ANALYSIS LAND USE SPATIAL TEMPORAL DATABASE DEVELOPMENT USING ArcGIS AND PostGIS

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GRADUATE SCHOOL
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DECLARATION

This thesis, written by MARONING USENG under the direction of his thesis advisor and approved by his thesis committee, has been presented and accepted by the Dean of Graduate Studies, in partial fulfilment of the requirements for the degree of Master of Computer.

I do hereby declare that the thesis entitled:

Analysis Land Use Spatial Temporal Database Development Using ArcGIS And PostGIS is my original work produced through the guidance of my academic advisors and that to the best of my knowledge it has not been presented for the award of any degree in any University. All of the incorporated material originated from other published as well as unpublished papers are clearly stated in the text as well as in the references.

Bogor, February 2013

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ABSTRACT

MARONING USENG, Analysis Land Use Spatial Temporal Database Development Using ArcGIS And PostGIS. Supervised by BABA BARUS and HARI AGUNG ADRIANTO

In Indonesia, there is a tendency of accumulation of spatial data particularly land use data as monitoring task become an important aspect for many institutions. This create new problem for handling large spatial data. Objective of this research is to develop spatio-temporal database which state and maintain spatio-temporal land use change with queries. Spatio-temporal database can perform a various land use changes. This research methodology is started from preprocessing to obtaina clean data, and planning to build a database such as conceptual planning, logical planning, and physical planning. Finally query analysis. This research use entire data of the land use in the Central Kalimantan on 2000, 2005, and 2009. This research can be finding the spatio-temporal database of land use change and to produce useful information to analyst and decision making of land use change. The database management system can performs of land use change query to be faster and easier than standard query.

Keywords: spatial temporal, spatial temporal database, query, land use change
MARONING USENG, Analisis Penggunaan Lahan dan Pengembangan Basisdata Spasial Temporal menggunakan ArcGIS and PostGIS. Dibimbing oleh BABA BARUS and HARI AGUNG ADRIANTO


Kata kunci: spatial temporal, spatial temporal database, query, land use change
SUMMARY

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In Indonesia, there is a tendency of accumulation of spatial data particularly land use data as monitoring task become an important aspect for many institutions. This create new problem for handling large spatial data. Objective of this research is to develop spatio-temporal database which state and maintain spatio-temporal land use change with queries. Spatio-temporal database can perform a various land use changes. This research methodology is started from preprocessing to obtain a clean data, and planning to build a database such as conceptual planning, logical planning, and physical planning. Finally query and analysis. The criteria of query and analysis are query process, time which includes (the preprocessing, execution and visualization time), flexibility. This research use entire data of the land use from The Roundtable on Sustainable Palm Oil Green House Gas – Working Group 3 (RSPO GHG-WS3) in the Central Kalimantan on 2000, 2005, and 2009.

This research systemically analyzes the problems existing among the land use spatial temporal data on a traditional system and then proposed a new land use spatial temporal data with the automatically system. The development systems of spatial temporal database with ArcGIS and PostGIS are successfully conducted. These models have respective advantages and disadvantages among them.
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MARONING USENG

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Bogor, February 2013

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Maroning Useng, the author of this thesis was born on the 27th October 1984 in Narathiwat Province, Thailand. The writer is the fourth son in the family of seven children. In 2004 the writer achieved Senior High School certificate degree from Bamrung Islam School in Thailand. In 2004 he was joined Yala Islamic University under the Faculty of Science and Technology in Information Technology and was graduated with Bachelor of Sciences in 2009. In 2009, the writer was get the opportunity to do a three years (with one year Bahasa Indonesia language course) Master of Computer degree in Computer Science at the Faculty Mathemetic and Natural Science in Bogor Agricultural University, Bogor, Indonesia under developing countries partnership scholarship program offered by the Ministry of National Education, Government of Republic of Indonesia.
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<td>Br</td>
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<td>Shrubs Grove Swamp</td>
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<td>Hutan Primer</td>
<td>Primary Forests</td>
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<td>Hutan Gambut Preime</td>
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CHAPTER I
INTRODUCTION

1.1 Background

The existence of satellite remote sensing in producing land use land cover has been recognized from several decades ago. Currently the use of satellite data has been growing rapidly as the availability of free data of remote sensing from particular sources such as Google, NASA, Landsat, or the price of images go down, etc. The increasing of amount of these data produces a need for a proper database.

One of the primary goals for the Land Cover and Land Use Change programs to develop the capability to perform repeated inventories of global land cover and to identify areas and quantify rates of land-cover change. The past decade has seen a rapid increase in collecting, analyzing and distributing quantitative information on land cover. In particular, the implementation of satellite-based measurement systems has been important in this respect. However, while there has been a large amount of data collected, there still remain critical issues of validation, data availability, and continuity of important data streams (Anthony 2004). For this purpose, the importance of database is undisputable.

The forest and land use map in Indonesia is synergized and widely accepted by all sectors and government as a fundamental to addressing the challenges that face Indonesia’s land-use management (Ardiansyah and Barano 2012). Geographical databases provide a foundation for the planning and implementation of development which is sustainable in environmental and social terms. Modern planning methodologies require multi-sectoral analyses and these in turn require a broad and up-to-date database. Improving the quality of information supplied to planners, policy and decision makers will improve quality of planning and implementation of development oriented activities (Harsono 1996). The planning and implementation of appropriate use of land has to be based on correct assessment of current, potential and future land use, and in combination with the above mentioned urgency of land use planning efforts on a digital approach with information system.
There are two aspects of land use change. The first relates to spatial character. A spatial land use can be a change in size to be smaller, bigger, change its area, etc. The second, it relates to temporal character. In temporal character, a change can be change in land use type, for example changing from garden to resident. Sometimes the change of land use will occur both in spatial and in temporal at the same time. These phenomena called spatio-temporal.

Inspired by the closed relationships between temporal and spatial phenomena there has recently been an increased interest in designing spatio-temporal data models and spatio-temporal databases that deal with geometries changing over time. Database is one of the most important parts of any geospatial information systems. This is especially for spatio-temporal GIS in which spatial and/or spatial information changes over time (Nadi et al. 2003). Progress in the Land Use and Land Cover Change Modeling community has led to the development of variety of land use models that explicitly incorporate a number of essential aspects of complexity of land use change, such as interrelation of spatial and temporal dynamics, land use history and scale dependence of land use change (Wassenaar et al. 2007).

Currently, people may store land use data in a particular format, such shape format where each file represent a particular time land use. So far, existing spatial land use data has not been sufficient temporal information and land use evolution. For example, an evolution of an object that turn into a desert due to forest fires or flooding. In fact, a forest change conducts many processes and takes a time to change of one object to another object. In this study the data is taken from year 2000, 2005, and 2009, of the land use in the Central Kalimantan. The data contains attribute of land use. This information is still insufficiency to store spatiotemporal information to be used in an analysis of its geographical phenomena and a recent model could not handle directly the relation between one database to a new one. Hence one type of object change to another object could not be exactly seen as what the original object is. This research of spatiotemporal will use a real data model in a form of polygon and will display the changing of land use. The evolution of polygon data process will represent in several processes.
such as expand, contraction, split, union, appear and disappear. Therefore we need a model which can solve this problem.

So that it is important to develop a spatial-temporal database that could store land use land cover change into database and testing its system by using query such as no change area, attribute change, expand, shrink, born and die query of land use change and others.

1.2 Objective

The objectives of this study are:

1. To develop a database spatial temporal with the land use data of the Central Kalimantan.

2. To test the ArcGIS and PostGIS systems by using simple query and spatial relational query.

1.3 Scope of Study

1. Scope of study is focus on the evolution of land use in the Central Kalimantan Province with the data year 2000, 2005, and 2009.

2. The query using in this systems are contains six queries v.i.z. no changes, land cover change, expand, shrink, born and die queries.

1.4 Benefit of Study

1. After implementing the development of spatiotemporal database in the land use data, this model show that which the processing of the land use spatial temporal database in ArcGIS or PostGIS will perform faster and easier.

2. Spatial temporal database can show the result by using application software of geography information systems to present the map and location of the evolution.
CHAPTER II
LITERATURE REVIEW

2.1 Land Use

The terms of land use and land cover is different, even though these mixed each other. Land use represents the human use of land, for example, small scale agriculture, grazing, wildlife reserves or industrial zone. Land cover represents the biophysical cover, for example, savanna, broadleaf forest, tea or built up area. Land use change is the use of particular land is changed from one to another over time, such as from natural vegetation / forest to cultivation: cultivation to grazing from swamp to cultivation (Briassoulis 2000). In this study the term of land use/land cover will be noted as land use.

2.2 Land Use Change

The land use change data can be generated through remote sensing. In a study land use change, it is first necessary to conceptualize the meaning of change to detect it in real world situation. Land use cover change means quantitative changes in areal extent (increases or decreases) of a given type of land use of land cover, at a very elementary level. Various studies of land use and land use change are not adopted usually similar definitions. The definition and the descriptions of these terms vary depending on the aim and the framework of a study. It is, consequently, essential to report some alternative definitions of land use (Briassoulis 2000). There are some definitions of land use as follows:

Land use involves both the manner in which biophysical attributes of the land are manipulated and the intent underlying that manipulation. The purpose for which the land is used (Turner et al 1995, Meyer 1995). Land use concerns the function of purpose for which a land is used by local human population and can be defined as human activities which are directly related to land, making use of its resources or having an impact on them (FAO 1995).

Land use change is the result of interaction of the natural environment and human society, and it is also an important manifestation of ecological
environment changes of the earth's surface (Zhou et al. 2012). Land use change not only has an important impact on regional biodiversity, actual and potential primary productivity, soil quality, river runoff and sedimentation rate, but also is one of the main driving forces of global and regional climate change (Ren et al. 2011).

2.3 Spatial Temporal Change

Change happened to spatial features different one from another; a spatiotemporal process corresponding to each change (Ping 2008). Characteristic features of the entire object they are spatial entities changing over time and that these changes are continuous. Changes refer to the motion, shrinking, growing, shape transformation, splitting, merging, disappearing, or reappearing of spatio-temporal objects. In particular, the capability of incorporating continuous change spatial objects over time belongs to the most challenging requirements of spatio-temporal data modeling (Erwig 2002). However this is a too simplistic view in a spatial context. Spatial objects may also split into two or more objects, and two or more objects may also be merged into a single one. There are different kinds of changes existed in the real world. Current spatiotemporal data models are usually short in supporting different types of changes completely. This is mainly because of the insufficient cognition to the real world (Jin and Yue 2005).

Thus, the spatiotemporal change of an object now could be any one among the following:

2.3.1 Type of change

Many research works can be found in some literatures which deals with how to design a spatio-temporal database Koeppel and Ahlmer (1993) divide temporal databases into two categories: attribute-oriented spatio-temporal databases, where changes in information about spatial entities; topology-oriented spatio-temporal databases that changes in positional information about features and their spatial relationships. Roshannejad and Kainz(1993) define databases according to the nature of the changes. Figure 1 shows metrics which show how the topology and attributes of a geographic object may or may not change over time (Abraham and Roddick 1998). This norm compares some any model if they are able to deal with changes in shape and size of the objects. Models are also evaluated whether a
change in the description of a spatio-temporal object that be combined with a synchronous representation of the change of an object’s position. Consequently, the morphology, topology and attributes of a spatio-temporal object may or may not change over time, allowing for eight different scenarios.

![Diagram of eight possible types of change of a spatio-temporal object](image)

Figure 1 The eight possible types of change of a spatio-temporal object (Roshannejad and Kainz 1995)

In various types of changing spatiotemporal there are only some changes will apply to this research such as change in geometry, change in attribute, and no change. Change in geometry is changing the shape, length, width and area of land use change. Change in attribute is a changing of type of land use, the changing from one object to another object. If there are no geometry change neither attribute change or topology change so this called no change of land use.

This norm further considers whether a model supports spatiotemporal real world objects that change continuously or just objects that are subject to discrete changes. An additional emerging criterion that further categorizes existing approaches that follow the continuous paradigm is whether the latter can deal with the movement of the spatial objects over time. This is an extra decisive factor that differentiates models that support changes upon the position and/or the extent of objects in the unified space-time continuum (Roshannejad and Kainz 1995).
2.3.2 Changing Process

According to Ping (2008), spatial data formats can be either vector or raster. Vector data model displaying and storing spatial data using points, lines or polygons and their attributes. Raster data model displaying and storing spatial data by using a matrix or pixels structure with grid. Geographic objects with a data line and polygons can experience a variety of processes in its evolution due to the existence of an object. The processes are:

1. **No change**: the object is stable. The initial and the last state of land use contains the same geometry and attribute.

2. **Attribute change**: The object changes to be others objects for example, changing from rubber plantation to village.

3. **Expand**: there exists two situations, a common phenomenon that aspatial-temporal object enlarges or longer it size due to a lot of reasons.

4. **Shrink**: Object decrease its space that occupied in the geo-spatial way, the size change to be smaller or shorter.

5. **Die**: the process is regarded as a termination of a spatio-temporal object, The Die process can be described in such a way, the identity of the object has change into another or the geometry has vanished, the process is a creation of the new objects, leading to the contrary process of Born.

6. **Born**: for each spatio-temporal object, the creation is the most and the very beginning step during its life circle, it is an opposite process of Die, means that a newly objects exist after a death of others, also has many instances.

However, the geographic object with the data type is polygon with the process appearance and disappearance in evolution process.

2.3.3 Spatiotemporal evolution sequence

Earlier version used to represent an object that makes up a state. The process is an object action taken during or after the event occurred on the object. There are three main classes of basic spatio temporal processes as the illustration in Figure
- Evolution of a single entity represents basic changes (appearance, disappearance, etc) transformation and movements of that entity.
- Functional relationships involve spatiotemporal processes between several entities (replacement, diffusion, etc).
- Evolution of spatial structures describes spatiotemporal processes involving several land-based entities (union, split, etc).

Figure 2 The land use example of evolution sequence result (Janetos 2004)

In a changing object, each kind of spatio-temporal object is composed of one or more types of spatio-temporal elements.

2.3.4 Spatiotemporal Process

As we know that the changing of some object in geographic will occur others object. Event causes the object turns into another version even be another object. An event also led to one or more processes on a geographic object. Figure 3 is a spatiotemporal process.
The definition of symbols use in Figure 3 of an example of spatiotemporal process as follows: A and B are objects, Vi is initial event, Vj is a second event, V1 is the changing object, Null is a fulfill requirement.

In a changing object, each kind of spatiotemporal object is composed of one or more types of spatiotemporal elements. We may take Figure 3 as an example. Figure 3 has an object A and B at t1. Because of an event occurring both object is merge at t2, object B merge with A and become A with new version and B disappear. The below one is object A and B are merge become C at t2. Because of an event object A and B merge to new object.

Figure 3 An example of Spatiotemporal Processes (Wang et al. 2005)
2.4 Spatiotemporal Data

Spatio-temporal data model includes spatio and temporal data. The core question is how to integrate the spatial dimension and temporal dimension effectively. There are two solutions: first, extend the temporal dimension based on space data model; second, extend the space dimension based on temporal dimension. Space data model may mainly divide into vector data model and raster data model. So, that adding time dimension of the model is what we combine of data temporal to vector-based data model or raster-based data model (Jiong and Cunjin 2009). Then, space data model may divide into position-based (raster) spatio-temporal model, object-based (vector) spatio-temporal model and time-based (event) spatio-temporal model (Erwig 2002).

Spatial-temporal data is records of spatial data changes in a period of time. It is a process complex phenomenon at the interaction between time and space (Peuquet 1994; Lee 2005). Spatial-temporal data is increased with time, so we can called “time-sequence object” for every spatial-temporal data. The length of time sequence is time state, and there are some specific events occurred during time sequence (Langran 1988).

Spatiotemporal data is a part of the geographic movement. Geographic information contains space information, attribute information, and time information. Space describes location, and shape. Attribute describes type of feature, name and other information related to geographic. Time describes behavior of changing, and to know the period of changes whether change is continuous, cyclical or intermittent. However, time is always changing. So, it is related to all components in the geographic movement. It means space and attribute is related to time (Rahim 2006).

Therefore there are two approaches to spatiotemporal data models: one from a temporal data model and the other from a spatial data model. Thus, spatiotemporal data is spatial data has a temporal element whereas spatial data is a data that have co-reference in which data various data attributes are located in different spatial units. When a space change with time, then the spatial data will be transformed into spatial data has atemporal element (Seo et al. 2011).
2.4.1 Spatiotemporal Database

Database systems in generally non-temporal which only store the current data (Date et al. 2003). Information about objects’ attributes and relationships among objects are valid when the object exits temporally (Sozer 2010). Temporal information is generally stored in databases in two forms. The first, the valid time is the time when the information about an object or relationship holds in the modeled reality. Second, the transaction time of a database entry is the time when the entry becomes a part of the current state of the database. The time when the ferry lines’ times are stored in the database is the transaction time of the entry. The valid time and transaction time database is a database with bitemporal table (Gunting and Scheneider 2001).

Currently most spatio-temporal database store the results of geographical change without take the reason of change into account. For instance, a land-use dynamic monitoring system, only records the original state and the latest state of objects. The reasons for the change are not in consideration. However, in cadastral management system, the land legitimacy proof are required, while the proof is an thematic information (Ping 2008).

Spatial database concerns the storing of data in relation to space. It offers spatial data types and stores information relating to geometric or geographical space. Thus, a spatial database stores a collection of space related data. Temporal database stores data relating to time instances. It offers temporal data types and stores information relating to past, present and future time. Thus, a temporal database stores a collection of time related data. The difference between temporal data and non-temporal data is that a time period is appended to data expressing when it was valid or stored in the database (Jaymin 2003).

Temporal databases are designed to store historical data (the past) as well as present and possible future data (Claramuntet al. 1999). In temporal databases, there are terms NOW and UC (Until Change). NOW is the time used for valid time end if the data is still valid in the real world to date, while UC (Until Change) is the value of the transaction-time end of the sign if the data in the tuple is still valid or correct. On the temporal development, a database can be drawn from the data all the time. Therefore, the spatiotemporal database not only stores the
current state of spatial data but also save the entire history of the development of spatial data (Gunting and Schneider 2001).

Transaction / Valid time: There are two different clauses that a model utilizes to associate time with spatial changes-processes. The transaction time (or registration time) indicates the time an event is actually recorded in the database. The valid time (or real-world time) describes the time that an event actually happened in the real world. A spatio-temporal model that supports both transaction and valid time is said to maintain bitemporal time (Kakoudakis 1996).

A spatiotemporal database is a system that manages both space and time information. Spatiotemporal databases are a generalization of spatial databases, which include features of variation coordinates in space (Kamaraj 2011). Temporal aspects have been the focus of attention in the literature, and applications often require that time information to be stored in the database.

Spatiotemporal databases deal with geometry changes over the time. It must consider how to store the changes of spatial data. Traditional relational database technology is not suitable for managing spatiotemporal data, which are multidimensional with complex structure and behaviour (Wang et al. 2000; Rahim 2006).

2.4.2 Designing spatio-temporal databases

Traditional database systems retain only the latest state of the modeled system, which presents a static view of the environment. The representation of time, the selection of appropriate temporal granularity, and level at which temporality should be introduced, and temporal reasoning are the basic issues in designing spatio-temporal databases.

There are a lot of tools of developing of spatiotemporal database. Table 1 shows that different geography database will use different RDBMS technologies. The technologies which are used in this research are commercial database and public database include PostgreSQL for RDBMS technology.
Table 1 Geodatabase management systems (David and Michel 2008).

<table>
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<th>Licensing</th>
<th>RDBMS technology</th>
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<td></td>
<td>Enterprise</td>
<td>SQL Server, PostgreSQL</td>
<td>- Support for versioning</td>
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<td></td>
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<td>- Supports spatial types</td>
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<tr>
<td>Workgroup</td>
<td>ArcGIS Server</td>
<td>SQL Server Express</td>
<td>- Support for versioning</td>
</tr>
<tr>
<td></td>
<td>Workgroup</td>
<td></td>
<td>- Maximum of 4 GB of data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 10 Concurrent users</td>
</tr>
<tr>
<td>Desktop</td>
<td>ArcGIS Desktop</td>
<td>SQL Server Express</td>
<td>- Support for versioning</td>
</tr>
<tr>
<td></td>
<td>ArcGIS Engine</td>
<td></td>
<td>- Maximum of 4 GB of data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 4 Concurrent connections</td>
</tr>
<tr>
<td>File</td>
<td>ArcInfo, ArcEditor, ArcView</td>
<td>No RDBMS – uses local file structure</td>
<td>- No versioning support</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 1 TB per table size limit (default)</td>
</tr>
<tr>
<td>Personal</td>
<td>ArcInfo, ArcEditor, ArcView</td>
<td>Microsoft Access (Jet Engine)</td>
<td>- No versioning support</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Maximum of 2 GB of data</td>
</tr>
</tbody>
</table>

In a spatio-temporal database management system, a time can be categorized into valid time and transaction time. Valid time or real-world time represents the time at which a change took place. Transaction or database time denotes the instant at which this was registered in the database. User-defined time means an attribute especially allocated by the user. A spatiotemporal database should be designed in such a way that it can handle alternative timelines, for example continuous, cyclic, branching, and terminating time in the GIS data model.

2.4.3 Step of Designing Database

The process of database design is divided into different parts. It consists of a series of steps (Simison et al. 2005). They are as follows:

2.4.3.1 Conceptual Design

This phase involves two parallel activities: a conceptual schema design and a transaction and application design. The first activity examines a data requirement and produces a conceptual schema. The conceptual schema is a concise description of a data requirement of a user and includes detailed descriptions of
the entity types, relationships, and constraints. It is usually a DBMS independent high-level data model. Because these concepts do not include implementation details, they are usually easier to understand and can be used to communicate with non-technical users. It can also be used as a reference to ensure that all users’ data requirements are met and that the requirements do not include conflicts. The second activity examines the database applications analyzed in phase one and produces high-level specifications for these applications. At this stage the designer specifies the functional characteristics of the transactions. To ensure that the database schema will include all the information required by the transactions.

The objective of conceptual planning is to generate conceptual scheme for database without specific DBMS. There are six relational in design database to explain the changing have occurred that is based map, spatial info, version, process, event, user. Some object has an initial value and it can evolution to be a new version or to be a new object because of some events. An event will operate various processes during it evolution such as expansion, contraction, union, split, appearance and disappearance.

2.4.3.2 Logical Design

Logical planning is a phase for mapping conceptual model to database model (relational model, hierarchy model, or network model) in the development of spatiotemporal database.

A logical entity-relationship model is provable in the mathematics of data science. Given the current predominance of relational databases, logical models generally conform to relational theory. Thus a logical model contains only fully normalized entities. Some of these may represent logical domains rather than potential physical tables. Where a logical data model has to be normalized, it must include the full population of attributes to be implemented and those attributes must be defined in terms of their domains or logical data types (e.g., character, number, date, picture, etc.). A logical data model requires a complete scheme of identifiers or candidate keys for unique identification of each occurrence in every entity. Since there are choices of identifiers for many entities, the logical
model indicates the current selection of identity. Propagation of identifiers as foreign keys may be explicit or implied.

2.4.3.3 Physical or Implementation Design

Physical design is concerned with the location of different parts of the database within the file system of computer. This may include considerations such as spreading the database across multiple disk drives to balance input/output load for security in the event of disk media failure. Physical design is the responsibility of database administrator and should be quite distinct from logical design, which represents the user’s view of the interrelationships between data as stored in its database. If physical and logical design are kept separate, users can access their data sets without having to concern themselves with details about where and how those data sets are physically stored (Erwig 2002).

In the last step is physical design phase, during which the internal storage structure, access paths, and file organizations for the database files are specified. For a given conceptual schema, there are many physical design alternatives in a given DBMS. Once a specific DBMS is chosen, the physical database design process is restricted to choosing the most appropriate structures for the database file from among the options offered by the DBMS.

2.5 Query and Analysis

Query support is one of the most important functions of an information system. The evaluation of a query is greatly influenced by the query type according to which an information system handles the query and by storage structures and indexes available to the information system (Tsotras et al. 1998). Furthermore, the identification of query types has profound implications for the design of spatiotemporal information systems and spatiotemporal information processing and mining because of the following three reasons. First, query types reflect the kind of information that the user would like to obtain. An information system must have the ability to represent the things of interest to answer questions about them. Second, query types reflect information structures in which the user is likely to pose questions and comprehend information returned by the information
system. Therefore, query types can provide guidelines for query language and interface design. The third reason relates to information retrieval. Data indexing structures should be in concert with query types (Yuan 2002).

2.5.1 Software Environments

There are three software uses in this study to support development of database and query processes vi-z PostGIS, Quantum GIS, and ArcGIS. May input spatial data is initially development in shapefile format data. a shape file spatial data is a non-topological spatial data that has simple structure data.

A shapefile is composed of three main files that contain spatial and attribute data. A shapefile can optionally have other files with index information. In the catalog, all these files that comprise a shapefile appear as one feature class (Zeiler 1999).

A. PostgreSQL is an open source object relational database system which has the most powerful function and the most plenty attribute. It supports almost all SQL standards and has all kinds of native programming interfaces to satisfy all development demand (Peng 2001). PostgreSQL provides PostGIS module to supports all types in OGC simple features specification and allows the database to store and operate GIS object.

B. Quantum GIS (QGIS) is a geography system which supports vector, raster and database for formats. QGIS also can runs on many operating system platforms. For example, Linux, UNIX, Mac OSX, Windows and Android (Official site, http://www.qgis.org).

C. ArcGIS provides a scalable framework for implementing GIS for a single user or many users on desktops, on servers for use in the enterprise and across the Web, and in the field. ArcGIS is an integrated family of GIS software products for building a complete GIS (ESRI).
CHAPTER III
METHODOLOGY

3.1 Time and Location

Central Kalimantan (Indonesian: Kalimantan Tengah often abbreviated to Kalteng) is a province of Indonesia, one of four in Kalimantan. The Indonesia part of the island of Borneo. Its provincial capital is Palangkaraya. The Central Kalimantan is the 3rd largest Indonesian province by area with a size of 153,800 km², about 1.5 times the size of the island of Java, which located on Latitude: 1°25′57″S, Longitude: 113°17′42″E. It is bordered by West and East Kalimantan provinces to the north, by the Java Sea to the south, by South and East Kalimantan provinces to the east, and by the West Kalimantan province to west.

The research is conducted at the Laboratory of Software Engineering and Information Sciences (SEIS). The research starts from January until November 2012.

Figure 4 Location of the Central Kalimantan Province
3.2 Materials

3.2.1 Data and Characteristic

The data used in the development of spatio-temporal data model is the land use data in the Central Kalimantan, Indonesia. The data from 2000, 2005, and 2009, the data take from The Roundtable on Sustainable Palm Oil Green House Gas – Working Group 3 (RSPO GHG-WS3). The land use data of Central Kalimantan contains differences characteristic of polygons, the data on 2000 contains 3140 polygons, 2005 contains 3123 polygons, and 2009 contains 3345 polygons.

3.2.2 System Environments

The specifications of software and hardware are using in the processes as follows.


Hardware: Acer Aspire one 722, CPU AMD Dual-Core Processor C60 with Turbo CORE Technology up to 1.333 GHz, Memory 2 GB DDR3 memory, Storage 320 GB HDD, monitor, keyboard and mouse.

3.3 Method

Procedures of development research in spatio-temporal data model same as the development of general database. The procedures can be seen in Figure 4 which shows the flow diagram in the development of land use spatial temporal database. The procedures of this thesis are start with study pre-processing data. This step is requires for selecting and cleaning data. After the data is completed, the cleaning starts to database development. The database development steps are conceptual design model, logical design model, physical design or implementation, and finally, analysis result with query. Further explanations of each of these steps are describes Figure 5:
3.3.1 Pre-processing data

Pre-processing data is used to clean unwanted and unmanagerial data. Steps of pre-process performed on all data used. The steps of pre-process as follows:

1. Data selection: These stages of process will perform the evolution of land use data in Central Kalimantan province in a year 2000, 2005, and 2009. In these data, performing only implements to data field required to speed up the processing of data.

2. Data cleansing: the field requires are id, year, and type of data.

3. Management system projection: In management system projection data the system is required to set up the geographic coordinate systems to get a correct position of the data with proper coordinate.
4. Geometry check and correction

Geometrical check and correction are conducted for unifying in geometry dataset after set up the geometry coordinate. When there is some warning occurs, the systems have to repairing the geometries.

5. Dissolve data

Dissolve is an aggregate feature based on specified attribute. Dissolve can create very large features in the output feature class. This is especially true when there is a small number of unique values in the Dissolve Field or when dissolving features into a single feature. The process of development spatiotemporal database as show in Figure 6.

![Figure 6 Process of creation for spatiotemporal database](image)

Figure 6 Process of creation for spatiotemporal database

The above Figure 6 is showing the process of creating spatiotemporal database which the steps is start getting the data from The Roundtable on Sustainable Palm Oil Green House Gas – Working Group 3 (RSPO GHG-WS3). Then import the data into ArcGIS and PostgreSQL software to query. Finally, display the result by using QuantumGIS software.

3.3.2 Conceptual Design

Here, a designer starts from an external view of the problem and provides a set of classes (or an equivalent E-R model). These classes encapsulate abstractions such as geometry, attributes and their changes. The purpose of this phase is to produce a conceptual schema for the database that is not dependent on a specific database management system. The use of high-level data models such as ER is often used in this stage. This conceptual scheme carries some details of database
applications and transactions that are known. There are two activities in the conceptual design of a database as follows

### 3.3.2.1 Designing conceptual schema

At this stage the activities carried out: checking on the needs of users for the data. The goal of design process is to bring together an understanding of the conceptual schema in database structure, semantic understanding, connectedness and their limits; this can be one creating a conceptual database schema using the data model ER irrespective of database management systems. There are two approaches to designing a conceptual schema:

- **Centralized**
  The needs of the application or user groups of different combined into a set of user needs and then designed into a conceptual schema.

- **The integration**
  The integration of the views that exist for each application or user groups are differently designed an external schema then view is incorporated into a conceptual schema.

### 3.3.2.2 Transaction

The characteristic of transactions planning that will be implemented irrespective of the chosen DBMS. These transactions are used to manipulate the database when implemented. At this stage will identified the inputs, outputs and functional. These transactions include: retrieval, update, delete, select and etc.

### 3.3.3 Logical Design

Logical database design (data model transformation). The transformation of the conceptual schema and external to the data model database management system chosen, there are two processes, namely:

- **Transformation is not dependent on the system, at this stage of transformation does not consider the specific characteristics or specific things that will be applied to the database management system.**

- **Adjustment of the scheme to a specific database management system, in doing an adjustment scheme resulting from phase 1 to be confirmed in the form of a specific implementation of a data model as used by the chosen database management system.**
3.3.4 Physical Design and Implementation

3.3.4.1 Physical Design

The process of selecting the specific storage structures and access database files to achieve the best performance in a variety of applications. Criteria for selection of physical design:

- Response time. When a database transaction during the execution of a response.
- The use of storage space. Amount of storage space used by the file and database structures access path.

The breakthrough that made the transaction file (Transaction throughput) is the average value of transactions that can be processed per minute by the database system and a critical parameter of the transaction systems. If the response time of the database does not achieve the optimization, the physical design stage can be done normalization. Normalization is process performed on a database that has been normalized, by modifying the structure of the table and ignore controlling data to improve database performance. Normalization process including: Combining separate tables to join and replicate / duplicate data in table.

3.3.4.2 Implementation

Implementation of land use spatio-temporal database into two systems, the first is the implementation with ArcGIS. In ArcGIS system, and the second is in PostGIS.

3.3.5 Query and Example of Analysis

This section classifies existing spatial temporal database models in terms of their query capabilities. An object analysis is performing by using query. Here are six simple categories of query statement.

- Which object is never change
- Which object is attribute change
- Which object is expand
- Which object is shrink
- Which object is die
- Which object is born
CHAPTER IV

RESULTS AND DISCUSSION

The results are presented in the five sections as follow:

4.1 Pre-processing Data

In the pre-processing section the data which has been dissolve will use in the whole query of this research. All the preprocessing process is used ArcMap application in management the raw data. The steps of preprocessing as follows:

4.1.1 Data selection

These stages of process perform the data of land use evolution in Central Kalimantan province only. The data was contain several years in one shapefile format such as the data year 2000, 2005, and 2009. So the data need to divide into small data like a data year 2000, 2005 and 2005 to be one shapefile format each. These each shapefile data will perform data field required to speed up the processing of data.

4.1.2 Data Clean

Clean data is to clean any data which will not use and unimportance in the geometry of land use spatiotemporal. The original data of Central Kalimantan was contain various data which not importance to the system such as the symbol of data, soil type, mix data year 2000-2005 and 2005-2009. The field requires are id, year, geometry, and type of data to use in this research. So need to clean and taken the data to use in this study only.

Table 2 The data before cleaning

<table>
<thead>
<tr>
<th>id</th>
<th>layer character</th>
<th>object_1</th>
<th>lid_lc_kal</th>
<th>objected integer</th>
<th>z000</th>
<th>z005</th>
<th>z000_z005</th>
<th>z009</th>
<th>z005_z009</th>
</tr>
</thead>
<tbody>
<tr>
<td>899</td>
<td>unknown area</td>
<td>15405</td>
<td>11981</td>
<td>SMB</td>
<td>SMB</td>
<td>SMB</td>
<td>SMB_SMB</td>
<td>SMB</td>
<td>SMB_SMB</td>
</tr>
<tr>
<td>900</td>
<td>unknown area</td>
<td>15405</td>
<td>11981</td>
<td>SMB</td>
<td>SMB</td>
<td>SMB</td>
<td>SMB_SMB</td>
<td>SMB</td>
<td>SMB_SMB</td>
</tr>
<tr>
<td>901</td>
<td>unknown area</td>
<td>15488</td>
<td>12064</td>
<td>SMB</td>
<td>SMB</td>
<td>SMB</td>
<td>SMB_SMB</td>
<td>SMB</td>
<td>SMB_SMB</td>
</tr>
<tr>
<td>903</td>
<td>unknown area</td>
<td>15540</td>
<td>12116</td>
<td>Br</td>
<td>Br</td>
<td>Br</td>
<td>Br_Br</td>
<td>Br</td>
<td>Br_Br</td>
</tr>
<tr>
<td>903</td>
<td>unknown area</td>
<td>15540</td>
<td>12116</td>
<td>Br</td>
<td>Br</td>
<td>Br</td>
<td>Br_Br</td>
<td>Br</td>
<td>Br_Br</td>
</tr>
</tbody>
</table>
Table 3 The data year 2000, 2005, and 2009 after data cleaning

<table>
<thead>
<tr>
<th>gid (PK)</th>
<th>Fid_lc_kal</th>
<th>Z000</th>
<th>var</th>
</tr>
</thead>
<tbody>
<tr>
<td>serial</td>
<td>integer</td>
<td>character</td>
<td>var</td>
</tr>
<tr>
<td>1</td>
<td>15405</td>
<td>SMB</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>15405</td>
<td>SMB</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>15488</td>
<td>SMB</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>15538</td>
<td>SMB</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>15540</td>
<td>Br</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>15635</td>
<td>Br</td>
<td></td>
</tr>
</tbody>
</table>

4.1.3 Management System Projection

In management system projection process the raw data of Central Kalimantan will open with ArcMap to manage the coordinate system. The original data may contains the error or incorrect coordinate. In projection system will set the coordinate of the data. If there is any error in coordinate the system will make a correction as the explanation in 4.1.4.

4.1.4 Geometry check and correction

Geometry check and correction conducted to make a geometry coordinate checking and repairing the error in the geometry dataset, if there is some warning occurs; the systems have to repairing the geometries. As the following illustration:-

Use ArcToolbox → Data Management Tools → Features → Check Geometry
Choose appropriate input features and click OK. From panel Result at the ArcToolbox window there are 7 Warning.

To fix the error, use a standard ArcToolbox → Data Management Tools → Features → Repair Geometry.

Repairing process is shown by the progress bar as below.

The result of projection set up and repair are saved.

4.1.5 Dissolve data

4.1.5.1 Dissolve

The process of getting dissolve data is started from import the original file of Central Kalimantan shape file which has been repairing the error of coordinate in the previous step into ArcMap system. The data of Central Kalimantan contains a
large data which include several years. In this step to gain the land cover map have to make a dissolve based on the year of the data.

Figure 7 The importing data to dissolve

In the figure above, every types of each type of land cover is marked with a different color. Show the features with ObjectId = 12 503 consists of several scattered polygons, however stay side by side with other features that have the same type of land cover (H2r).

To get a map of land cover based on the year then conducted fusion using facilities ArcToolbox → Data Management Tools → Generalization → Dissolve. Select one column Z000, Z005 or Z009 to get the land cover at the mention year. Set also the Create Multipart Features option OFF.

Figure 8 The result after dissolve the data
There are eight data to be dissolved in two differences system, five dissolve data using in ArcGIS system which the data year 2000, 2005, 2009, 2000 to 2005, and 2005 to 2009, and there are three dissolve data using the PostGIS system which the data year 2000, 2005, and 2009.

4.1.5.2 Managing data in ArcGIS and PostGIS

Developing spatiotemporal database management, the land use need to record and manage the land use change information, type of changing, and year. This research chooses the object relational database PostgreSQL as the base database. PostGIS and ArcGIS is a desktop software to make a comparison of the query and analysis the result of each query system.


4.1.5.3 The development system

In PostGIS, before importing the shape file format into PostgreSQL, first the developer have to create database, the database automatically creates two tables: geometry_columns and spatial_res_sys which respectively record the space field information and project system information. Then add the land use table years 2000, 2005, and 2009 into the database. In database there are many basic tables and need query the information of some filed at some time. Firstly confirm which year it belong to in order to confirm which basic table we will use, then query the changing information based on the basic table and finally get the query result of land use changing.

In ArcGIS, the dissolve data directly import to the system, before query the changing of land use with ArcGIS, the dissolve data have to overlay between two years of data.
4.2 Conceptual Design

In the conceptual planning will checking on the needs of users of the data, in which the goal of the design process is bring together an understanding of the conceptual schema in the database structure, connectedness and their limits, by creating a conceptual database schema with use the data model ER irrespective of database management systems as shown in Figure 7.

Figure 8 The entity relationship between land use data and attribute

In Figure 8 the explanation of entity relationship contains attribute and land use data. Attribute entity have several attribute the first is code which refer to the name of each land use for example H2, SMB and so on. Id as primary key and Remarks is a description of land use name. There are three years of land use data and each year contains its own geometry.

4.3 Logical Design

In the section of logical design contains transformation and adjustment. The system is not dependent transformation to database management system and adjustment scheme result to be confirm in the form of specific implementation of a data model which database management system are chosen.
4.4 Physical Design

In a section of physical planning the data which has been dissolve are stored into database. This research, data are stored in PostgreSQL and only PostGIS systems interacts with this database management system. In ArcGIS the system saves all data or information into shapefile format. Both systems have each relationship as shown in Table 2.

Table 4 List of tables land use 2000 and its characteristics

<table>
<thead>
<tr>
<th>Table</th>
<th>Type</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>lc_2000</td>
<td>Gid</td>
<td>Integer</td>
</tr>
<tr>
<td></td>
<td>Z000</td>
<td>Varchar</td>
</tr>
<tr>
<td></td>
<td>Geom</td>
<td>Geometry</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table</th>
<th>Type</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>lc_2005</td>
<td>Gid</td>
<td>Integer</td>
</tr>
<tr>
<td></td>
<td>Z005</td>
<td>Varchar</td>
</tr>
<tr>
<td></td>
<td>Geom</td>
<td>Geometry</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table</th>
<th>Type</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>lc_2009</td>
<td>Gid</td>
<td>Integer</td>
</tr>
<tr>
<td></td>
<td>Z009</td>
<td>Varchar</td>
</tr>
<tr>
<td></td>
<td>Geom</td>
<td>Geometry</td>
</tr>
</tbody>
</table>

Table 2 shows that in query of spatial temporal database land use table takes information in attribute table. The relation is Z000, Z005, and Z009 of land use with the code in table attribute.

4.5 Database

The result of data of land use and its details during database developments can be seen in Table 3.

Table 5 The Data File in ArcGIS and PostGIS

<table>
<thead>
<tr>
<th>No.</th>
<th>Application</th>
<th>Data</th>
<th>File type</th>
<th>Size (kb)</th>
<th>Character of data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ArcGIS</td>
<td>Landuse 2000</td>
<td>.shp</td>
<td>7756</td>
<td>Polygon</td>
</tr>
<tr>
<td>2</td>
<td>ArcGIS</td>
<td>Landuse 2005</td>
<td>.shp</td>
<td>7750</td>
<td>Polygon</td>
</tr>
<tr>
<td>3</td>
<td>ArcGIS</td>
<td>Landuse 2009</td>
<td>.shp</td>
<td>7928</td>
<td>Polygon</td>
</tr>
</tbody>
</table>
The development of database spatiotemporal by using ArcGIS and PostGIS has to realize the characteristic of data in each system.

a.) ArcGIS

ArcGIS is desktop application which not requires the data to save in the database management system. In the detection of land cover change in ArcGIS systems is required to make an intersection. In ArcGIS, there are five databases which save in shapefile format. The databases are year 2000, 2005, 2009, 2000-2005, and 2005-2009, the database year2000-2005, and 2005-2009 is the result of intersection. Then result of an intersection will import to ArcGIS systems for query to see the land use change and to analysis the changing of each year.

b.) PostGIS

In PostGIS, there are only three data will import to the PostgreSQL database, the original data is also shapefile format of the year 2000, 2005, and 2009 after importing to PostgreSQL database the shapefile format automatically will change its file to be postgis object file. PostGIS database, the data have a various types file format such as .backup file, tar.qz file, and .sql file. PostGIS need to connect with the database as initial state to query. The management of spatial database is in Postgresql/PostGIS via QuantumGIS.

Firstly, create new database’s name in Postgresql, then make a connection in QGIS to connect with Postgresql database. In QGIS, after making a connection will import the shapefile data year 2000, 2005, and 2009 to store in Postgresql database. Finally, make a query in QGIS and initialize the result of query.
The difference of ArcGIS and PostGIS database is different in process of storing the data, number of database and database size.

4.6 Query and Analysis

In a query of an object analysis is performing by using six queries. The observation is conducted in three processes as follows.

Observation Process

1. Query Process
2. Time
   a. Preprocessing
   b. Execution
   c. Visualization
3. Flexibility

4.6.1 Query Process

This section classifies existing spatial temporal database models in terms of their query capabilities. Here are six categories of query statement.

1. No Change: It means the object is stable
2. Attribute Change: It means the object change to be other object.
3. Expanding: It means the spatial extent of the feature instances expands (area increases) such as the expansion of the city and the settlement.
4. Shrinking: It means the spatial extent of the feature instances shrinks. For example, the cultivated land shrink because of the expanding of settlement. Roads traverse the settlement and split them into some spatial object.
5. Born: It means new object occur such as new building appear in particular area.
6. Die: It means the original feature instances disappear because of some reasons, for example, the changes of instructed thematic attribute of the feature instances or other feature instances expanding.

a. Queries in ArcGIS

1. Find an area that does not change the attributes of land cover

```sql
SELECT * FROM intersect WHERE "Z000" = "Z005"
```

![No change](image1)

2. Find areas that are changing the attributes of land cover

```sql
SELECT * FROM intersect WHERE "Z000" <> "Z005"
```

![Attribute change](image2)
3. Find the area in 2000 is SMB and in 2005 has change the type of land cover

```
SELECT * FROM intersect WHERE ("Z2000" = 'SMB') AND ("Z2005" <> 'SMB')
```

4. Find the area in 2000 is SMB and in 2005 is Hti

```
SELECT * FROM intersect WHERE ("Z2000" = 'SMB') AND ("Z2005" = 'Hti')
```
b. Queries in PostGIS

Some PostGIS queries can be formed by using the facilities has mention are:

1. Find areas that are no changing of land cover

   ```sql
   ```

   In the first Postgis query returns 2482 rows in 30061 milisecond

2. Find an area that the attributes of land cover change

   ```sql
   ```

   The query returns 53 rows in 8387 milisecond
3. Find the expand area

```
```

The query returns 202 rows in 106889 milisecond

4. Find the area that shrink of land cover

```
```

The query returns 192 rows in 79864 milisecond
Find the disappear of land cover

```
```

Find the new born area

```
```

Both of ArcGIS and PostGIS software process of spatiotemporal database, there are some difference in query as following:

**ArcGIS**

1. Fast in query and execution.
3. In query cannot using join function to combine each table.

**PostGIS**

1. Use less table in database system and save space.
2. Query can use join function.
3. Take a long time in execution.
4.6.2 Time

The initial step of calculating the process in ArcGIS and PostGIS is imported the dissolve data into each system. The comparison of preprocessing in ArcGIS and PostGIS as shown in Table 3.

Table 6 The Comparison Preprocessing

<table>
<thead>
<tr>
<th>Type of Change</th>
<th>Preprocessing</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ArcGIS (Sec.)</td>
<td>PostGIS (Sec.)</td>
</tr>
<tr>
<td>Import ShapeFile</td>
<td>10</td>
<td>104</td>
</tr>
<tr>
<td>Intersection</td>
<td>30</td>
<td>x</td>
</tr>
</tbody>
</table>

In a preprocessing process both systems start to import shapefile format which has been dissolve. In ArcGIS have to run two times preprocess before making a query. In PostGIS only one step process but use takes time longer in importing the shapefile data. After import the data into each systems then start to query as show in Table 4.

Table 7 The Comparison of Execution Time

<table>
<thead>
<tr>
<th>Type of Change</th>
<th>Execution</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ArcGIS (Sec.)</td>
<td>PostGIS (Sec.)</td>
</tr>
<tr>
<td>No Change</td>
<td>36</td>
<td>78</td>
</tr>
<tr>
<td>Attribute Change</td>
<td>35</td>
<td>76.2</td>
</tr>
<tr>
<td>Expand</td>
<td>35</td>
<td>153</td>
</tr>
<tr>
<td>Shrink</td>
<td>33</td>
<td>154.8</td>
</tr>
<tr>
<td>Disappear</td>
<td>x</td>
<td>134.4</td>
</tr>
<tr>
<td>Born</td>
<td>x</td>
<td>138</td>
</tr>
</tbody>
</table>

In execution process, two types of change cannot query in ArcGIS because ArcGIS cannot detect the spatial change. Otherwise PostGIS can query all types of changing. Table 5 shows the time of visualization from each systems.

Table 8 The Comparison of Visualization Time

<table>
<thead>
<tr>
<th>Type of Change</th>
<th>Visualization Time</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ArcGIS (Sec.)</td>
<td>PostGIS (Sec.)</td>
</tr>
<tr>
<td>No Change</td>
<td>2</td>
<td>30.06</td>
</tr>
<tr>
<td>Attribute Change</td>
<td>2</td>
<td>8.38</td>
</tr>
<tr>
<td>Expand</td>
<td>2</td>
<td>1849.90</td>
</tr>
<tr>
<td>Shrink</td>
<td>2</td>
<td>1912.95</td>
</tr>
<tr>
<td>Disappear</td>
<td>x</td>
<td>106.88</td>
</tr>
<tr>
<td>Born</td>
<td>x</td>
<td>79.86</td>
</tr>
</tbody>
</table>
In visualization, in ArcGIS, there are two types of land use cannot queries that are born and die process. In PostGIS Born and Disappear take longer time. Because the query of born and disappear have to run an intersection then grouping the location which contains the changing area, and finally use a having function to check the sum of the area.

### 4.6.3 Flexibility

Flexibility is the ability of a system, such as a manufacturing process, to cost effectively vary its output within a certain range and given timeframe. In terms of working with two GIS query system, it relates to how flexibility working such a query a software that easier in executing a particular command which means the first is more flexible in its system. In this study, the execution command is easier in PostGIS, as the script can be copied and improved easily, however the execution command used in the study was not very complex than the effect was not clearly seen.

The flexibility of the system is when making an intersection in ArcGIS need more space to save a shapefile format has been created and also spends more time in processing but in PostGIS is just keep the original shapefile then import into PostGIS.

In other cases, if there is a new data will update to the system, in ArcGIS the data have to make an intersection with the previous data to compare the changing in each year. After data was intersection then make a query. Otherwise, in PostGIS after the data import to the database system, the system needs only one command in updating query. For example, if a new data need to add the data year 2012, just input the table name and appropriate editing the attribute run processes.
CHAPTER V
CONCLUSION AND SUGGESTION

5.1 Conclusion

This research systematically analyzes the problems existing among the land use spatial temporal data on a traditional system and then proposed a new land use spatial temporal data with the automatically system. The development systems of spatial temporal database with ArcGIS and PostGIS are successfully conducted. These models have respective advantages and disadvantages among them.

The process of getting data is management system projection, geometry checking and dissolve data.

The database of both systems are different is as the number, size, and unit of database. ArcGIS have five data are stored in database and PostGIS have three data are stored in PostgreSQL database management system.

The queries of land use spatiotemporal are changing, stable, shrink, expand, born and die, there have some change cannot be query in ArcGIS. The difference is ArcGIS does not consider the geometry of the polygon so it has not been able to explain the history of land cover in the whole polygon. In PostGIS, it takes too long time in running process of each query but PostGIS can save all the history of changing of land cover.

4. The preprocessing step in ArcGIS takes a longer time do intersection but it make query faster because the intersection function has been taken. Otherwise the processing step in PostGIS takes longer time in execution process because PostGIS has to make an internal computation.

The flexibility of the system is when making an intersection in ArcGIS needed more space to save a shapefile format which has been created and also spends more time in processing but in PostGIS is just keep the original shapefile then import into PostGIS.

5.2 Suggestion

The suggestion for the future work is development the application of spatial temporal database also need perfect the query and index to make the model
truly be applied to application. In addition, we should pay attention on creating database design model.
REFERENCES


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Jiong X, Cunjin X A top-down hierarchical spatio-temporal process description method and its data organization. Center for Earth Observation and Digital Earth, CAS, Beijing, China.


MaroningUseng, the author of this thesis was born on the 27th October 1984 in Narathiwat Province, Thailand. The writer is the fourth son in the family of seven children. In 2004 the writer achieved Senior High School certificate degree from Bamrung Islam School in Thailand. In 2004 he was joined Yala Islamic University under the Faculty of Science and Technology in Information Technology and was graduated with Bachelor of Sciences in 2009. In 2009, the writer was get the opportunity to do a three years (with one year Bahasa Indonesia Language Course) Master of Computer degree in Computer Science at the Faculty Mathematics and Natural Sciences in Bogor Agricultural University, Bogor, Indonesia under developing countries partnership scholarship program offered by the Ministry of National Education, Government Republic of Indonesia.
APPENDIX
<table>
<thead>
<tr>
<th>Kode</th>
<th>Tutupan Lahan</th>
<th>Land Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Br</td>
<td>Semak Belukar Rawa</td>
</tr>
<tr>
<td>2</td>
<td>H1</td>
<td>Hutan Primer</td>
</tr>
<tr>
<td>3</td>
<td>H1r</td>
<td>Hutan Gambut Primer</td>
</tr>
<tr>
<td>4</td>
<td>H2</td>
<td>Hutan Sekunder</td>
</tr>
<tr>
<td>5</td>
<td>H2r</td>
<td>Hutan Gambut Sekunder</td>
</tr>
<tr>
<td>6</td>
<td>Kc</td>
<td>Kebun Campuran</td>
</tr>
<tr>
<td>7</td>
<td>Kr</td>
<td>Kebun Karet</td>
</tr>
<tr>
<td>8</td>
<td>Ks</td>
<td>Perkebunan Kelapa Sawit</td>
</tr>
<tr>
<td>9</td>
<td>Ltg</td>
<td>Lahan Tegalan</td>
</tr>
<tr>
<td>10</td>
<td>Mv</td>
<td>Mangrove</td>
</tr>
<tr>
<td>11</td>
<td>Rp</td>
<td>Alang-alang</td>
</tr>
<tr>
<td>12</td>
<td>Rr</td>
<td>Alang-alang Rawa</td>
</tr>
<tr>
<td>13</td>
<td>SMB</td>
<td>Semak Belukar</td>
</tr>
<tr>
<td>14</td>
<td>Sw</td>
<td>Sawah</td>
</tr>
<tr>
<td>15</td>
<td>X2</td>
<td>Pemukiman</td>
</tr>
<tr>
<td>16</td>
<td>X3</td>
<td>Tubuh Air</td>
</tr>
</tbody>
</table>
### Spatial Relationship

<table>
<thead>
<tr>
<th>No.</th>
<th>Types</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
</table>
| 1   | Equal | - Equal returns t (TRUE) if two geometries of the same type have identical X,Y coordinate values.  
- Geometries are equal if they have matching X,Y coordinates. | ![Example Images] |
| 2   | Contains | - Contains returns t (TRUE) if the second geometry is completely contained by the first geometry. The contains predicate returns the exact opposite result of the within predicate. | ![Example Images] |
| 3   | Intersect | - returns true if geometry A intersects geometry B | ![Example Images] |
| 4   | Within | - Within returns t (TRUE) if the first geometry is completely within the second geometry. Within tests for the exact opposite result of contains. | ![Example Images] |
| 5   | Coverby | - returns 1 (TRUE) if no point in Geometry A is outside Geometry B | ![Example Images] |
| 6   | Area | - returns the area of the geometry if it is a polygon or multi-polygon | ![Example Images] |
|     | Sum | - aggregate to return a sum for a set of records | ![Example Images] |