation came from limitation of documentation availability of NSDI developments through internet. Several NSDI provide web portal to access NSDI achievements, but several do not provide enough documentation. Thus, it is difficult enough to get the current information of NSDI development.

Lack of information also hampered the analysis which was performed by utilizing Technology Watch (RM-ODP (ISO/IEC 10746-1:1998)). We could not examine some analysis due to the availability of documents, especially related to Engineering

Overview analysis. However, Technology Watch is very useful to identify the development of NSDIs in the study area in a structural way.

When developing the strategy for establishing regional SDI, many interests are also considered, for example: the political and financial issues in each country will be different each other. Regardless the governmental issues, the privacy and data sharing agreement are necessary issue as well.

In the implementation part, the data sets available for implementation come from Indonesia and Malaysia. Sample data sets from Brunei Darussalam are not available. Therefore, the availability of data sets from Brunei may show more complexity of GI among countries in HoB area.

6.3 Future Work

According to the conducted research, the GI in HoB area needs more improvements. Currently, incomplete information is available in GI, such as metadata, which has been identified as important part of GI. More researches and socializations for GI will assist the development of GI among the country members.

At the implementation part, the prototype geoportal need to improve further in the future. Basic operations can be performed by capitalizing GeoNetwork opensource. However, more improvements can be achieved by developing some plugins such as tools to convert local datum used by data provider to international standard.

To deliver more accurate result, more sample data sets will be needed in the implementation study. In this research, the data sets come from Betung Kerihun National Park, WWF Indonesia, and WWF Malaysia. Adding other sample data from Brunei Darussalam will provide more information for experiencing the geoportal prototype.

It is obvious that the development of regional SDI in HoB will need a lot of efforts, especially at the beginning level of the initiative. The establishment of specific institutions to take in charge for GI management in HoB will be one of possible

solutions to support the development of regional HoB SDI. Therefore, the support and proactive actions from governments and some NGO involve in the initiative will assist the implementation, not only for conceptual framework of regional SDI in HoB.

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