Web-based Geographic Information System Design of Rabies Spread in Bali

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Article Info	ABSTRACT
	Rabies is still a serious threat in the province of Bali. As a densely populated area, Bali has a high population of dogs due to peculiarities of socio-cultural and bio-geography of Bali where there is a very close interaction between people and pets. The high population of dogs in Bali resulted in high rates of spread of rabies. Nowadays, data management still uses spreadsheet technology that oriented to attribute data. Bali needs a better management system that can process data and information to support the government to make decision for preventing rabies outbreak. Geographic Information System (GIS) is a system that has the ability to process, analysis the process and analysis spatial data or data with geographic coordinates. This article will discuss the implementation of GIS that show the spread of rabies in the province of Bali by using GeoServer as the server to provide geospatial data via web services. This GIS application is supported by PostGIS database as storage and processing of spatial data and OpenLayers as an interface. This application can support government for making priority decision to focus on areas which has the most high of rabies outbreak. *Copyright @ 2012 Institute of Advanced Engineering and Science. All rights reserved.*

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1.   INTRODUCTION

Rabies is a major public health problem in Bali. Government has declared Bali Island as rabies outbreak area. The statement contained in the Minister of Agriculture Regulation Anton Apriyantono on December 1, 2008 [1]. The threat of rabies is not only about the death of human or a pet, but also can lead local residents to loss sense of safety. Rabies outbreak caused the deaths of thousands of dogs that tested positive due to rabies, or suspected of carrying rabies because rabies symptoms or had close contact with rabies positive dogs [2].

Human fatalities occur because of a lack of knowledge regarding rabies risk, the poor management of dog bites, and the limited availability of Rabies immune globulin (RIG) [3]. Increasing public awareness of dog bite management, increasing the ARV (availability of anti-rabies vaccine) and RIG, and implementing an island wide dog vaccination campaign will help prevent human rabies cases.

Government of Bali has been collecting the data of rabies cases every period. However, current data management system still uses spreadsheet technology that oriented to attribute data. That system is inadequate for the efficient management and controlling the rabies outbreak.

Geographic Information System (GIS) is a computer-based tool or system for mapping and analyzing spatial data [4]. GIS is an organized collection of hardware, software and geographic data designed to efficiently capture, store, update, and manipulate all forms of geographically referenced information [5]. One benefit of GIS is that it can be used by the various fields of science, such as health or medical field.

With this in mind, a web-based GIS application of rabies spread was created by using GeoServer to record the spread of rabies, PostGIS database to stored and managed data from the maps, and OpenLayers as a client application to display map data in a web browser. This application provides a new resource for the rapid mapping and displays the dissemination of data on rabies cases in order to show information about any rabies infected area.

The rabies cases are shown in the points form (markers) in the map based on the coordinates of locations. Each region will be displayed in different colors according to the range number of rabies cases that occurred. The point radius showed the radius running of a dog in relation to show rabies outbreak. Submissions detail of rabies cases also can be viewed via popup that appears automatically when the rabies cases location were selected on the map. This application is useful in determining vaccination schedule so that Bali Animal Husbandry Department can easily track and perform priority control in areas with the most widely spread. It also showed the data historically, which means the spread of rabies can be tracked not only based on region but also time.

2.   RESEARCH METHOD

2.1. Geographic Information System (GIS)

Geographic Information System (GIS) is a database system that has a special ability to input, store, manipulate, and display spatial data or geographic coordinates of the following set of operations that manage the data [6]. GIS technology is used to make decisions and visualize categorized data in many aspects of the society. The most important components in a GIS is data and data is organized and managed with the help of a database management system (DBMS) [5].

Like maps, GIS can represent the real world in front of a computer monitor. Map is a graphical representation of the real world. Objects presented on a map are called a map element or map features, such as the rivers, bridges, and buildings [6]. Maps can organize the elements based on its locations, very good in showing an element relationship, the units that connect a set of map elements with their attributes in GIS called layer. Examples of layers include buildings, roads, sea, administrative boundaries, and plantations. Collection of this layer will form a GIS database.

2.2. Rabies

Rabies *(hydrophobia)* is a fatal *neuropathogenic* disease caused by the rabies virus, which is an enveloped RNA virus of the *Lyssavirus* genus, *Rhabdoviridae* family [7]. Transmission of rabies usually occurs through the bite of an infected animal, contamination of fresh wounds or mucous membranes with saliva or brain of animals that have been infected. The main route of infection is the bite of rabid dogs. In the specific case the transmission through the air may also occur [8].
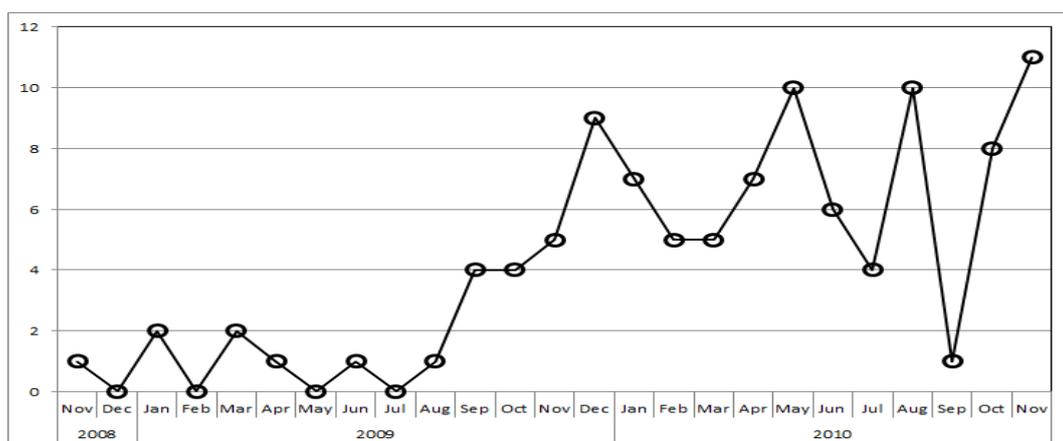
Figure 1. Number of human rabies cases (persons) from November 2008 to November 2010 by month

Rabies in Bali Province disease reappeared on 17 November 2008, the first human death from rabies virus infection occurred in Ungasan, Bali, following a dog bite [9]. By 27 December 2009, 27 human cases had been reported occurring in widely separated parts of the island, but predominantly in the south, in Tabanan and Ungasan [9]. As of 13 March 2010, the number of human deaths reported had surpassed 40

[10]. Prior to 2008, Bali was considered rabies-free. With the current outbreak and the current estimated dog population on the island being 500 000, the Bali Veterinary Agency is attempting to control the canine rabies outbreak through a mass vaccination programmed and the destruction of animals [10]. Figure 1 shows the number of human rabies cases by month from November 2008 to November 2010 of the outbreak [3].

The increase in numbers of clinically diagnosed cases in 12 months after the initial case report can be seen. Cases were reported in eight districts (Figure 2) with most coming from rural districts, including Karangasem (28.8%), Buleleng (19.2%) and Tabanan (17.3%) [3]. The proportion from the Badung District, where the index case occurred was 13.5% [3].

Figure 2. Map of Bali Province and distribution of human rabies during November 2008-November 2010

There were 104 human rabies cases in Bali during November 2008-November 2010 [3]. Patients' average age was 36.6 years (range 3-84 years; SD 20.7), most were male (56.7. Almost all (92%) cases had a history of dog bite [3]. Only 5.8% had their wounds treated and received an anti-rabies vaccine (ARV) after the bite incident [3]. No patients received Rabies Immuno Globulin (RIG). The rabies virus genome was detected in 50 of 101 patients (49.5%) with the highest detection rate from post-mortem CSF samples [3].

2.3. GeoServer

GeoServer is open source software that is built using Java that allows users to display and manipulate geospatial data [11]. GeoServer is designed for interoperability that is published data from all sources of spatial data using open standards. As a community-based project, GeoServer is developed, tested, and supported by a diverse group of individuals and organizations from around the world. Geoserver is the implementation of the Open Geospatial Consortium (OGC) Web Feature Service (WFS) and Web Coverage Service (WCS) standards, as well as high performance Web Map Service (WMS).

2.4. PostGIS

PostGIS is an open source relational database system, extension of the PostgreSQL Database Management System [12]. By adding PostGIS in Postgre SQL, the database will have the ability to store spatial data as the data range, region, state, and in particular the intersection of the geometry data type into the database as the data location of an object on the map. PostGIS functionality similar to other several databases that support spatial database such as SQL Server 2008 that supports spatial data, ESRI ArcSDE, Oracle Spatial and DB2 spatial extender [13]. Latest release of PostGIS is now packaged with the DBMS PostgreSQL as an optional add-on. As of this writing, the latest release is 1.4 and PostGIS 1.5 in beta version.

2.5. OpenLayers

OpenLayers is a javascript based client application for displaying map data in a web browser and does not depend on the web server used [14]. OpenLayers implements a JavaScript API used to build web-based GIS applications. OpenLayers is similar to Google Maps and MSN Virtual Earth APIs, with one main difference that OpenLayers is free software, developed for and by the community of Open Source software.

2.6. Design system

There are five types of entities related to the application of rabies GIS, namely Animal Husbandry Department, administrator, submissions sender, pet owner, and user. Modeling system with unified external relations shown in the system context diagram in Figure 3.
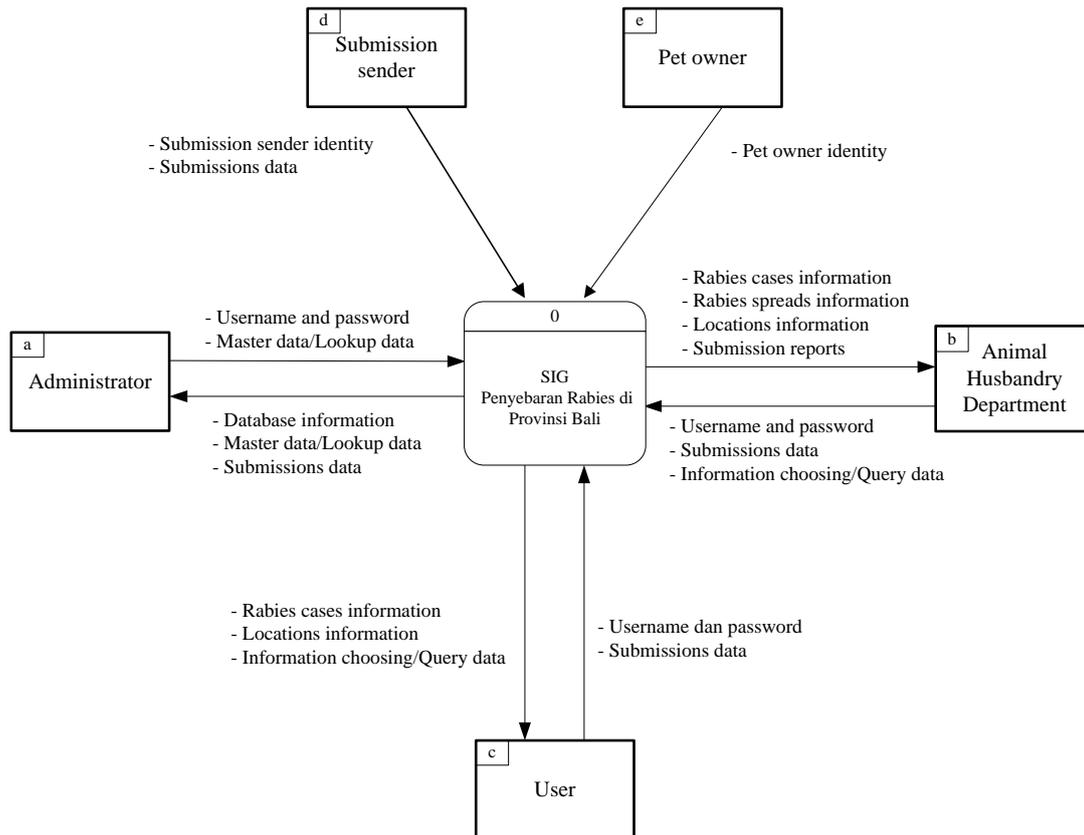
Figure 3. GIS application context diagram

Each entity has a special duties and rights in the application The administrator have full access rights to the master data processing, as well as the data manipulation is not possible for other users. The head of the Animal Husbandry Department have a duty of validating the data in cases of rabies submissions received from the reporting done by locals and then take a decision in determining the priority of the response to the infected area. Users is an employee of the Animal Husbandry Department who access this geographic information system applications, which is allowed to query and regional elections, in accordance with the spatial query and navigation options and assigned to enter data reporting as results of public rabies submissions. The rabies cases will be reported by the people whom we call submission sender and the report will be recorded as data submission. Animal owners who have pets suspected of contracting rabies will be questioned according to the condition and behavior of their pets.

The processes that occur between entities in the system and database involved in each process are described in the Data Flow Diagram (DFD) level 0 systems as shown in Figure 4.
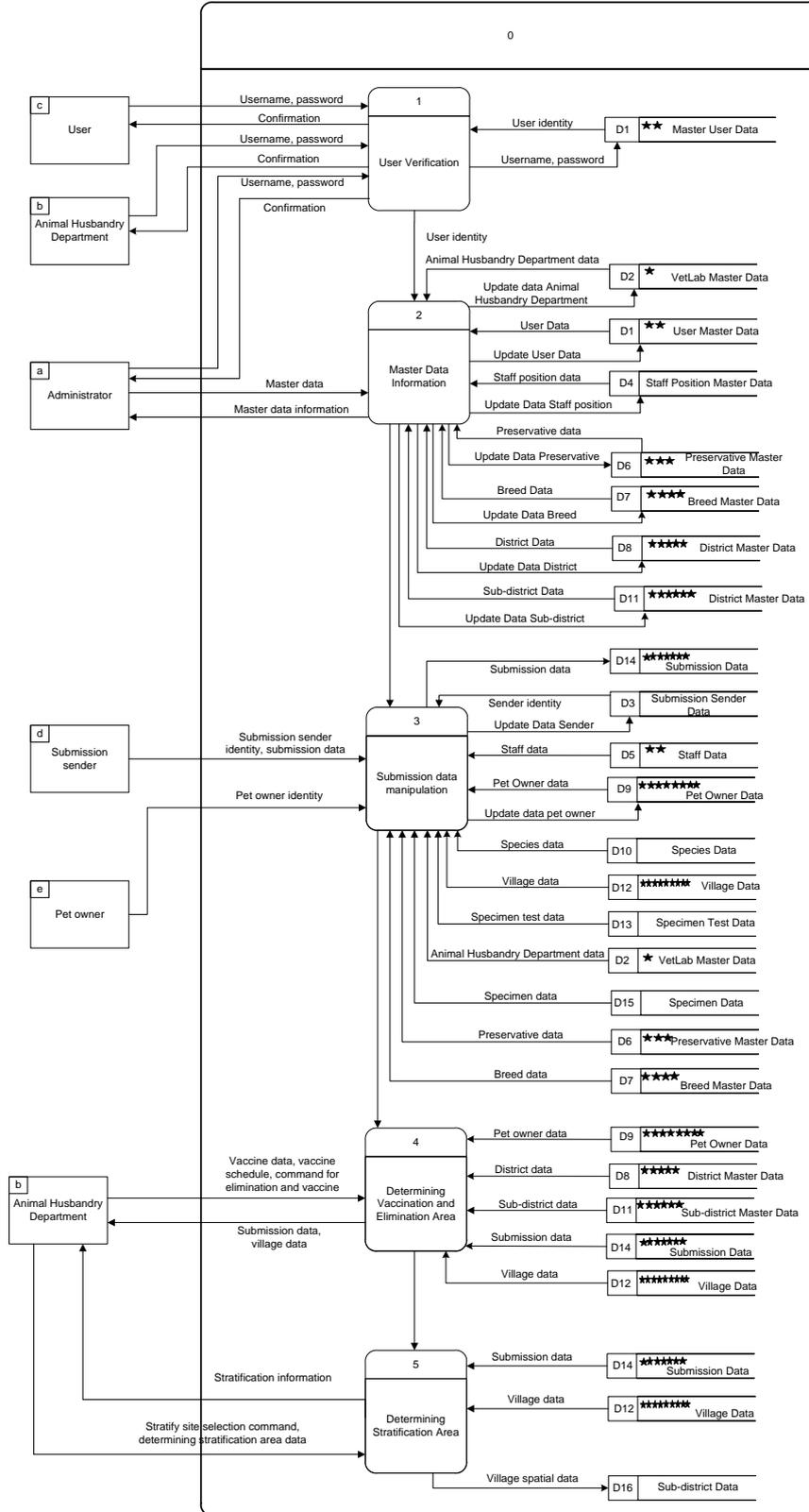
Figure 4. GIS application data flow diagram (DFD) level 0

There are five processes in the Data Flow Diagram (DFD) in this level, the user verification process, the master data manipulation, submissions data manipulation, determining vaccination and elimination area, and determining stratification area.

2.7. Relationship between spatial data and non-spatial data

The relationships between the spatial data with non-spatial data (attributes) are stored in a PostGIS database. Relationship is the case because any spatial data (maps) must have an attribute or tabular data in a database. The relationship is depicted in Figure 5.
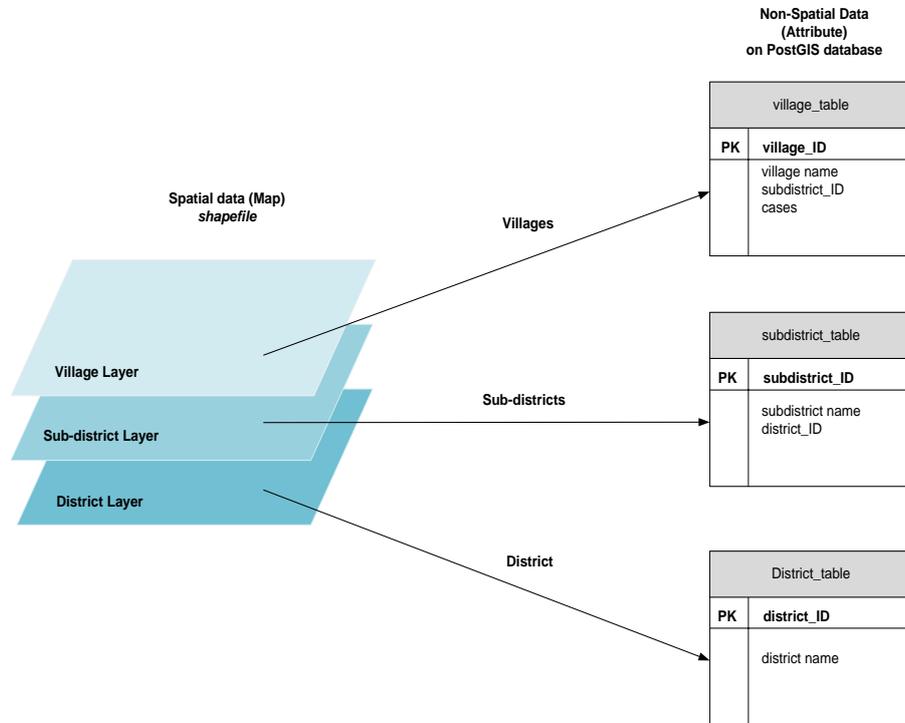
Figure 5. Relationship between spatial data and non-spatial data

Figure 5 shows relationships between the spatial data and non-spatial data (attributes) which is stored in PostGIS database. Relationships are between village table and village layer, sub-district table and sub-district layer, district table and district layer.

3. RESULTS AND ANALYSIS

Rabies disease research has been done before in United States. The research was not investigated the cases of rabies that occurred in dogs, but include rabies that occurred on skunk, raccoon, fox, and mongoose [15]. Contrast to this research which using GeoServer as geospatial data provider server via web services, the previous research used ArcGIS as a system for designing and managing solutions through the application of geographic knowledge [15]. The difference also found between databases, that is previous research was using SQL server as database instead of PostGIS [15].

This geographic information system manages data and information on mapping the spread of rabies in the province of Bali, where this system is equipped with the ability to analyze the focus rabies area by dynamically coloring on the stratification area according to the rabies cases. Level of deployment will be distinguished by color according to the high cases of rabies that occurred in each region.

This application can handle the election map by district. Figure 6 shows an example of election districts that want to appear on the map.
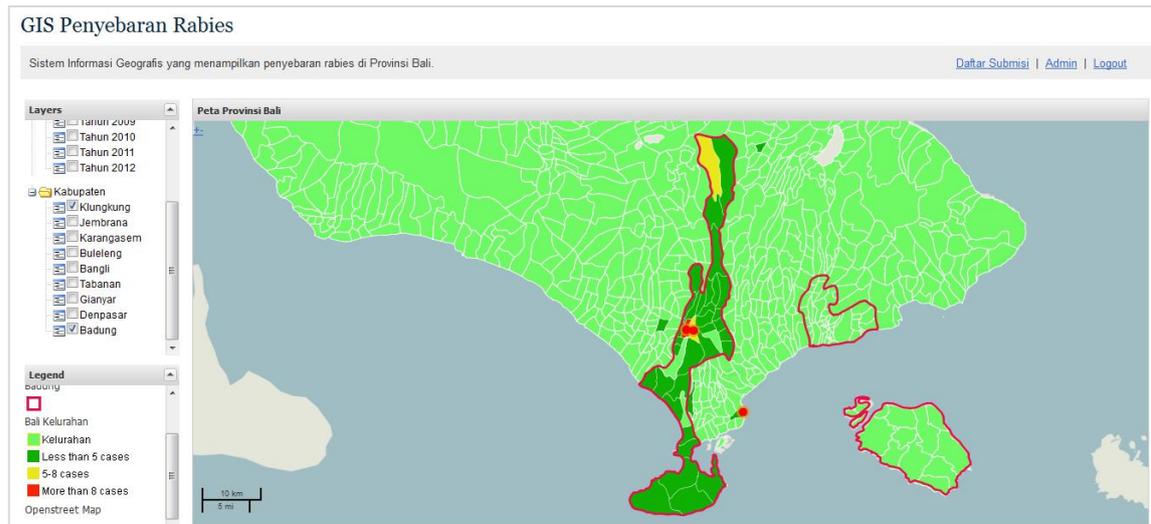
Figure 6. Map view by district election

The application comes with *getfeatureinfo* OpenLayers feature that allows users to obtain detailed information of an area by selecting the area on the map. Detail information includes details of rabies cases spread in the selected areas. In addition to showing a map of rabies spread, the application is also equipped with data storage capabilities for reporting animal rabies carrier bites, specimen reports, specimens test reports, and specimen test of animal rabies carrier results, as shown in Figure 7.

Figure 7. Submission page

If the result of the test specimens is positive, then the system will automatically give color to the place on the map where the case of rabies happened. The red color indicates high cases of rabies, yellow for intermediate cases of rabies and green for low cases of rabies.
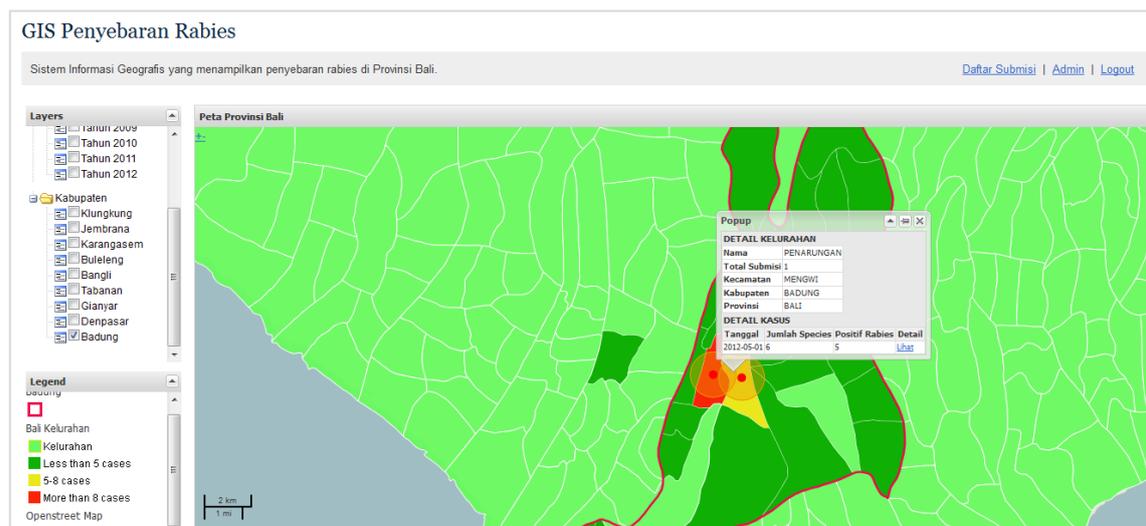
Figure 8. Rabies cases detail view in badung district

4. CONCLUSION

In this paper we can conclude that the application of rabies GIS can store and report submissions data about dog bites in Bali Province that are suspected carriers of rabies into the database. This GIS application also can show the spread of rabies on the map where the case of rabies happened, so users can determine the condition of the spread of rabies in one area and can compare it to other areas and can assist in the prioritization decision to focus on areas which has the most high of rabies outbreak.

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