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Spatial data warehouse: an analysis in tourism sector of west java province

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ABSTRACT

In the tourism business, the use of geospatial, sometimes known as geospatial information systems, is essential to the collection of data in various different ways. A collection of historical data and a set of tools to enable decision-making are both components of a geographic data warehouse. In this study, we investigate the requirements for developing a recommendation of spatial data warehouse (SDW) that makes advantage of the implementation the geographical data analysis and data visualization in tourism sector. Methodology of this research using qualitative analysis. The SDW Tourism sector technology model, on which work has been going on for some time, will be a driving factor in this study that aim to create a recommendation for integrated tourism data environments to assist with decision-making. It is possible to bring together in a single location not only non-spatial data but also spatial data, as well as applications that are now running on multiple platforms and databases. The output of this research makes a recommendation to construct a spatial data warehouse based on existing data, and diagram of how the data from the data warehouse will be used in the tourism sector.

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1. INTRODUCTION

Geographic Information Systems (GIS) have been used in urban administration and planning for decades, but only recently, because of developments in graphics, distributed processing, and network connections, has software progressed to the point where it can be used consistently and efficiently, sometimes called smart cities or smart urban which include tourism sector [1][2]. Geographic or Geospatial Information Systems are crucial to several methods of collecting data in the tourism industry [3][4][5] and has had a significant impact on the tourism industry, and as a result, there has been renewed interest in the use of spatial data warehouse in the tourism sector to manage large, diverse geographical databases for urban applications [6][7]. Many people in the tourism industry use dan will collect data, including those who use social media and the government use the data to make an impact to improve the tourist attraction or to make a benefit as an income or invest for the government [8]. Simply put, a geographic data warehouse is just a repository of historical data and a set of decision-supporting tools that may be included in long-term planning [9][10].

In this study, we analyze numerous data technologies for spatial data administration in urban and tourism contexts and then propose a novel technique for integrative data management to aid decision-making in tourism and behavior [11][12]. The research examines what is needed to create a new data strategy utilizing the principles of the spatial data warehouse [13][14]. As an illustration of how to put this into practice, a whole data management architecture for the tourism industry is presented. There is an intensive investigation of the structure and implementation of a geographic data warehouse. Information efficiency has been a major issue. Planning for urban data management can be broken down into three phases: transaction-based, database-based data management and processing, and data warehouse-based management and decision-making. This research based on these phases will create a recommendation for spatial data management in the form of a spatial data warehouse in the tourism sector [8].

2. RESEARCH METHOD

The research methodology can be presented in the form of a research flow chart as follows in figure 1, but not all the stages [15][16].

Figure 1. Research Methodology Analysis of Spatial Data Warehouse[17]

An explanation of each research stage (methods and outputs of each research stage)[18][19] can be seen in Table 2.

Table 1. Research Stage

Stages	Method / Tools	Output
Study literature	conventional and online literature.	This first stage contains the search for foundations and supporting theories regarding the implementation of the OLAP method, making ETL, storage in the data warehouse, the concept of dimensional models, making OLAP cubes, analyzing operations contained in OLAP, creating OLAP Spatial data visualizations into maps and OLAP Spatial data analysis.
Data Collecting	Collecting spatial and non-spatial data from open data related to tourism	Dataset of Tourism such as Tourist Attraction, Object, Location (Coordinate), and related to the attraction. Dataset could be gathered from specific stakeholder such as (Tourism Department, etc.) or accessing the open data from geoportal available.
Analysis	Analysis of Data from the Tourism Mobility Sector	The analysis results are based on spatial and non- spatial data on the mobility of tourists and tourist objects, which show information related to mobility.
Design	Design Spatial Datawarehouse dan SOLAP	he Staging Area is a stage where data is processed before it is stored in the database. This stage involves transferring non- and non- spatial spatial data from open sources (excel, SQL Server DB, Oracle DB) to an internal database. The audit data is entered into a table by separating the header and details.
Recommendation	Give recommendation	The result of combining the data in the title and details into dimensional data that can be analyzed later using tools, which GeoMondrian, GeoServer, etc.,

3. RESULTS AND DISCUSSIONS

3.1 Spatial data warehouse of tourism existing.

Geographic information systems (GIS) have proven instrumental in the development of municipal databases for example development of geoportal or map web apps [20][21][22], in this research, this existing database shows in Table 1. Tourism data, like the vast majority of urban data, is obtained and used based on location. Due in large part to the expansion of commercial data warehouses inside tourism enterprises, spatially enabled data warehouses have recently gained a lot of interest. You might want to think about the point of traveller data management solutions that don't need maps. Geographical data warehousing, which focuses on spatial data use and is increasingly being applied to industries like tourism, seems like a logical progression from traditional data warehousing. Like corporate data warehouses, the idea of tourist attraction and traveller behaviour geodata emerged from the need to store, manage, and make readily available enormous amounts of geospatial data for analysis and decision-making.

A spatial data warehouse houses a variety of geospatial data. It offers a unified framework for storing and processing spatial and nonspatial data. In this framework, data can be filtered, transformed, aggregated, summarized, integrated, and deployed. Its primary function, in contrast to operational systems, is to archive information that has already been gathered, such as vector-based geographic features collected at different epochs. This data's significance in the tourism industry lies in the fact that it may be mined for insights and subsequently used to inform pivotal policy choices. Catalog data, meta-data, and administrative data are also kept in a spatial data warehouse. Collecting data can be tracked in terms of methodology, scope, coverage, accuracy, and depth. In addition to storing and organizing data, a spatial data warehouse also provides users with a set of tools for tabular reporting, spatial query, visualization, online analytical process, and data mining. While the technology behind data warehouses for enterprise applications is maturing, a geographic data warehouse is also being developed. It can combine spatial data from several sources, including those that use different GIS software, run on different computers, and store their information in different formats [23]. Dealing with several data formats such vector, raster, matrix, and text, Adaptable to a wide variety of spatial data types for input or transformation, Archiving datasets with a temporal dimension. Maintaining support for advanced data visualization and analytical tools; facilitating online datasets and access; facilitating geographical aggregation and generalization; Supporting spatial data mining and on-line data analysis processing.

Table 2. Source Spatial Data based on Municipalities.

No	City	Source of Spatial Data	Spatial Data of tourism sector	Technology
1	Kabupaten Bandung	Geoportal	no	No
2	Kabupaten Bandung Barat	Geoportal	no	No
3	Kabupaten Bekasi	Geoportal	available	Leaflet, Google Maps
4	Kabupaten Bogor	Geoportal, Tourism Web	no	No
5	Kabupaten Ciamis	Geoportal	no	No
6	Kabupaten Cianjur	Geoportal	no	No
7	Kabupaten Cirebon	Geoportal	no	No
8	Kabupaten Garut	Geoportal	no	No
9	Kabupaten Indramayu	Geoportal	no	No
10	Kabupaten Karawang	Geoportal	no	No
11	Kabupaten Kuningan	Geoportal	no	No
12	Kabupaten Majalengka	Geoportal	no	No
13	Kabupaten Pangandaran	Geoportal	available	No
14	Kabupaten Purwakarta	Geoportal, Open Data, Tourism Web	available	Google Maps
15	Kabupaten Subang	Geoportal	no	No
16	Kabupaten Sukabumi	Geoportal	available	Leaflet, PostgreSQL
17	Kabupaten Sumedang	Geoportal, Open Data	no	Leaflet, Google Maps
18	Kabupaten Tasikmalaya	Geoportal	available	Leaflet, Google Maps
19	Kota Bandung	Geoportal, Open Data, Tourism Web	available	Leaflet, Google Maps, Esri
20	Kota Banjar	Geoportal	No	No
21	Kota Bekasi	Geoportal	available	Leaflet, Google Maps, Esri
22	Kota Bogor	Geoportal, Open Data, Tourism Web	available	Leaflet, Google Maps, Esri

No	City	Source of Spatial Data	Spatial Data of tourism sector	Technology
23	Kota Cimahi	Geoportal	available	Leaflet, PostgreSQL
24	Kota Cirebon	Geoportal, Open Data, Tourism Web	available	Leaflet, Google Maps, Esri
25	Kota Depok	Geoportal, Open Data	available	Leaflet, Google Maps
26	Kota Sukabumi	Geoportal, Open Data, Tourism Web	available	Leaflet, Google Maps, Esri
27	Kota Tasikmalaya	Geoportal, Open Data	available	Leaflet, Google Maps

3.2 Transaction-based analysis.

Vincent Tao demonstrates the first stage is transaction-based systems are information systems that only serve to automate previously manual tasks. This system processes based on input activity (transaction) through a simultaneous of programs that alter the data before writing the most recent information into the files (Figure 1).

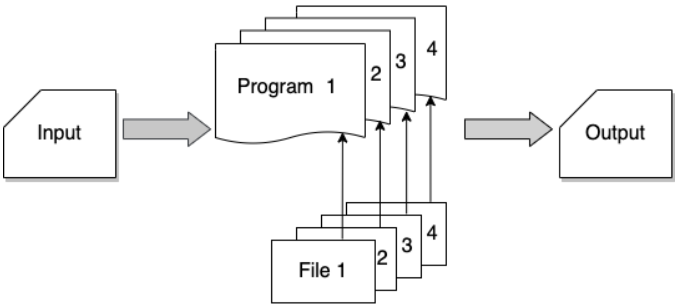

Figure 2. The architecture of the transaction-based system

This activity of transaction is performed in most situations due to their focused design and small amount of data processed. Systems become more complex and difficult to manage as they are extended or additional apps and files are added. The transaction design gradually loses its performance advantage due to the complex processing flow and insufficient data file organization. As a result, municipal administrations ran into problems with these systems. Figure 2 shows one example of a complex flow of data processing. One could expect that such a system could be difficult to maintain and improve.

3.3 Spatial database management systems.

The creation of database systems addresses the above-described difficulty (DBMS). Database management systems (DBMS) isolate data from programs, systems, and processes. While knowing the physical architecture of such data contained in the databases, various programs and applications can be built utilizing a database that maintains urban data [24]. Data updates or modifications have no influence on the programs, and changes to the programs have no effect on the data. It simplifies application software implementation and considerably reduces data redundancy. Furthermore, it allows for the creation of a unified system or centralized data repository in so that you may manage your data's authenticity, privacy, and usability. Such systems have a lengthier development cycle than transaction-based systems.

Moreover, the cost of installation is substantial, overall, this means difficult. This is due to the fact that such a system is utilized by more than one function and benefits a variety of businesses. These connected departments' cost savings are not easily measurable. This was one of the primary reasons why people were afraid to create database-based solutions. This is no longer an issue due to the lower expenses of hardware, software, and databases.

The majority of cities employ a centralized database strategy to exclusively manage base location information such as topographic data, survey controls, land records, road networks, etc. because these data sets are regarded essential and must be shared by the majority of departments

[25][26]. Other spatial and nonspatial data types are collected, managed, and stored as part of the business activities of the affiliated departments. For illustration, the environmental services department is accountable for its own waste and polluted data. Using this data method, a dedicated data processing unit may maintain and update core data to ensure the data's integrity, quality, and currency. It delegated authority regarding data consumption and application development to departments. Several departments, for example, have identified and applied their own operating systems for specific purposes, such as transport systems, utilities management systems, and emergency response systems. Despite the fact that some systems use shared base mapping data as input, the data has been removed, modified, or purified to match the application's specific requirements. Before being included in an operational database, the shared data is frequently blended or integrated with the department's heritage data, whether geographic or non-spatial [23]. As a result, a plethora of operational systems for various urban applications are created, leading in the two-tiered architecture represented in Figure 4. This architecture is often used in modern urban data management scenarios.

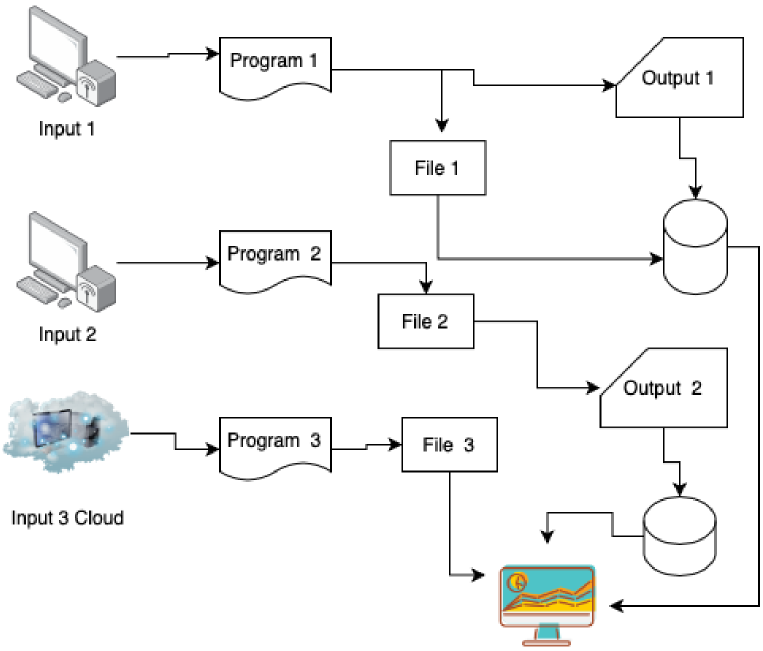

Figure 3. An expanded transaction-based data processing system

3.4 Integrated tourism data management.

By looking at how data warehousing has developed over time, we can see that operational and analysis systems have very different needs. Both the operating and analytical systems need to function at peak efficiency. It has been conventional wisdom that business analysis should not be allowed to detract from the efficiency of running systems.

The SDW Tourism method is the best way to create a digital setting in which experts in the tourism industry may investigate, organize, and find answers to difficult issues [22]. Over the next decade, the informal decision-making environment will be given significantly more attention as urban data management evolves. There will be space for both solo and collaborative data exploration here. Spatial modeling, simulation, and planning can all be brought together with its help. It also paves the way for distributed communication and decision-making across systems. The most significant aspect is that it can be used by both technical experts and regular people. The Internet's meteoric rise over the past two decades is undeniable proof of the potential of these kinds of settings. The development of geographical data warehouses will be crucial to this shift.

It's common knowledge that the proliferation of so many unique operational databases and GIS has exacerbated the issue of disjointed data. One of the difficult issues has been the management and archiving of the historical data from these systems. The proliferation of laptops and WiFi has led to a splintering of formerly cohesive data sets. SDW claims to consolidate the information from these several GIS apps and operational databases into one easily accessible location.

a. Data warehouse.

Planning and decision-making have become increasingly vital to the long-term growth of cities as urban management and applications have advanced [27]. Plan and implement an urban information system to provide data at all three different levels: operational, management, and policy [28]. The complicated process of decision support comprises strategic analysis, operational scheduling, and investment evaluation. The system should be able to utilize data from several departments and information from different phases of business activities to facilitate decision-making. In addition to sophisticated and robust analytical skills, the system should aid decision-makers in problem-solving.

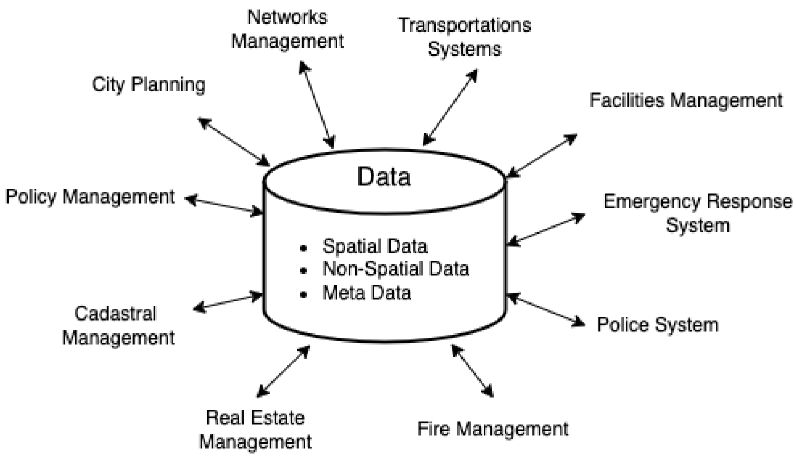

Figure 4. Centralized data repository supporting various data applications

Lastly, this technology enables the users to alter the significance of analytical components, which may be used to analyze the sensitivities of alternatives and to reflect varied views and objectives for the solutions. Operational systems (illustrated in Figure 4) designed for specific purposes are unsuitable for offering stakeholders or management staff an impactful consolidation and multi-dimensional perspective of the data, as high-level executives require the capability to slice and dice the same data rather than drill down to examine the data detail. Comprehensive information analysis and selection tools Data warehousing is a repository for vast quantities of historical data [7]. It is also a group of decision support tools designed to assist (executives, managers, and analysts) in making quicker and more accurate decisions.

Furthermore, data warehousing systems are most effective when their architecture is consistent with the overall business structure (Executive, manager, and analyst) to make informed and stimulate decisions, and modern data warehousing systems include a variety of data analysis tools that were not available in their predecessors [29][30]. It is no longer necessary to base the design of a data warehouse on a list of predetermined requirements, and modern data warehouses make use of a wide number of analytical tools that were not previously available [31]. Moreover, as we will see in the following section, data warehouses perform best when their design is in line with the larger organizational structure.

b. Architecture of SDW tourism

Figure 3 depicts the SDW architecture [27][28]. There are multiple levels, each responsible for a different aspect of the data lifecycle: transformation, management, and access/use. SDW draws its information from either internal records or retrieved when needed. Spatial vector data, computer-aided design (CAD) data, pictures, and multimedia content stored in active databases, files, and networks are all examples. By way of the data transformation module, these data sources are brought into the data warehouse. In order to transform data, we can filter and clean it, validate it, integrate it, and aggregate it. The detail data normally found in operational databases must be aggregated before being loaded into the data warehouse. The data management component consists of an extended database management system (E-DBMS) to facilitate the storage, maintenance, and accessibility of geodata. A spatial data module, which is an engine for managing geographical data in relational databases, is one of the fundamental modules in data management. This approach supports geographic data operations while preserving interoperability, data security, and data integrity. In recent years, numerous geographical data modules or extensions have been produced. Some of them are ubiquitous, meaning they can be plugged into other databases to spatially enable them, such as the ESRI Spatial Data Engine. Others are privately owned. It is intended to enhance the capabilities of existing databases to manage spatial data, such as Oracle Spatial Module, IBM DB 2 Spatial Extender, and Postgis Extension, among others. In data warehouses, meta-data management is also a significant element. It provides a comprehensive description of the data warehouse's stored information. In addition, it describes the predefined queries and reports, as well as data aggregation and summary information.

SDW Tourism can be used as a foundation for merging data from many existing applications. As an example, a tourism transportation system may have migrated from a mainframe-based, custom-developed legacy application to a more modern, industry-standard solution. Data from both legacy and modern applications is combined in a data warehouse.

c. Building a spatially enabled data warehouse tourism sector.

As can be seen in Figure 4, the current two-tiered design might benefit from the addition of a spatially enabled, integrated, distributed, non-volatile spatial data warehouse. As the final layer in a three-tier architecture, this system can be implemented atop any preexisting GIS or non-GIS application infrastructure. This structure is depicted in Figure 4 below. Data was formerly stored on DBMS by dated systems.

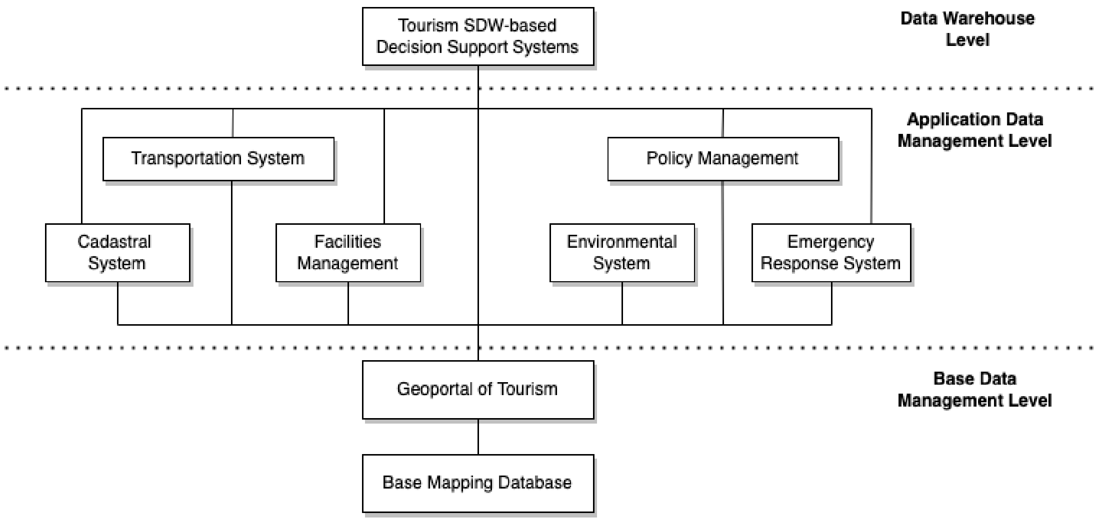

Figure 5. The architecture for tourism SDW data management

Many analysis reports used these tapes or mirrored data sources when the system was dormant to keep operating system performance to a minimum or cloud data as a service. The process of building a data warehouse could begin with the simple act of storing previously collected information. Once the data has been entered into the data warehouse, the expense of keeping it up to date is low. Data transfer and data cleaning account for the bulk of the major expenses. Data warehouses allow for the storage of information for very extended periods of time. As a matter of fact, many data warehouses are constructed simultaneously with the rollout of the operational software. The following technological challenges are of special importance to the future development of functional web apps when constructing an SDW-specific tourism data as a solution, in addition to the institutional and managerial issues.

d. Common data model.

This is a generalizable and scalable paradigm. It's made to accommodate information coming from a wide variety of places (external sources, operational databases, and multiple GIS applications). The first thing to think about is how to combine spatial and nonspatial information without any hiccups. This method can be used to represent a variety of geometric properties, including those in vector, raster, and matrix formats. It also allows for many geometric representations of the same attributes to be stored. It is essential that the common data model be carefully constructed to enable optimum flexibility and accessibility in light of the wide variety of spatial data structures in tourism and spatial activities such as behavior or temporal dimension of travellers. Efficient spatial indexing and partitioning must be taken into account in both the logical and physical construction of the model.

e. De-normalization.

In a relational database, normalization is the process by which large tables are broken down into smaller ones until all of a relation's attributes are highly correlated with that relation's primary key. When modelling data, most people aim for the "Third Normal Form" of all the relations before de-normalizing for performance or other reasons. Similar to an operational system, standardizing the data warehouse model can improve performance and simplify management. When it comes to relational databases, data normalization trades off performance for impressive adaptability. It's possible that the volume of data involved in a geographic data warehousing system will be significantly higher, which will increase the performance cost significantly. Depending on the size of the tables involved, a three-way join in an operational system may be acceptable in terms of performance cost, but the same join may take an unacceptable amount of time in a spatial data warehouse.

All characteristics of a relation are firmly associated with the primary key until the connection has been normalized, which is a process in relational database modeling in which the relations or tables are progressively divided into smaller relations. The data warehouse model can benefit from normalization for the same performance and simplicity reasons as an operational system in tourism apps. With relational databases' data normalization, you have a lot of but at the expense of performance. Considering the potential for significantly bigger data sets in a spatial data warehouse supplied by expended tourism apps or mining of behavior traveler data to make a spatial analysis, this performance penalty is dramatically magnified. In an operational system, the time it takes to complete a three-way join on relatively small tables may be acceptable, but in a spatial data warehouse, the time it takes to complete the join may be unacceptable.

f. Metadata.

The usage of a tent repository in SDW tourism has been advocated as a solution to the problem of data heterogeneity (data, databases, and applications from different sources). Metadata and metainformation are the two parts that make up the meta-content. Metadata regulates the data in a database in preparation for system analysis, whereas meta-information specifies the data’s quality and suitability for its intended use. To take use of established and developing international standards like ISO/TC 211, it is necessary for the create meta content of tourism data to be consistent with an open approach.

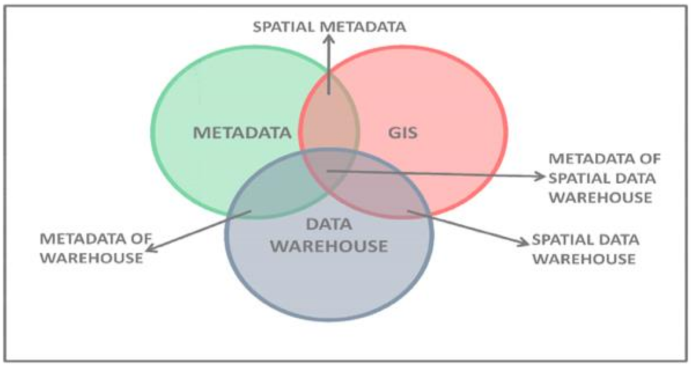

Figure 6. Meta-data of SDW

4. CONCLUSION

The growth of geographical data warehousing technologies in the tourism industry may be traced back to the inefficiency of operational databases in supporting effective and support decision-makers. Based on every stage of this research, the SDW recommendations of traveler behavior and tourist attractions improved the spatial analysis warehousing process delivering an adaptable data environment for the study of massive amounts of tourism data. Spatial and non-spatial data, as well as applications running on different platforms and databases with different schema, can all be brought together in one central location with this system, figure 4. As mentioned, most towns already use two-tiered data environments in which a geographical data warehouse for the tourism industry can be constructed. This allows for the establishment of architecture for a unified manageable data platform in tourism settings. With this in mind, the author hopes that the recommendation of the SDW Tourism sector technology model has been working on will be a driving force in future studies aimed at creating integrated tourism data environments to aid in decision-making and measure the performance of recommended architecture with the future applications such as spatial analysis and visualization.

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