THE ATLAS AS A PORTAL FOR DATA DISCOVERY IN THE GDI: PROSPECTS AND DEVELOPMENTS

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ABSTRACT

In order to enhance the benefits of the Geospatial Data Infrastructure as a sharing mechanism, the implementations of its user interfaces for searching the data wanted, must be appropriate to the users' need and providing an effective means to complete discovery tasks. This paper will describe the use of the atlas concept to develop an appropriate yet an effective portal to discover geospatial data. The atlas as a portal is proposed to reach that objective since the atlas has three positive characteristics that are essential for a portal: providing structured navigation, broader access, and comparisons capabilities. This work defines three conceptual issues providing a framework towards the atlas as a portal, i.e. information structure, metadata mapping, and presentations of the search results. These three issues are essential foundations to develop interfaces that allow browsing and searching interactions depending on the users' need in completing their tasks.

1. INTRODUCTION

The conception of atlas, especially the national atlas, in the cartography literature has been evolving over past few decades. The advent of computer technology is the influencing factor for this new conception. Moving towards from paper to digital atlas and later to web atlas has opened up new possibilities as well as challenges for the atlas design (see e.g. [1]). This format shift is not the only subject in which researchers and atlas designers have been concentrating; the objective of the atlas is also a subject for change as well. Originally, it was for representing social-economic information or presenting sovereignty of a country, then steered towards planning and problems solving [2], for instance.

When one looks for the "atlas" definition through online dictionaries (such as Dictionary.com, Merriam-Webster online) though, the given definition for "atlas" is "a book or bound of maps including illustrations, tables, and graphic analyses". The digital and web format as well as being not merely as a collection of maps for representing many features of the country have not been elaborated in those dictionaries. In fact, only few online encyclopedias distinguish electronic means in the atlas dissemination (i.e. in CD-ROM), such as Wikipedia.org. From that point of view, although the atlas definition has been renewed over years, it appears there are no clear significant changes to the common users' perspective. The noticeable reason for the use of atlas is for its familiarity to users in dealing with geographic questions. For example, the atlas will be 'picked up' first mostly when they have inquiries about geographic names, economic development, politics for a certain place [3]. Thus, it is still quite difficult to measure whether the atlas built has been perceived and used properly as it was designed. Many questions regarding users' acceptance and satisfaction for the new form and concept of atlases remain unknown. In such position, Keller [4] suggests for more involvement of the users research in the atlas development. This is to articulate users willingness and needs successfully in the new face of the (national) atlas. In this direction, the new face of (national) atlas should recognize the people needs for geographic information regardless their levels of interest and expertise [5], beyond their perception to simply find answers for their geographic questions.

This paper attempts to advance further the concept of (national) atlas and at the same time involving users experiences and needs in the design. The atlas is positioned as a geoportal – a web application as a gateway to access data and services in a geospatial data infrastructure (GDI) framework. The metadata and information related to the GDI are juxtaposed with thematic maps and supporting information in the atlas. The atlas has been proven to be effective to convey multi-thematic information. This leads to an argument that it should be possible to represent related information to enable data access via the atlas [6]. However the challenges are immediately emerging. First, the GDI is an evolving concept involving interrelationships interactions across policy, social, economy, and technology aspects. Secondly, the information updateness within the GDI requires a strong cooperation and collaboration across the institutions (thus not only concerning technology matters). Thirdly, and is more technical aspect, a scheme for mapping metadata into usable information for supporting data discovery tasks is needed. It is considered, as a geoportal, the atlas is not merely seen as an old cartographic artifact focused for geospatial visualization, but should be seen more as a supportive tool enabling decision-making.

This paper will only deal with the third challenge mentioned. First, it will describe the supporting rationales for utilizing the atlas as a portal. Subsequently, it will discuss the methods developed in respond to that challenge.

2. PROSPECTS

Two factual arguments provide prospective foundations for developing the atlas as a geoportal. First, the map ("sub-unit" of atlas) has been used in many applications as a metaphor to provide decision-support in solving geo-related problems. Secondly, the atlas provides appropriateness (termed as "cognitive suitability" in [7]) as a metaphor in the access to the GDI.

2.1. The map metaphor for supporting decision-making

As illustrated by Tufte [8 p. 27 - 37], John Snow's map (1855) was the key to reveal cause and effect of the cholera outbreak in the London city. He placed non-spatial information in the context on top of spatial features enabling him to associate between cholera and proximity to the Broad Street pump and to draw quantitative comparisons between the living and the dead. This reflects potential uses of a map to enabling knowledge constructions in support of decision-making.

That old John Snow's map exemplifies the validity of the mapping concept to assist our searching and reasoning to understand geo-related problems. Among the various methods for searching geospatial information, the visual metaphor in the form of map has benefits in providing possibilities to explore, navigate and ease people's understanding [9]. In the world of information retrieval and visualization, the mapping techniques have been applied extensively beyond its natural domain (cartography) [10]. Today this can be of spatialization of non-spatial information [e.g. 11] or charting items of interest into conceptual networks [12] or social networks [13] representations.

Regarding the GDI, information to be visualized are spatial (e.g. administrative units) and non spatial (e.g. metadata). The map can play a significant role to allow users finding the data required for their project. Offered as a spatial search engine, the map is an effective medium to define area of interest of the search [14] or to be used as a preview of available data during the search process [15]. Even it can be used further as an indexer of spatial and non-spatial information [16]. However, the strength of the use of a map in the GDI environment is beyond its search engine ability. It is envisaged that this map enables the combination of spatial analysis and data discovery in support of locating data for decision-support.

The development of web technology has been extending the use of map in supporting decision-making. Its range of applicability includes mapping for office and mobile applications as well as for collaborative works. The rise of eXtensible Markup Language (XML) as the interchange formats broadens possibilities to provide a lightweight map display with Scalable Vector Graphics (SVG) [e.g. 17], to generate content-based with a uniform representation using eXtensible Stylesheet Language Transformation (XSLT) [e.g. 18], and to enable information interchange using OGC compliant Web Map Service (WMS) (e.g. Atlas of Canada at http://atlas.gc.ca/) and Web Feature Service (WFS) [e.g. 19]. The portability of web map applications is also becoming more diverse with supports of computing device, such as PDA and other multimodal interfaces for collaboration works [20].

2.2. The cognitive suitability of atlas as metaphor

Since the map often deals with a single topic and the GDI offers a multitude of topics, the 'map-approach' is extended to the 'atlas-approach'. By definition, an atlas consists of various thematic maps regarding a defined area, presented based on a narrative together with tools for navigation, information retrieval, and analysis for specific uses, e.g. planning or education [5].

The atlas is an appropriate source for developing a metaphor in the access to the GDI for its understandability and its familiarity. Those two are some of important criteria to determine the appropriateness of a metaphor [7, 21]. GDI users are assumed to have the atlas knowledge they learned from their earlier educations at school and practice. Groot [22] concluded that “there are certain classes of planners, administratiors, scholars, students and private industry” that depend on the atlas. A supporting finding also signifies that test persons select the atlas as a first choice to complete required tasks in regional exploratory studies [23].

Design desiderata for developing “search interfaces” is attributed to Shneiderman et al [24]. The atlas, especially the digital atlases, has at least three important factors that are relevant and conforming to some of the principles suggested: provides consistent and easy navigation means (relevant to strive for consistency and permit easy reversal of actions), extends possibilities to access to the relevant data and links (relevant to offer informative feedback), and enables users to build comparisons (relevant to support user control).

To explicitly show advantages of those three factors, the following finding will be given to clarify. For studying the requirements in developing geoportal, a contextual inquiry activity has been done to a number of test participants, working with Netherlands Clearinghouse. From this activity, it was found that most of test participants requiring a “topic directory” style of the portal when the task to be accomplished required browsing. Atlases has this style already (“simple and consistent in its navigation means”) regardless changes and diversities of the topic organization among them. In addition it provides well-prepared and engineered related information [4] next to the map presented (“offer informative feedback”). Thus it is not so surprising when all test participants commented that atlas would be helpful and they would use it if available next to their computer for completing a particular task in which requiring them to do browsing.

3. DEVELOPMENTS

From the previous explanation, it seems achievable to have the atlas a geoportal. However in the beginning it has been indicated, the scheme for mapping metadata into usable information for supporting data discovery task is wanted. To develop a useful and effective scheme, users expectations and the lacking of current functionalities should be used as the basis. From interviews to the colleagues considered as potential “GDI users”, it was obvious that users expect usable navigation tools to control the searching. From observations of current geoportal functionalities, it was clear that most geoportals suffer users’ understanding supports [25]. These requirements are valuable information to design the atlas as a geoportal.

The definitive goal of geoportals is to provide useful information enabling users (can be of providers and group or individual users) accessing GDI resources (data and services). In this context , besides considering users needs, understanding how the information processed in the GDI framework is also important. Social and technological aspects very much influence how the geo information is processed in a GDI framework. This paper will only discuss this from the technology point of view. As shown in figure1, the information presented in the geoportal is derived information from the previous data acquisition and data documentation steps that should meet the information need posed by users. Loosely speaking, the geoportal can be seen as a medium interfacing information interest between providers and users.

A set of GDI data is considered to exist when there is a provider willingly shares this data to be accessed. It serves possibilities to be used in a certain application domain, and it covers a definitive geographic area of the country. Data shared can be any forms of information sources concerning spatial information, such as: place name databases, map, field data, and aerial images. The applicability of these data might be suitable beyond the application domain for which they were originally produced. Considering the nature of the data acquisition process, these data can have arbitrary geographic extent covering various administrative boundary levels. Because of this three dimensionality of the nature of data, the degree of variety of data to be presented is very high. Hence, It is considered to be useful to organize corresponding metadata using these three elements: availability (i.e. provider), applicability (i.e. topical coverage and usage), and administrative level (i.e. geographical coverage). In this context, providers should provide metadata. Metadata is required not only to properly documenting these data but also to enable users performing data discovery via a geoportal.

In organizing metadata, geoportals commonly use two approaches, i.e. clearinghouse and collection-level metadata (CLM) mechanisms [26]. The first requires the availability of metadata and an indexing server on the provider’s site (using discovery protocol ISO 23950) to set up the infrastructure [27]. This can be seen as a registry service looking for “query-matched” metadata across providers at a one time. The second is a well-arranged metadata service in which is customized similar to “bibliographic-collections” in the traditional library. When users search of a specific metadata item through the interface of central digital-library, the mechanism applied is first to visit the collection-level and then searching “query-matched” items within the collection [28]. An essential building block for this is the collection-level component [29].

From a perspective of users seeking data, the clearinghouse mechanism has disadvantages because of its setting, i.e. there is no classification mechanism applied. As seen in most portals implement this, search results are presented based on data availability per providers, which is of course not always the users' preference when looking for data. Therefore it will not be used here. For the purpose of this work, the CLM is also not suitable, because the data structure used in CLM is too detail and library-oriented centric. At collections-level, multiple metadata items are indexed as a group either covering identical topic or mixed. As indicated by Janee and Frew [29] as one of CLM limitations, joined-queries (involving geographical coverage, temporal coverage at one query, for example) will be difficult to be handled with this structure. Thus, it is difficult to build up the association to a single topic or map in the atlas using multiple indexes (such as topical and geographical coverage). For this reason, this approach is also not used; instead the notion of metadata summaries is introduced.

As a medium interfacing users-providers and assisting decision-support in a sharing initiative environment, the use of the geoportal can be very broad, depending three factors of it usability: portability, interactivity, and users diversity. Portability refers to its use in various computing devices as the information locator and integrator (e.g. used in PDA, large screen). Interactivity refers to its support to facilitate human interaction to control the data and information presented. The users' diversity corresponds to users task (tightly or loosely defined task of data discovery) and profiles (individual or groups, novice or experts).

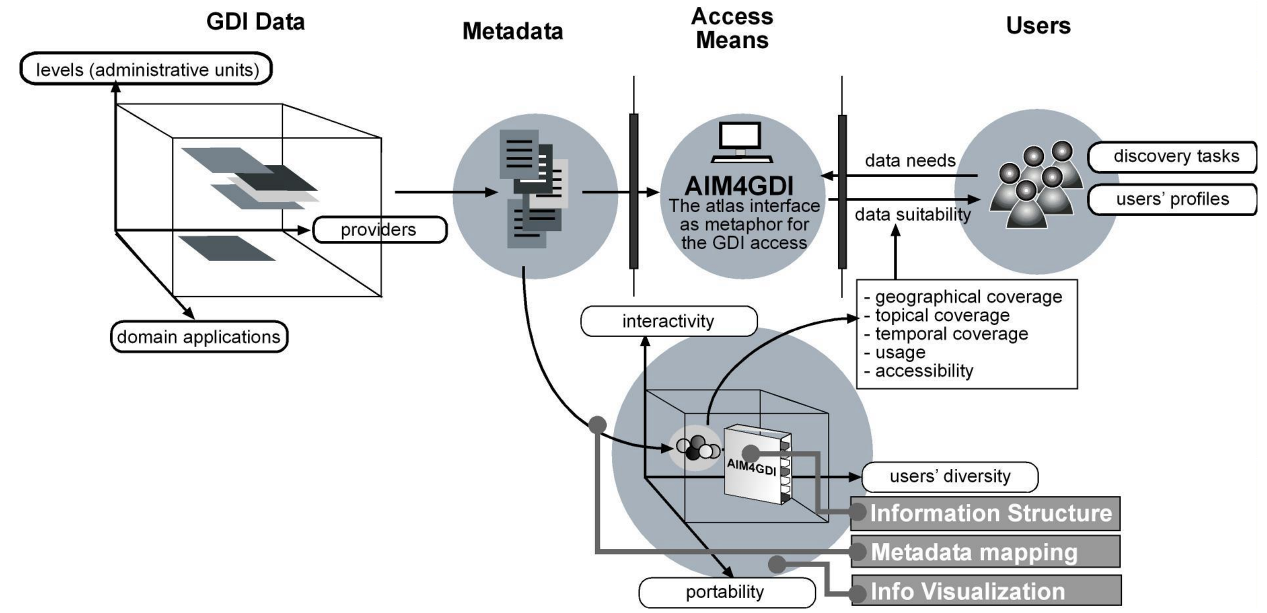

Figure 1. A generalization of the GDI's information flow with its dimensionalities in its data component and access component: The three fundamental issues in the development of atlas as geoportal are information structure, metadata mapping, and information visualization.

As seen in the right-bottom area in the figure 1, three important issues emerge. These three issues are essential within the atlas development. Another essential part of this work, which is not covered in this paper, is to implement user-centered design in the development through observing users experiences with contextual inquiry and usability testing techniques. The subsequent sections will discuss the notion of these three issues. First, it is defining a schema for structuring the atlas contents, secondly is applying some cartographic principles for representing metadata elements into the maps and explorer windows, and thirdly to integrate the prior steps into the interfaces enabling users to complete discovery tasks.

3.1. Atlas Information Structure

Like other atlases, within the atlas proposed (called AIM4GDI: the atlas interface as metaphor for accessing GDI resources), each topic is represented by relevant maps to deliver a coherent visualization of several themes. To extend users' perspectives, multi-views in forms of tables, charts, images or movies, and explanatory text are associated to individual maps. For organizing such atlas contents, an atlas information structure is introduced. This structure is used to control the scope of the maps visualized as well as the linkage between each of maps to a set of multi-views mentioned for storyline exploration. An essential key in this work is the inclusion of metadata into the atlas information structure to develop multivariate visualizations of the metadata to support discovery tasks performed.

3.2. Mapping Metadata

The focus of this step is to provide a visual overview about characteristics of the data available in the GDI, accessible via their metadata. Metadata published by providers are collectively summarized to include five important elements, i.e.: geographical, topical, temporal coverage, accessibility (including provider information) and usage elements (e.g. scale, data format). Transforming original XML metadata into the metadata summary format (XML transformations) can be done automatically, given that providers specify the address of each metadata published and its category through a registration submission. Within the atlas information structure, each of summaries is linked to a thematic map based upon the thematic content of the data offered.

The five elements mentioned are defined in the atlas structure as abstract classes, specified further into sub classes with some properties attached. This can be seen as a semantic reference to broaden the exploration of data characteristics for assessing their fitness for use. To effectively support this, elements of each summary are mapped as symbols. With graphic variables applied in these symbols, the nature of the elements (either quantitative or qualitative) and the differences among them can be recognized and compared. The differences of metadata for permitting comparisons include what in [30] specified as qualitative differentiation, ordered differentiation, and proportional differentiation. To depict intuitively those differences for various levels of measurement, some visual variables plus text are chosen to represent the value of each element.

		Graphic variables								Measurement scale: Nominal	Ordinal	Interval	Ratio
Elements of Metadata Summary	symbol type	shape	picto graph	size	hue	value	transpa rency	pattern	text	Qualita tive	Quantitative		
Geographical cov.													
boundary extent	polygon	✓			✓		✓						
administrative unit	point		✓	✓	✓					Prov			
placename	point				✓				✓	Delft			
Topical cov.													
category	point				✓				✓	Agriculture			
title	point				✓				✓	Bossenkart 1983			
Temporal cov.													
time-stamp	point		✓						✓				12-10-1990
range	point polygon	✓	✓			✓	✓		✓			1980 1983	
Accessibility													
provider	point		✓						✓	Alterra			
access	point				✓				✓	free			
language	point		✓										
Usage													
format	point		✓										
scale	point		✓	✓					✓				
spatial reference	point				✓				✓	WGS 84			
spatial resolutions	point		✓			✓		✓					
Differences to be shown:										Qualitative	Order	Distortion	Proportional

Figure 2. Graphic variables applied on each element of metadata summary regarding to their measurement levels and differentiations to be exposed. Based on [30], [31, 32], [33].

3.3. Interfaces for Supporting Discovery Tasks

Once the structure to control navigations and presentations has been defined and metadata summaries have been linked to the structure, mapping metadata can be implemented into the atlas to support discovery tasks required. For this, metadata mapping is: (1) applied over the maps to deal with loosely defined tasks through *browsing* or (2) applied over the explorer window to deal with tightly defined tasks through *searching*.

3.3.1. Maps Browser and Story-teller.

Regarding mapping metadata to facilitate loosely defined tasks, each element of metadata is represented over the corresponding map using a selected symbol. The representations of data available can also be superimposed over the other maps by interacting with metadata legend. For each map displayed, to support browsing, a set of relevant multi-views (tables, charts, images, or movies) is offered.

With this setting, users can reveal the similarities, patterns, and density of the data available that relevant to a theme they are interested in. Yet, analysis can go further by comparing metadata items with a thematic map, e.g., comparing the density of metadata items regarding roads with a trend of land uses topic.

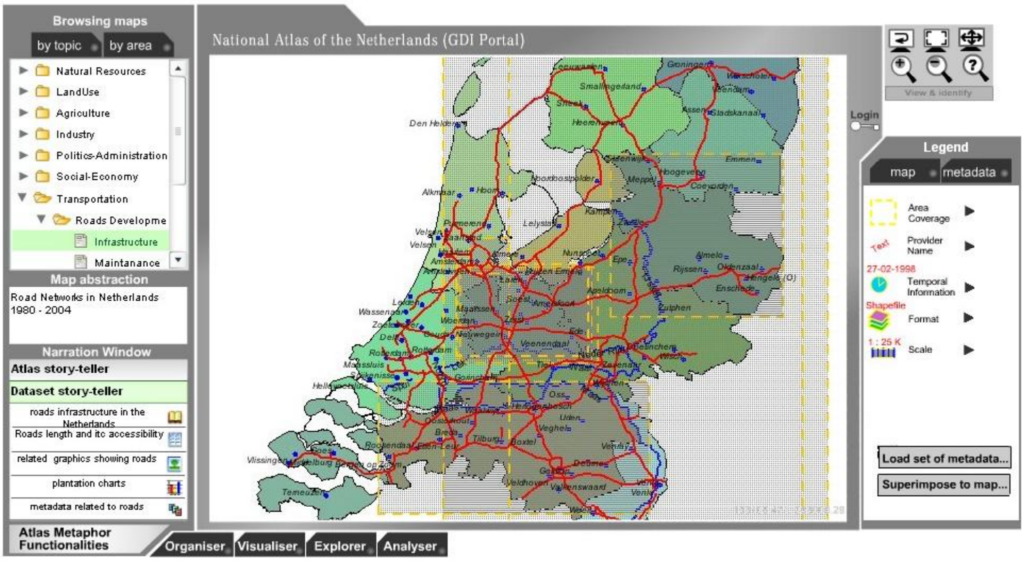

Figure 3. The atlas developed with maps browser , story-teller (left side), map and legend windows (centre and right side) are offered to support browsing mode.

3.3.2. Explorer windows.

Regarding mapping metadata to facilitate tightly defined tasks, first, users need to formulate questions. Using “explorer” tab, the user has possibilities to ask: where, what, when questions (corresponding geographical, topical, temporal values of the data required) within its sub-tabs. The items of metadata summaries that match to questions submitted then are listed in a table. Thumbnails and short abstract for each item offered to present an overview about the data. To better differentiate the item, each item can be mapped either into the related thematic map (as implemented for supporting loosely-defined task) or into the basic map. When projected over a specific thematic map, users can compare the item to other items that topically are relevant. Meanwhile when projected together with other items of search results; users can examine the suitability of the item among the others.

To effectively assess the data suitability, a possibility to examine the search relevance is offered too. For this purpose, attributes mapping is also applied on the bull’s eye metaphor. As already used as a metaphor for describing accuracy and precision of the measurement in the field of statistics: the more accurate, the closer to the centre; the more aggregated as a grouped, the more precise. Thus, the closer to the query, the items plotted closer to the centre. The principle beyond this metaphor is that the arrangement of metadata items and the use of colors are important aspects to provide an effective means to support visual search [34]. To specify the differentiation of the topical attributes, visual variables applied.

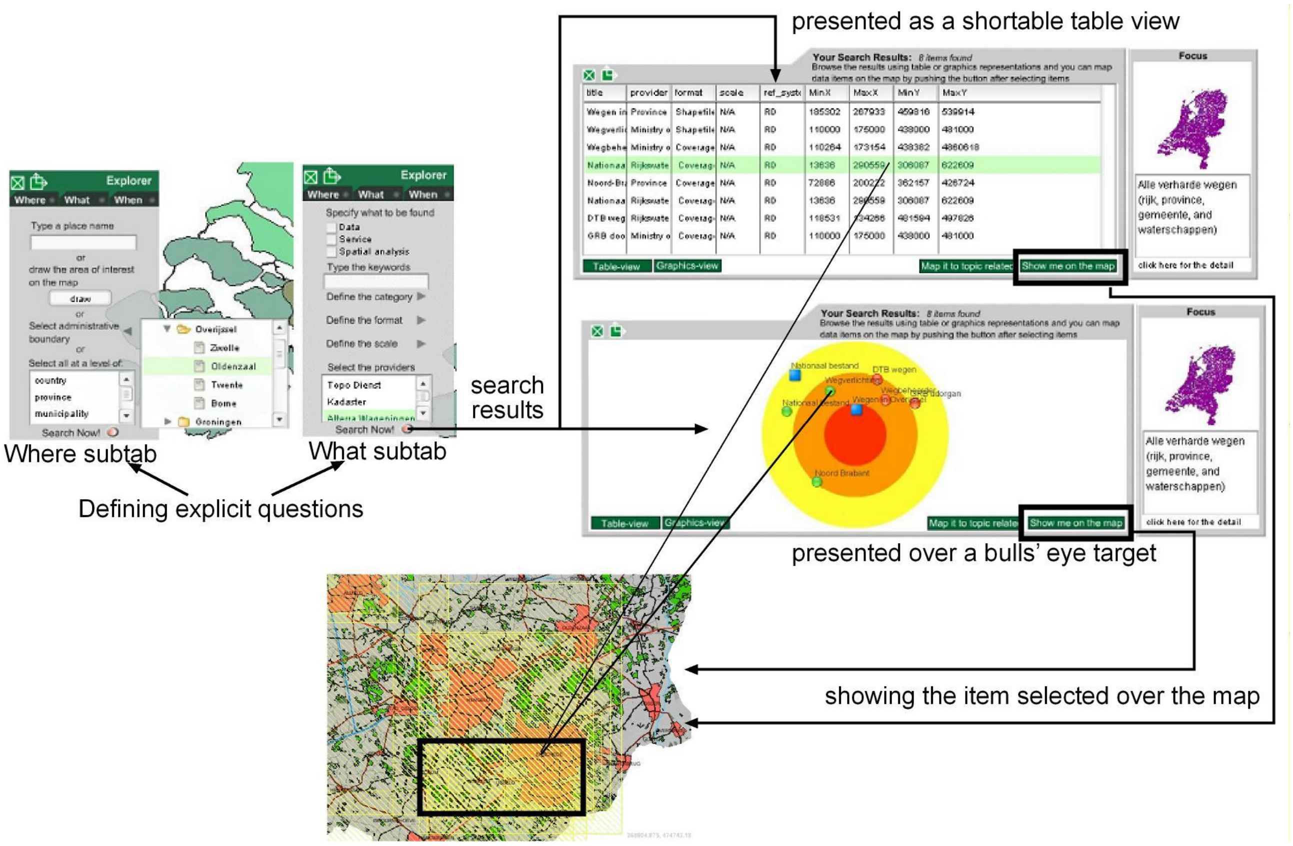

Figure 4. The developed explorer windows to enable searching and assessing the data suitability through mapping metadata into the thematic map and bulls' eye metaphor as well as the table view representation.

4. CONCLUSIONS

This paper signifies the suitability for using the atlas concept in developing a geoportal. The appropriateness and supporting factors (such as being a map-based representation, already familiar and understandable to users) were discussed. However, this paper also considers that such interface development should also consider the users needs. The information presented in the geoportal should fulfill the information need posed by users. As a medium interfacing providers and users, it should provide effective interfaces to get meaningful information out of metadata published. For this purpose visual representation with maps and visual variables can be helpful. Metadata mapping is an important method that permits identification and comparison for assessing the data suitability. The natures of comparisons can be of geographical comparisons (comparing density, pattern, or the extent of the data) or topical comparisons (comparing thematic attributes). Through the atlas, the characteristics of data are not merely explored with maps for clarity but are interacted with the external elements (such as multimedia related to maps and metadata) to present a relevant context that supports the discovery task required.

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6. A SHORT BIOGRAPHY OF THE PRESENTING AUTHOR

Trias Aditya (1975), from Indonesia, joined the GIP Department of ITC in April 2003 as a PhD student. He got degrees in geodetic engineering from Gadjah Mada University, Indonesia in 1998 and MSc in geoinformatics from ITC, the Netherlands in 2003. In his current PhD study, the research focuses on the use of Geovisualization and Human Computer Interaction techniques for developing a usable metaphor in the access to the GDI.