WEB GIS BASED ANIMAL DISEASES SURVEILLANCE SYSTEM

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submitted by **FUNDA ARIKAN** in partial fulfillment of the requirements for the degree of **Master of Science in Geodetic and Geographic Information Technologies Department, Middle East Technical University** by,

Prof. Dr. Canan Özgen Dean, Graduate School of Natural and Applied Sciences	_______________
Assoc. Prof. Dr. Mahmut Karslıoğlu Head of Department, Geodetic and Geographic Information Technologies, METU	_______________
Assoc. Prof. Dr. Nurünnisa Usul Supervisor, Civil Engineering Dept., METU	_______________

Examining Committee Members:

Assoc. Prof. Dr. Şebnem Düzgün Mining Engineering Dept., METU	_______________
Assoc. Prof. Dr. Nurünnisa Usul Supervisor, Civil Engineering Dept., METU	_______________
Assoc. Prof. Dr. Nuri Merzi Civil Engineering Dept., METU	_______________
Assoc. Prof. Dr. Can Bilgin Dept. of Biological Sciences, METU	_______________
H. Haluk Aşkaroğlu Head of Animal Health Department, Ministry of Agriculture and Rural Affairs	_______________

Date: 11 February 2009

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name: Funda Arıkan

Signature:

ABSTRACT

WEB GIS BASED ANIMAL DISEASES SURVEILLANCE SYSTEM

Arıkan, Funda

M.Sc., Department of Geodetic and Geographic Information Technologies
Supervisor: Assoc. Prof. Dr. Nurünnisa Usul

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Today, infectious animal diseases and the propagation speeds of these diseases have been threatening the human health. Threats from animal disease outbreaks such as Avian Influenza have increased in both number and complexity. So, it is extremely important to determine the animal diseases at first appearances and to take precautions according to propagation speeds of the diseases.

Geographic Information Systems (GIS) have become an important tool in veterinary epidemiology, surveillance and monitoring of animal diseases. Such approaches can be used for public health planning and predicting disease risks. This study aims to build a GIS web-based animal health surveillance system in Turkey in order to monitor and analyse disease outbreaks. Different sources of data; geographical data, animal holding locations, disease outbreak recordings, reporting information and special GIS functions have been incorporated in the application. It enables to determine the first, second and third degree risk zones of a disease, query the animals, holdings and disease events, create thematic maps and show the results of explored landscape features associated with Avian Influenza outbreak of 2006 and present graphically illustrated reports. This study will make the management of the disease outbreak situation easier, enhance the response mechanism of the decision makers, help to make better decisions, control the disease as quickly as possible, protect both the animals and humans against diseases, also provide a tool to evaluate different strategies to prevent the spread of infectious diseases. So, in an infectious disease case, emergency precautions can be taken and control strategies can be planned.

Keywords: Web-based Geographic Information Systems, Infectious Animal Disease, Outbreak, Veterinary Epidemiology, Avian Influenza

ÖZ

INTERNET VE CBS TABANLI HAYVAN HASTALIKLARI TAKIP SISTEMI

Arıkan, Funda

Yüksek Lisans, Jeodezi ve Coğrafi Bilgi Teknolojileri
Danışman: Doç Dr. Nurünnisa Usul

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Günümüzde, bulaşıcı hayvan hastalıkları ve bu hastalıkların yayılma hızları insan kitlelerini sağlık açısından tehdit etmektedir. Kuş gribi gibi salgın hayvan hastalıklarından kaynaklı tehlikeler gün geçtikçe artmıştır.

Coğrafi Bilgi Sistemleri (CBS) hayvan hastalıklarının gözetim ve takibinde, veteriner epidemiyolojisinde kullanılan en önemli araçlardan biri haline gelmiştir. Bu tür yaklaşımlar, halk sağlığı ve hastalık risklerinin planlamalarında kullanılabilir. Bu çalışma, salgın hastalıkların takibi ve analizi için Türkiye'de internet ve CBS tabanlı bir hayvan sağlığı gözetim sistemi kurmayı hedefler. Uygulamada, farklı veri kaynakları; coğrafik veriler, hayvan işletmeleri yerleri, salgın hastalık kayıtları, raporlama bilgileri ve özel CBS fonksiyonları biraraya getirilmiştir. Program, bir hastalığın 1., 2. ve 3. dereceden risk bölgelerinin belirlenmesini, hayvanların, işletmelerin ve hastalık vakalarının sorgulanmasını, tematik haritaların oluşturulmasını ve 2006 kuş gribi salgını bağlamında arazi özelliklerinin incelenmesini ve sonuçların grafiksel gösterilmesini sağlar. Bu çalışma, hastalık salgınları dönemlerinin kolayca yönetilmesini sağlayacak, karar

vericilerin müdahale mekanizmalarını güçlendirecek, daha doğru kararlar almalarına yardımcı olacak ve hastalıkları mümkün olduğunca çabuk kontrol altına almalarına yardımcı olacaktır. Hem hayvanların hem de insanların hastalıklara karşı korunmasını ve salgın hastalıkları önlemede farklı stratejilerin belirlenmesini sağlayacak bir araç olacaktır. Böylece, bir salgın hastalık durumunda, acil durum önlemleri alınabilecek ve kontrol politikaları oluşturulabilecektir.

Anahtar Kelimeler: Web-tabanlı Coğrafi Bilgi Sistemleri, Bulaşıcı Hayvan Hastalıkları, Salgın, Veteriner Epidemiyolojisi, Kuş Gribi.

To my adorable and sweetheart sister Ergül,

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CHAPTER 1

INTRODUCTION

1.1 Background

Disease surveillance has been defined as: 'the continued watchfulness over the distribution and trends of incidence through the systematic collection, consolidation and evaluation of morbidity and mortality reports and other relevant information and the regular dissemination of such data to all that need to know' (Ward, 2007). There are two specific reasons that animal disease surveillance is critical. The first, being the direct impact to the human and the second, being an economic impact. Animal disease surveillance can serve as sentinels for bioterrorist or natural infectious disease epidemics. As such, it is important to understand how animal disease affects humans and how this information can be obtained and monitored on a regular and timely basis (Wurtz and Popovich, 2002).

In Turkey, Animal Health Services Department of General Directorate of Protection and Control of Ministry of Agriculture and Rural Affairs is responsible for protection and improving the health, quality, and marketability of animals of our nation, animal products and veterinary biologics by preventing, controlling and/or eliminating animal diseases, and monitoring and promoting animal health and productivity. Turkey has a series of contingency plans for the management of outbreaks of all major animal diseases. A Veterinary Information System-VIS (TURKVET) is developed since 2004 in the context of a project that has been financed by European Union based on EUROVET. TURKVET is an animal health information system for the collection, storage, analysis and reporting of non-spatial information related to the health of animals. TURKVET Veterinary

Information System consists of the following modules; Animal Diseases Notification System (ADNS), Laboratory Sample Management System (SMS), holding records related to poultry, determination, controlling the poultry, and monitoring and recording of the animal movements – Bovine Tracking System.

Field veterinary services are organized through 81 provincial livestock offices, and 921 district offices. The usual flow of animal health information is from the animals and their owners, up through the district, provincial and regional offices, to the central administration. Disease control measures in Turkey are mainly based on a traditional approach and eradication policies range from culling and stamping-out to movement restrictions of animals and commodities (URL 1).

1.2 Statement of the Problem

Over the last fifty years, up to 75% of emerging disease outbreaks in humans such as the avian flu are zoonotic diseases (transmissible between humans and animals, causing infection in both species) of animal origin. These diseases are transboundary, respecting no territorial or geographic borders, stealthily spreading worldwide (Babalobi, 2007). Because many animal disease agents are zoonotic, their management and prevention are crucial to improving public health on a global scale. Animal diseases spreading between countries, such as foot-and-mouth disease and avian influenza, are having a severe economic and social impact. Such animal diseases are on the rise as a result of international trade and the movement of people and animals (URL 2). Outbreaks of highly contagious animal diseases severely affect the global economy, seriously disrupting domestic economies and the international trade of livestock and animal commodities. Animal diseases that cross borders need an immediate and effective regional or international response. Recent epidemics of highly contagious diseases such as foot and mouth disease, or avian influenza in Turkey have massively disrupted the livestock community and all the economic sectors directly and indirectly linked with animal production.

The first outbreak of deadly form of bird flu in Turkey occurred in the Manyas district of Balıkesir in October 2005. It was followed by an outbreak in the Aralık district of Iğdır and then spread to 53 provinces of Turkey. In order to control the disease over 2.5 million poultry have been destroyed in Turkey, a transit country for migratory birds. According to the data obtained from the World Health Organization (WHO), 12 people were infected with the H5N1 virus, of which 4 children died (URL 3).

Protection of the poultry industry is crucial in Turkey, as it generates annual average revenue of 3 billion dollars and employs over 2 million people. Aside from the economic aspect of the issue, increasing the capacity of early response by enhancing diagnosis methods is vital for public health (URL 4). In a global market that includes the international trade of animals and animal products, the effective control of animal disease outbreaks, response, and crisis management require powerful crisis management tools.

As aptly illustrated by the ongoing worldwide occurrence of avian flu (and other emerging diseases) outbreaks, animal diseases and human health problems transcend local and international borders, requiring attention to their geographic, spatial and temporal patterns before effective prevention and control can be implemented (Babalobi, 2007). An integrated system is required for the management of veterinary emergencies. Traditional tools for epidemiological data management and analysis are very poorly equipped to handle information on the geographical distribution of disease, as the relationships between adjacent or distant areas cannot be examined. Traditional non-spatial database management systems can handle storage and analysis of the other factors. However, the use of a GIS offers the ability to include the spatial distribution of disease in the analysis of all the other factors. GIS is one of the veterinary geo-informatics technologies employed in this information age for capture, storage, retrieval, update, analysis, mapping, display and rapid worldwide communication of data for the management of animal diseases (Freier, 2000).

Current animal health data management system in Turkey is not able to fully incorporate the spatial component of animal health information. Mostly, animal diseases spatial data are managed with the use of manually prepared disease maps. The level of detail and accuracy, time taken for preparation, and absence of analysis severely weaken the value of these manually prepared disease maps. A GIS based program had been developed for Animal Health Services Department of General Directorate of Protection to manage the animal health data in 2004, but it did not work efficiently and is not used today. A proper understanding of the geographical distribution of disease is essential for the development of rational disease control programs, the establishment of disease free zones, and management of veterinary resources. The spatial component of disease distribution is another form of data that needs to be integrated with the existing data sources to achieve better data management and more efficient analyses.

1.3 Objectives and Scope of the Thesis

When used correctly, a GIS can help identify clusters of disease, manage and predict disease outbreaks, identify risk factors, assess sample and population distributions, and supplement other areas of food safety and animal health surveillance and research. GIS provides a powerful means of managing data related to a disease outbreak, especially in designing surveillance strategies and monitoring spatial-temporal trends as disease cases are reported (Engel et al., 2004). This study aims to build a GIS web-based animal health surveillance system in Turkey in order to monitor and analysis disease outbreaks. This study will enhance the response mechanism of the decision makers, help to make better decisions, control the disease as quickly as possible, and protect both the animals and humans against animal origin diseases.

In the study a Web-based GIS was designed to integrate epidemiological information with the corresponding geographic component. The system works on a disease basis (disease specific maps) for ten of the most contagious and common diseases in Turkey (avien influenza (AI), foot and mouth disease (FMD), blue tongue (BT), sheep and goat pox (SGP), pest des petits ruminants (PPR), rabies, sheep-goat brucellosis (SGB), cattle brucellosis (CB), bovine tuberculosis (TB), anthrax). It utilizes GIS technology to aid in the detection and prevention of disease.

Its key functions are the retrieval and querying of animal diseases, animal counts and disease outbreak data by considering the date and the creation of reports and interactive maps to visualize them. Number of registered animals, holdings and disease events can be queried according to some criteria and thematic maps can be created on the base of region, province and district. And resulting reports with statistical graphics are achieved. The system allows information to be rapidly spread by displaying data and providing explorative analysis tools. With disease – effect analysis it is possible to determine the 1st, 2nd and 3rd degree risk zones of a disease around its focal point and get the list of villages that fall inside of these buffer areas. Moreover, GIS was utilized in spatial analysis of landscape features associated with 2006 Avian Influenza outbreak.

The system is expected to serve as a decisional and management tool to be used by the different organizational levels of national veterinary services (local health units, i.e. field veterinarians, regional government and Ministry of Agriculture and Rural Affairs). The developed Web-GIS system will provide both decision-makers and stakeholders (veterinarians, farmers, slaughterhouses, etc.) with a powerful tool to integrate data derived from different sources.

The overall objective is to provide information which enables decision makers to help improve or maintain the health and productivity of animals, and through this, the well-being of their owners and the wider community. The program will make mapped information available to decision-makers and field personnel in real time.

1.4 Structure of the Thesis

The following chapters define the subject in a wide perspective. Chapter 2 is dedicated to a comprehensive literature survey about general information about each animal disease covered in this study and how GIS is utilized in animal disease cases in the world and in Turkey and spatial epidemiology. Chapter 3 introduces the data and the production processes used. Chapter 4 describes the web-based system design process. A discussion with concluding remarks and recommendations for future studies completes the thesis in Chapter 5.

CHAPTER 2

LITERATURE REVIEW

2.1 Livestock Animal Diseases

Livestock play an important role in developing countries. The control of livestock diseases depends on a clear understanding of the diseases present, their distribution and impact. Diseases affecting livestock can have a devastating impact on animal productivity and production, on trade in live animals, meat and other animal products, on human health and, consequently, on the overall process of economic development (URL 5).

In Turkey, there is an obligation to notify some of the animal diseases. The list of 33 notifiable animal diseases defined in 3285 numbered Animal Health and Constabulary Law (Item 4) (1 April 2004, 25420) is available in Table 2.1 (URL 6).

As a result of globalization and climate change, the world is currently facing an unprecedented increase of emerging and re-emerging animal diseases and zoonoses (animal diseases transmissible to humans). Any disease and/or infection which is naturally "transmissible from vertebrate animals to man" is classified as a zoonosis. Some examples of zoonoses are; Avian Influenza, Cattle Brucellosis, Rabies, Bovine Tuberculosis, Anthrax, etc. (URL 7). Some of the important ones are described below very briefly, and Avian Influenza is given in a little more detail, since it is studied as a case for this thesis.

Foot-and-mouth disease (FMD) is a highly contagious and sometimes fatal viral disease of cloven-hoofed animals, including domestic animals such as cattle, water buffalo, sheep, goats and pigs, as well as antelope, bison and other wild bovids, and deer.

Table 2.1 Notifiable Animal Diseases

1	Cattle plague	18	Avian influenza
2	Foot and mouth disease	19	Newcastle disease
3	Bovine tuberculosis	20	Pullorum
4	Cattle brucellosis	21	Typhoid
5	Bovine spongiform encephalopathy	22	Scrapie
6	Anthrax	23	Feline spongiform encephalopathy
7	Rabies	24	American foulbrood disease of bees
8	Sheep- goat pox	25	Varroa
9	Sheep and goat brucellosis	26	Infectious haematopoietic necrosis
10	Pest des petits ruminants	27	Bonamiosis
11	Bluetongue	28	Marteiliosis
12	Horse pest	29	Spring viraemia of carp
13	Ruam	30	Viral Hemorrhagic Septicemia
14	Durin	31	Infectious Pancreatic Nekrosis
15	Equine infectious anemia	32	Bacterial Kidney Dise
16	Vesicular stomatitis	33	Crayfish Plague
17	Equine encephalomyelitis		

Pest des petits ruminants (PPR) is an acute or subacute viral disease of goats and sheep characterized by fever, erosive stomatitis, conjunctivitis, gastroenteritis, and pneumonia. Goats are usually more severely affected than sheep. Presently, PPR occurs in most African countries situated in a wide belt between the Sahara and Equator, the Middle East (Arabian Peninsula, Israel, Syria, Iraq, Jordan), and the Indian subcontinent. The name of the disease is in French, but it is also used with this name in English.

Rabies is a viral zoonotic neuroinvasive disease that causes acute encephalitis (inflammation of the brain) in mammals. It is most commonly caused by a bite from an infected animal, but occasionally by other forms of contact. If left untreated in humans it is almost invariably fatal. In some countries it is a significant killer of livestock.

Sheep-Goat Brucellosis: Brucellosis is one of the most important zoonotic diseases. Sheep and goats brucellosis is a zoonotic infection with important effects on both public health and animal health and production and is widespread in many areas of the world, particularly in some Mediterranean and Middle Eastern countries. This disease causes decrease in lactation, decrease in value of breeding and sterility.

Sheep and goat pox are highly infectious diseases of sheep and goats characterized by fever, lacrimation (tear production), salivation, nasal discharge, and eruptions of numerous nodules in the skin. Typical pox lesions appear on the skin and on the lining of the respiratory tract, stomach, and intestines. There is a high mortality rate in susceptible populations. Sheep pox virus and goat pox viruses are usually host specific; however, strains exist that can infect both sheep and goats. Sheep and goat pox viruses can replicate in cattle but do not cause any clinical signs of disease in cattle.

Cattle brucellosis: The bacterium Brucella abortus is the principal cause of brucellosis in cattle. The bacteria are shed from an infected animal at or around the time of calving or abortion. Once exposed, the likelihood of an animal becoming infected is variable, depending on age, pregnancy status, and other intrinsic factors of the animal as well as the amount of bacteria to which the animal was exposed. The most common clinical signs of cattle infected with Brucella abortus are high incidences of abortions, arthritic joints and retained after-birth.

Bovine tuberculosis is a chronic bacterial disease of cattle that occasionally affects other species of mammals. This disease is a significant zoonosis that can spread to humans, typically by the inhalation of aerosols or the ingestion of unpasteurized milk. Bovine tuberculosis is still common in less developed countries, and severe economic losses can occur from livestock deaths, chronic disease and trade restrictions. In some situations, this disease may also be a serious threat to endangered species.

Anthrax is an acute disease caused by the bacterium Bacillus anthracis, which is highly lethal in some forms. The disease affects domestic animals - such as cattle, sheep, goats, horses, donkeys, pigs and dogs - as well as wild ruminants such as antelopes, gazelles and impalas. It causes mortality mostly in sheep, goat and bovines. It can be seen at every region of our country in every season.

Bluetongue (BT) is an infectious, non-contagious, arthropod-borne disease transmitted by biting midges of the genus Culicoides. Ruminants are susceptible to the infection, but the disease primarily affects sheep, with a mortality rate varying from 0 to 30%. Bluetongue is caused by a virus (BTV) belonging to the Orbivirus genus of the family Reoviridae. At present 24 distinct serotypes have been serologically identified (URL 6).

Bird Flu /Avian Influenza (AI) is an infectious disease of birds caused by type A strains of the influenza virus. The disease occurs worldwide. While all birds are thought to be susceptible to infection with avian influenza viruses, many wild bird species carry these viruses with no apparent signs of harm.
Other bird species, including domestic poultry, develop disease when infected with Avian Influenza viruses. In poultry, the viruses cause two distinctly different forms of disease – one common and mild, the other rare and highly lethal. In the mild form, signs of illness may be expressed only as ruffled feathers, reduced egg production, or mild effects on the respiratory system.

To date, all outbreaks of the highly pathogenic form of avian influenza have been caused by viruses of the H5 and H7 subtypes. Some species of migratory waterfowl are carrying the H5N1 virus in its highly pathogenic form and introducing it to new geographical areas located along their flight routes (URL 8).

Apart from being highly contagious among poultry, Avian Influenza viruses are readily transmitted from farm to farm by the movement of live birds, people (especially when shoes and other clothing are contaminated), and contaminated vehicles, equipment, feed, and cages. During 2005, an additional and significant source of international spread of the virus in birds became apparent for the first time, but remains poorly understood. Scientists are increasingly convinced that at least some migratory waterfowl are now carrying the H5N1 virus in its highly pathogenic form, sometimes over long distances, and introducing the virus to poultry flocks in areas that lie along their migratory routes.

Avian Influenza virus infection is endemic in a range of free-living bird species worldwide, particularly species associated with water. Waterfowl and shorebirds can be infected by all subtypes of type A influenza viruses with few or no symptoms. These species are probably responsible for the spread of viruses between regions. In the northern hemisphere, influenza virus infection rates are highest during spring migration for shorebirds, whereas waterfowl infections peak in late summer and early autumn. Juvenile waterfowl are more susceptible to infection; when the birds are migrating south; a higher prevalence is expected than in the spring, when the juveniles have matured. Avian influenza outbreaks (both high and low pathogenic) in poultry are often assumed to occur from exposure to wild avian species (Ward, 2007).

Highly pathogenic viruses can survive for long periods in the environment, especially when temperatures are low. For example, the highly pathogenic H5N1 virus can survive in bird faeces for at least 35 days at low temperature ($4^{o}C$). At a much higher temperature (37°C), H5N1 viruses have been shown to survive, in faecal samples, for six days (URL 4).

Avian Influenza is first and foremost a question of animal health. It represents a constant and serious threat to animal and human health worldwide (URL 9). It has recently become an emerging issue for world health: the pathogenic H5N1 influenza strain circulating in Asia, Africa, the Middle East and Europe has caused numerous disease outbreaks in domestic poultry and wild bird populations, and threatens human health (Ward, 2007). Avian Influenza has been recognized as a highly lethal generalized viral disease of poultry since 1901. As of 10 September 2008, 245 (63%) of 387 humans known to have been infected with H5N1 since 2003 and reported to the World Health Organization (WHO) have died in 16 countries in South-East Asia, China, the Middle East and Africa. Cumulative Number of Confirmed Human Cases of Avian Influenza A/(H5N1) Reported to WHO is given in Table 2.2 (URL 10).

Turkey is particularly at risk, being on major migratory routes of wild birds that can carry the disease. In October 2005, during the bird migration period, AI was first detected in Manyas district, Balıkesir province in a turkey farm, where the birds were raised outdoors. A second outbreak was reported in November 2005 in Aralık district of Igdır province. The disease spread to 53 provinces, mainly in backyard poultry. Over 2.5 million birds were culled for disease control. 12 cases of H5N1 in people were confirmed by the World Health Organization, of whom four children died. There were no confirmed outbreaks after March 2006 and by May 2006 all restrictions around outbreaks had been lifted (URL 9).

Table 2.2 Cumulative Number of Confirmed Human Cases of Avian Influenza A/(H5N1) Reported to WHO

Country	2003		2004		2005		2006		2007		2008		Total	
	cases	deaths	cases	deaths	cases	deaths	cases	deaths	cases	deaths	cases	deaths	**cases**	**deaths**
Azerbaijan	0	0	0	0	0	0	8	5	0	0	0	0	**8**	**5**
Bangladesh	0	0	0	0	0	0	0	0	0	0	1	0	**1**	**0**
Cambodia	0	0	0	0	4	4	2	2	1	1	0	0	**7**	**7**
China	1	1	0	0	8	5	13	8	5	3	3	3	**30**	**20**
Djibouti	0	0	0	0	0	0	1	0	0	0	0	0	**1**	**0**
Egypt	0	0	0	0	0	0	18	10	25	9	7	3	**50**	**22**
Indonesia	0	0	0	0	20	13	55	45	42	37	20	17	**137**	**112**
Iraq	0	0	0	0	0	0	3	2	0	0	0		**3**	**2**
Lao People's Democratic Republic	0	0	0	0	0	0	0	0	2	2	0	0	**2**	**2**
Myanmar	0	0	0	0	0	0	0	0	1	0	0	0	**1**	**0**
Nigeria	0	0	0	0	0	0	0	0	1	1	0	0	**1**	**1**
Pakistan	0	0	0	0	0	0	0	0	3	1	0	0	**3**	**1**
Thailand	0	0	17	12	5	2	3	3	0	0	0	0	**25**	**17**
Turkey	**0**	**0**	**0**	**0**	**0**	**0**	**12**	**4**	**0**	**0**	**0**	**0**	**12**	**4**
Viet Nam	3	3	29	20	61	19	0	0	8	5	5	5	**106**	**52**
Total	**4**	**4**	**46**	**32**	**98**	**43**	**115**	**79**	**88**	**59**	**36**	**28**	**387**	**245**

2.2 Utilizing GIS as a Tool in Surveillance and Monitoring of Animal Diseases

Geography plays a major role in understanding the dynamics of animal health and the spread of disease. The geography-centric nature of this system makes GIS the ideal technology choice. Geographic information systems (GIS) have several functions, including input (database functions), analysis (interpolation, cluster detection, identification of spatial risk factors) and output (sampling design, disease risk maps). These functions allow the design, implementation and assessment of surveillance systems (Ward, 2007).

GIS has frequently been considered a tool that has potential to be utilized in several aspects of animal related disasters. Through several different examples, GIS has shown its applicability for improving disaster response efficiency by supplying maps and spatial analysis capabilities. The internet is used increasingly as an effective means of disseminating information. Using internet-based technology allows users to create dynamic, customized maps and perform basic spatial analysis without the need to buy or learn desktop geographic information systems.

Recently, there have been a growing number of applications of geographic information systems (GIS) in epidemiology. This section of the thesis aims to describe and give an overview of the potential uses of a Geographical Information System (GIS) in the field of surveillance and monitoring of animal diseases.
The following areas in which GIS and special GIS-functions could be incorporated in controlling the animal diseases are:

a) Recording and reporting information of animal disease

GIS can be used to produce maps of disease incidence, prevalence, mortality, morbidity on farm, province, region, or national levels. Showing these kinds of data on map makes easy to update the data and to report the information to related departments (Kroschewski et al., 2006).

b) Epidemic emergency

In case of an outbreak of an infectious disease, GIS can provide an excellent tool for identifying the location of the case farm and all farms at risk within a specified area of the outbreak. Buffer zones can be drawn around those farms as shown in Figure 2.1 and with a link to tables of the addresses of the farms at risk. Then the farms can be informed within a short time after a notified outbreak. Buffer zones can also be generated around other risk areas or point sources, such as roads where infected cattle have been driven or around market places. Further, the maps can assist the field veterinarians to plan their work in the current situation, and for the veterinary authorities in how to handle a potential outbreak (Norstrom, 2001).

c) Cluster analysis

To effectively support disease control and eradication programs, the spatial distribution of the disease and the susceptible population must be understood. The establishment of a disease-free zone for international trade purposes requires a clear understanding of the spatial distribution of disease and risk factors in and around the zone. Maps can be a valuable tool to help epidemiologists identify spatial patterns of disease as cases occur.

Cluster analysis of the disease is done to analyze whether a disease is clustered in space, time or in time and space. The visualization of the disease rates on digital maps can be misleading because the eye tends to interpret point patterns as clusters more often than what is real. Therefore, a cluster analysis should be carried out for an objective evaluation of the reported disease cases (Norstrom, 2001).

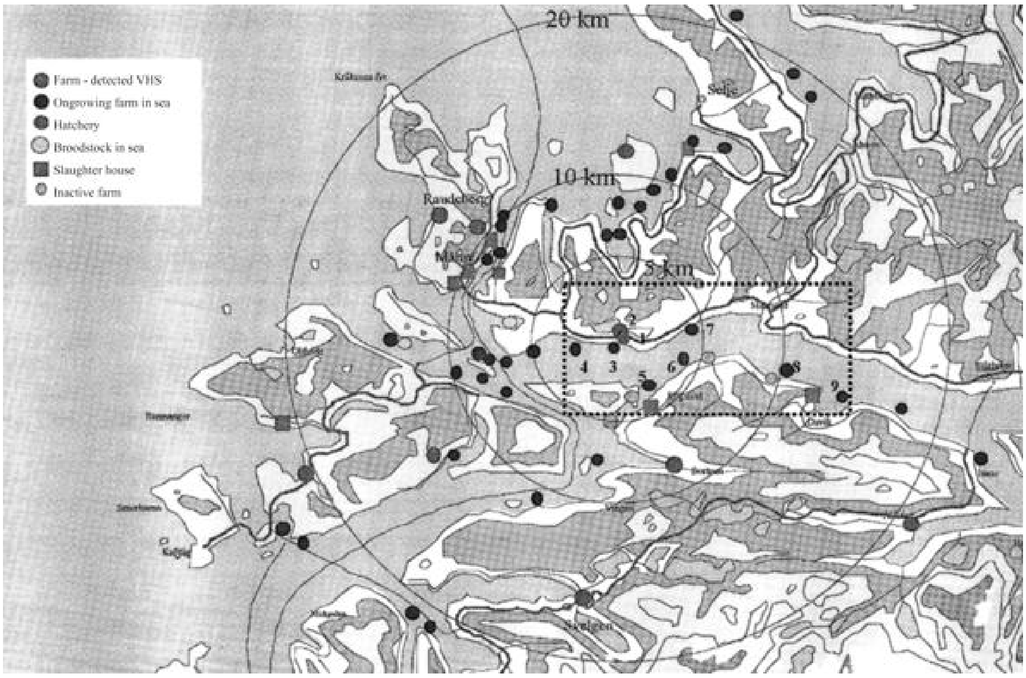

Figure 2.1 A map showing an example of how buffer zones with the distance of 5, 10, and 20 kilometers were created around a fish farm

d) Modeling disease spread

Integrated simulation models can be used within GIS. Such simulation models can incorporate farm information such as herd size, production type as well as spatial factors like distance to the source of outbreak, population density and climate conditions, vegetation and landscape, all of which have been defined as risk factors for the spread of the modeled disease (Norstrom, 2001). A model of a potential outbreak of foot and mouth disease has been developed in New Zealand in 1994 (Sanson et al., 1994).

e) Planning control strategies

The neighborhood analysis function can be used to identify all adjacent farms to an infected farm. It is a function that identifies all adjacent features with a certain criteria to a particular feature. Contact patterns such as common use of grasslands or sources of purchasing etc. could be visualized with a so-called spider diagram. This could provide insight into the possibility of transmission of infectious diseases between herds. In the planning of eradication of diseases, GIS has the possibility to perform overlay analysis to find high or low risk areas for diseases which depend on geographical features or conditions related to the geography (Norstrom, 2001).

2.3 Web-based GIS Applications in Epidemiology

Examples introduced in this section are typical applications for utilizing GIS in animal disease cases surveillance and internet based map server applications in the world.

A Web-based geographic information system for the management of animal disease epidemics in Italy, 2007

Italy has a series of contingency plans for the management of outbreaks of all major animal diseases. Given the marked terrain differences in Italy, the uneven distribution of farms and animal population, the presence of potential disease hotspots constituted by high-density clusters of farms and animals, etc., maps have always been a common working tool for the Italian veterinary services to identify location of premises, define the perimeter of the infected and control zones, etc. The Italian Ministry of Health has requested an integrated system for the management of veterinary emergencies. One of the main features of the system is an interactive, customizable and user-friendly Web-based geographic information system (GIS). A Web- based GIS has been designed to integrate epidemiological information with the corresponding geographic component. The system works on a disease basis (disease-specific maps) for fifteen of the most contagious diseases (Foot and mouth disease, Swine vescicular disease, Vescicular stomatitis, Classical swine fever, African swine fever, Rinderpest, Peste des petits ruminants, Contagious bovine, Pleuropneumonia, Lumpy skin disease, Rift Valley fever, Sheep and goat pox, Bluetongue, African horse sickness, Highly pathogenic avian influenza, Newcastle disease, West Nile virus) and is accessible through the Web, allowing for real-time recording of new outbreaks. Figure 2.2, 2.3 and 2.4 represents the screenshots.

The map services were created using the Environmental Systems Research Institute (ESRI) internet map server technology (ArcIMS™ 9.0); the geographic layers were shaped and were managed with ArcGIS™ desktop 9.0 and ArcSDE™ 9.0. The geo-database used to collect spatial and epidemiological data was a relational data base management system (RDBMS) based on Oracle® 8.1.7. (Savini et al., 2007).

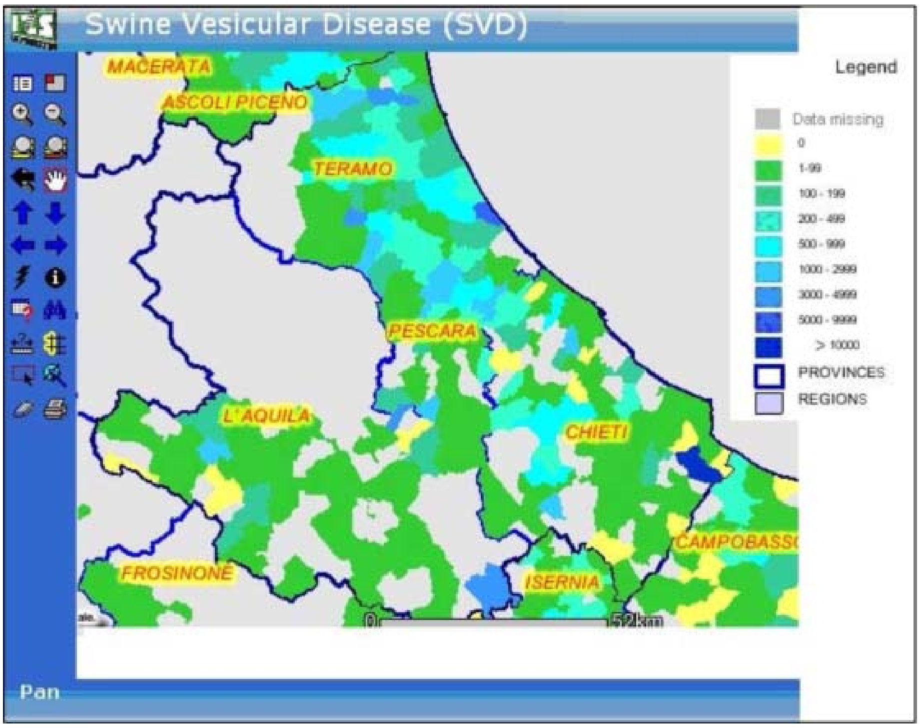

Figure 2.2 Pig density in Abruzzo by administrative unit

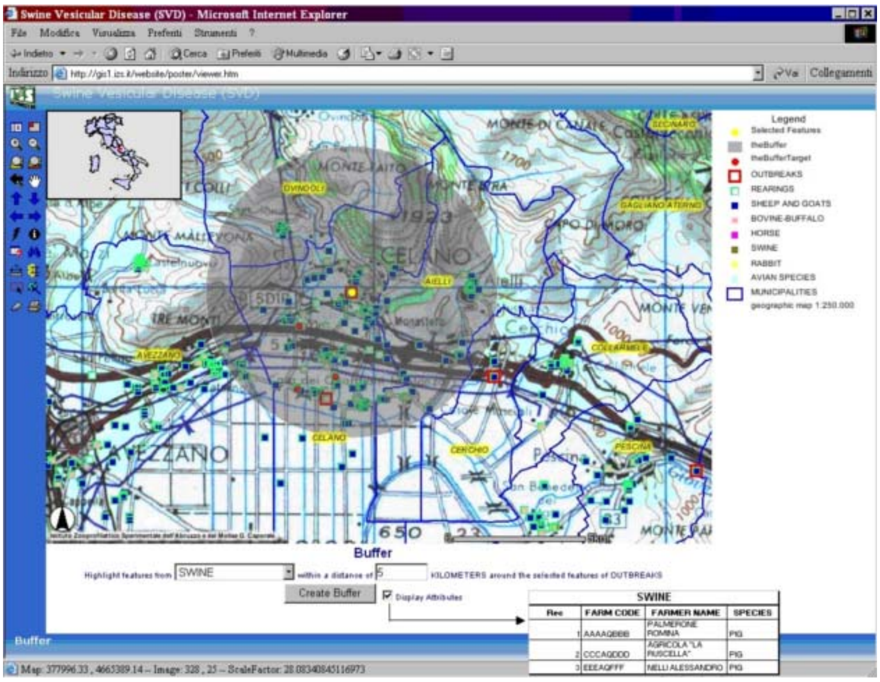

Figure 2.3 All swine farms within a 5-km radius of the outbreak

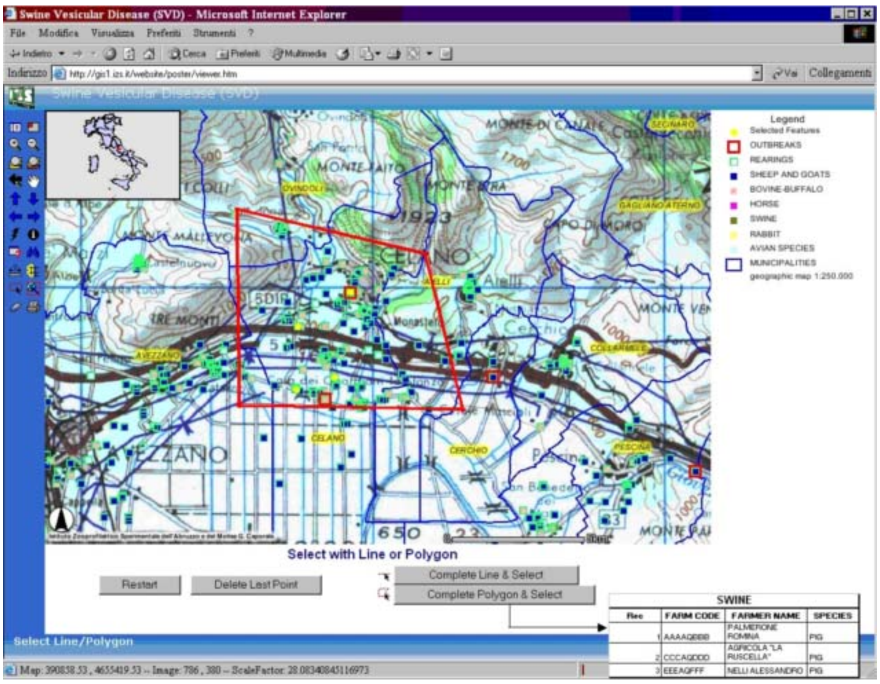

Figure 2.4 All swine farms present in a defined polygonal area

Development and application of geographical information systems (GIS) and spatiotemporal methods in the epidemiology of food borne bacterial zoonoses in Denmark, 2006

The overall aim of this project is to establish a European network for geographic information systems. The major route of transmission of bacterial zoonoses is assumed to be the consumption of contaminated foodstuffs of animal origin. However, in recent years, an increasing number of outbreaks and sporadic cases of infection with VTEC, Salmonella or Campylobacter have been associated with foods of non-animal origin or with non-food-borne routes of transmission. The strong geographic and environmental components in the dynamics of populations that participate in a zoonotic cycle renders GIS and spatio-temporal statistical analyses particularly suitable as tools for the analysis of the complex interactions among host, vectors and pathogen populations (Figure 2.5). The main objectives of the project are; the development of a GIS competence catalogue for European institutions involved in surveillance of food-borne pathogen and diseases, the evaluation of current and future GIS needs within Europe, building a GIS capacity, including training and provision of technical assistance, undertaking a pilot study using available existing data (URL 11).

The use of a Web-based interactive Geographical Information System for the surveillance of bluetongue in Italy, 2002

Since 2000 Italy has experienced five epidemics of bluetongue, an arthropodborne disease that affects primarily sheep and asymptomatically cattle, goats and wildlife ruminants. In four years the disease spread through Southern and Central Italy, involving 14 Italian regions out of 20. To control the disease, the Ministry of Health of Italy established a surveillance system that included clinical, entomological and serological surveillance elements. The National Reference Centre for Veterinary Epidemiology developed a Web-based National Information

System (NIS) and a Geographical Information System (GIS) to collect and manage data from Veterinary Services across Italy. The system was designed to gather and spread information in order to support the management of control activities and to provide an early warning system. Surveillance data are displayed to the user in different ways: reports, tables and interactive maps (Figure 2.6). The system has many objectives as well as determining infected areas, defined as all the municipalities whose boundaries intersect a 20-km radius buffer from an infected holding (clinical outbreak or sentinel animal eroconversion) where the circulation of BTV has been detected in the last 60 days. The infected holding is identified by its latitude and longitude, when provided, or by the administrative boundary of its municipalities (Conte et al., 2005).

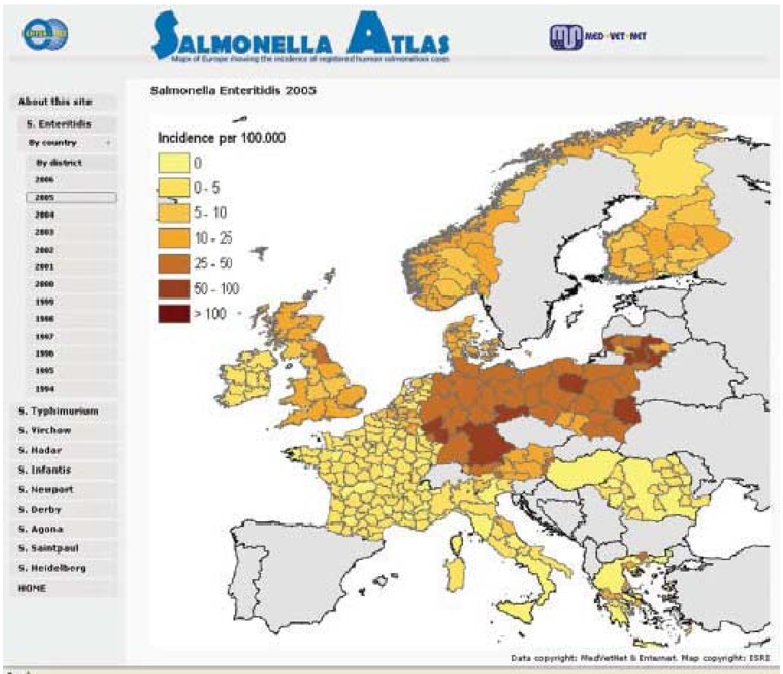

Figure 2.5 Map of Europe showing the incidence of registered human salmonella cases

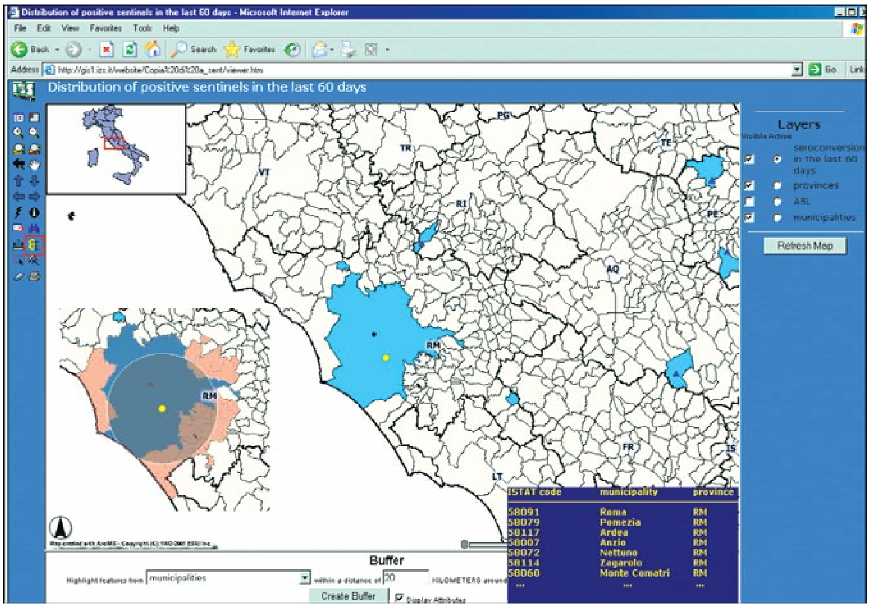

Figure 2.6 20-km buffer around a seroconverted farm and definition of infected municipalities

2.4 Web GIS Architecture

Internet allows all levels of society to access geospatial information, and provides a media for processing geo-related information with no location restrictions. Web-based GIS is evolved from different Web maps and client-server architecture to distributed ones. Disseminating spatial information on the Internet improves the decision-making processes.

In performing the GIS analysis tasks, Web GIS is similar to the client/server typical three-tier architecture. The geo-processing is breaking down into server-side and client-side tasks. A client typically is a Web browser. The server-side consists of a Web Server, Web GIS software and Database (Figure 2.7) (Alesheikh et al., 2002).

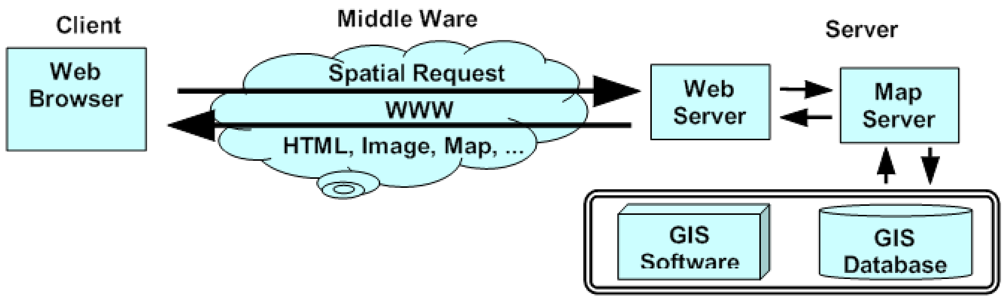

Figure 2.7 How a typical Web GIS model works

In this model processing of geographic queries and serving maps are conducted within three-tier architecture. These tiers are client, web server and map server. The client is used to retrieve maps as image or vector file formats through HTTP, TCP/IP requests and web server transmits client's requests to be processed in the map server tier. Web server mainly operates as a mediator that sends and receives client's requests to be processed by the map server. To differentiate between types of systems architectures, each model is discussed below in detail.

The **thin client architecture (server side applications)** is used in typical architecture. In a thin-client system, the clients only have user interfaces to communicate with the server and display the results. All the processing is done on the server. In server side internet GIS, a web server is used to execute all GIS analysis and map retrieval operations. Vatsavai et al. (2000) mention that tasks can be performed on either web server or a GIS server. The server computers usually have more power than the client, and manage the centralized resources. Besides, the main functionality is on the server side in thin architecture, there is also the possibility for utility programs at the server side to be linked to the server software. Figure 2.8 shows schematic communication between Web browser, Web Server and GIS server.

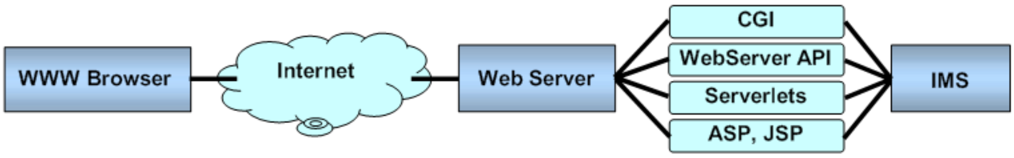

Figure 2.8 Server Side Web-based GIS Model

Takatsuka and Gahegan (2001) state that in thick client architecture (client side applications) spatial data and analysis tools are downloaded to the Web browser with plug-ins (e.g. Applet or an ActiveX component). The plug-in, used in the browser, enables GIS analysis in one single frame. Therefore, the application inherits every static or dynamic function of GIS with these components. As the vector data comes along through server, this data structure could be used in analysis like a regular GIS functionality. This advantage allows various geographic queries to be implemented in the component itself. Furthermore, vector data structure allows better visualization of features, which is extremely important to digital maps with human perspective (Campbell, 2001). Figure 2.9 shows the client side Web-based GIS model.

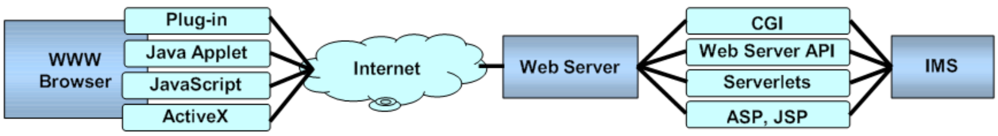

Figure 2.9 Client Side Web-based GIS Model

For avoiding vector data in client side and reducing problems of previous architectures, **Medium Client** is suggested. With using extensions in both client and server side, clients may have more functionally than thin client architecture.

In Figure 2.10 these four components in interactive map are pictured as services, each with interfaces, which can be invoked by clients of that service.

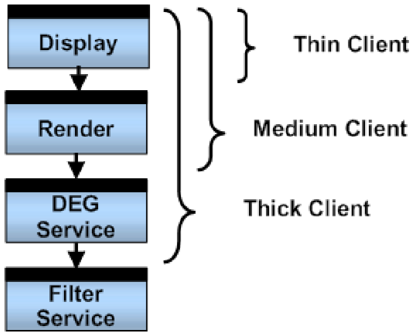

Figure 2.10 Medium Client Architecture

If a user's computer contains just the display service, then that user would be said to be using a thin client. If the user's computer additionally contained a render service, then that user would be said to be using a medium client. And finally, if the user's computer also contained the display element generator service that would indicate the user is using a thick client (Doyle, 1999).

The general idea of the distributed GIS service model is that a client program, in either an internet browser or an independent application, should be able to access the resources distributed in the entire network. The resources here refer to both geodata and geoprocessing components available in the network. The client and the server in this context do not refer to a specific machine. Any machine, when it requests the remote resources during the processing, is a client, and any machine that provides such resources is a server. In a specific program, a client may connect to several servers if needed and a specific machine may be the client at one time and the server at another time. An ideal distributed GIS service model should be a "geodata anywhere, geoprocessing anywhere" model, which means the geodata and geoprocessing tools could be distributed with the largest flexibility virtually anywhere in the network. The geodata and geoprocessing components do not have to be in the same site, but they should be able to cooperate or integrate whenever they are needed to finish a specific task (Yuan, 2000).

The Service Oriented Architecture (SOA) tries to construct a distributed, dynamic, flexible, and re-configurable service system over Internet that can meet information and service requirements of many different users. A Web service is defined by the World Wide Web Consortium (W3C) as "a software system designed to support interoperable machine-to-machine interaction over a network". Service-oriented architecture is a design for linking computational resources (principally applications and data) on demand to achieve the desired results for service consumers (either end users or other services). A SOA is essentially a collection of services. These services communicate with each other. The communication can involve either simple data passing or it could involve two or more services coordinating some activity. Some means of connecting services to each other is needed. The combination of services - internal and external to an organization - makes up a service-oriented architecture. Web services can be used to implement architecture according to service-oriented architecture concepts, where the basic unit of communication is a message, rather than an operation. The core components supporting a service-oriented architecture are presented in figure 2.11. These components include service providers, service consumers, and implementation of a service directory.

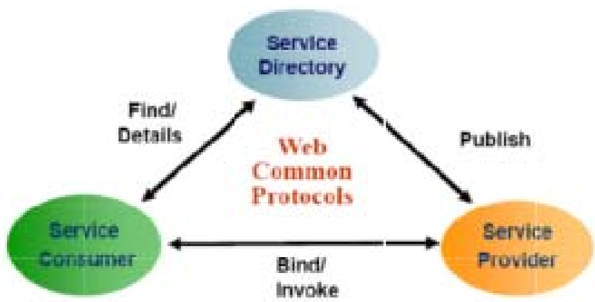

Figure 2.11 Service Oriented Architecture

GIS is by nature a service-oriented technology with inherent fundamental characteristics that bring diverse information systems together to support real-world decisions. GIS services can be grouped into three categories (Sahin and Gumusay, 2008):

Data Services: These types of services are tightly coupled with specific data sets and offer access to customized portions of that data. Web Feature Service (WFS), Web Mapping Service (WMS) and Web Coverage Service (WCS) can be considered in this group. WMS produces maps as two-dimensional visual portrayals of geospatial data. WCS provides access to un-rendered geospatial information. WFS provides geospatial feature data encoded in Geography Markup Language (GML).

Processing Services: These types of services provide operations for processing or transforming data in a manner determined by user-specific parameters. They provide generic processing functions such as projection and coordinate conversion, rasterization and vectorization. Coverage Portrayal Service (CPS), Coordinate Transformation Service (CTS), and even WMS can be considered in this group.

Registry or Catalog Service: These types of services allow users and applications to classify, register, describe, search, maintain, and access information about Web Services. Web Registry Service, Web Catalog Service, and our implementation of registry catalog service, Fault Tolerant High Performance Information Service (FTHPIS), are considered in this group.

2.5 Spatial Decision Support Systems (sDSS)

Spatial Decision Support Systems (sDSS) developed in parallel with the concept of Decision Support Systems (DSS). An sDSS is an interactive, computer-based system designed to support a user or group of users in achieving a higher effectiveness of decision making while solving a semi-structured spatial problem (Sprague and Carlson, 1982).

An sDSS is sometimes referred to as a Policy Support System. A spatial decision support system typically consists of the following components;

- A database management system: This system holds and handles the geographical data. A standalone system for this is called a Geographical Information System, (GIS).
- A library of potential models that can be used to forecast the possible outcomes of decisions.
- An interface to aid the user's interaction with the computer system and to assist in analysis of outcomes.

2.6 Situation in Turkey

Due to its geographical position, Turkey is under potential risks in the scope of animal diseases. Out of the world's estimated 10 billion migratory birds, 1 billion follow migration paths that pass through Turkey, making the country an important route. It is difficult to control animals and products of animal origin in country. In Turkey, epidemiological studies which employed information systems have been limited.

Animal Health Services Department of Ministry of Agriculture and Rural Affairs is responsible for protection and maintenance of animal health. TURKVET Veterinary Information System has been developed since 2004 in the context of a project that has been financed by European Union based on EUROVET. EUROVET aims to improve surveillance of livestock in European Union countries through closer computerized monitoring of animal life history and movements.

TURKVET is an animal health information system for the collection, storage, analysis and reporting of information related to the health of animals in Turkey. TURKVET Veterinary Information System consists of the following modules;

- Animal Diseases Notification System (ADNS),
- Laboratory Sample Management System (SMS),
- Holding records related to poultry,
- Bovine Tracking System (BTS)

TURKVET is an animal health data management system but it is not able to fully incorporate the spatial component of animal health information. A GIS based program had been developed within the scope of TURKVET project for Animal Health Services Department but it did not work efficiently and is not used today. Animal diseases spatial data are managed with the use of manually prepared disease maps.

CHAPTER 3

DATA FOR A GIS FOR ANIMAL HEALTH IN TURKEY

Data related issues are depicted in this chapter. Correct data acquisition, data production, data formats and characteristics are very important issues in a software development period.In section 3.1, content and sources of non-graphical data are described. In section 3.2, graphical data which formed base map are presented. Produced 2006 Avian Influenza case event data, point locations of wetlands of international importance based on waterfowl, main routes of migratory birds in Turkey are covered in section 3.3.

3.1 Non-graphical Data

In Turkey, Animal Health Services Department of Ministry of Agriculture and Rural Affairs is responsible for protection and maintenance of animal health. TURKVET Veterinary Information System has been developed since 2004 in the context of a project that has been financed by European Union based on EUROVET. EUROVET aims to improve surveillance of livestock in European Union countries through closer computerized monitoring of animal life history and movements.

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- Laboratory Sample Management System (SMS),
- Holding records related to poultry,
- Bovine Tracking System (BTS)

ADNS, BTS and SMS modules form the main system and all directorates of the Ministry of Agriculture, field services, institutes and veterinarians have been making data entry to the system. Field veterinary services are organized through 81 provincial livestock offices, and 921 district offices. The usual flow of animal health information is from the animals and their owners, up through the district, provincial and regional offices, to the central administration. Village livestock information (population, disease outbreaks) is reported, data gathered from livestock markets (vaccination records, numbers of animals) is collected by district veterinary officers, and livestock movements are reported at checkpoints. Turkey has a central veterinary authority (General Directorate of Protection and Control) and each province has a veterinary department. Information of holdings and herds, animals, animal movements, diseases, sanction/restrictions are all kept in the system. Entered data are kept with Oracle in a central database via a web based application (developed with asp.net technology). Veterinarians in regional offices are entering and updating data via this web based software.

The source of all the tabular data used in this study is TURKVET Veterinary Information System database. Data for WEB GIS based animal diseases surveillance system is based mainly upon:

a) **Recordings of all suspected and confirmed disease cases in terms of date, district and provinces of Turkey.**

The structure of the table which “Disease date query” uses is available in Table 3.1. In the thesis, ten kinds of animal diseases (Avian influenza, Foot-and-mouth disease, Pest des petits ruminants, Rabies, Sheep-Goat Brucellosis, Sheep and goat pox, Cattle brucellosis, Bovine tuberculosis, Anthrax, Bluetongue) information have been used which were obtained from TURKVET database on 09/27/2008. They are the most prevalent animal disease cases in Turkey and zoonoses (animal diseases transmissible to humans) diseases (URL 12).

Table 3.1 Structure of DISEASE_DATE Table

FIELD NAME	DESCRIPTION
NOTIFICATION_ID	Unique ID for each disease notification
DISEASE_OIE_CODE	Code of the disease
NOTIFICATION_DATE	Notification date of the outbreak
CONFIRMATION_DATE	Confirmation date of the outbreak
DATE_OF_END_OF_SICKNESS	Date of end of sickness
LEVEL_1_CODE	Code of regions of Turkey
LEVEL_2_CODE	Code of province
LEVEL_3_CODE	Code of district
LEVEL_4_CODE	Code of village

b) Data about animal counts according to animal types in terms of provinces and districts in Marmara and Aegean regions.

"Animal Count Query" uses the EV_ANIMALS table to produce thematic maps from number of animals according to their types (Table 3.2).

Table 3.2 Structure of EV_ANIMALS Table

FIELD NAME	DESCRIPTION
ANIMAL_IDENTIFIER	Unique ID for each animal
ANIMAL_SPECIES_CODE	Animal type information
BIRTH_DATE	Birth date of the animal
DEATH_DATE	Death date of the animal
LEVEL1	Code of regions of Turkey
LEVEL2	Code of province
LEVEL3	Code of district
LEVEL4	Code of village

c) Recordings of animal holdings; number, type

"Holdings Query" uses the EV_HOLDINGS table to produce thematic maps from number of holdings according to their types (Table 3.3).

Table 3.3 Structure of EV_HOLDINGS Table

FIELD NAME	DESCRIPTION
HOLDING_NUMBER	Unique ID for each animal holding
HOLDING_TYPE_CODE	Code which defines type of holding
HOLDING_SUBTYPE_CODE	Code which defines subtype of holding
LEVEL_1_CODE	Code of regions of Turkey
LEVEL_2_CODE	Code of province
LEVEL_3_CODE	Code of district
LEVEL_4_CODE	Code of village

3.2 Graphical Data

Spatial data collection and database construction is important to ensure the GIS provide appropriate information to decision makers, because the data quality in the database affects secondary information quality. A well-prepared database can make analysis fast and efficient and provides versatile support in animal health decision making. Data collection using Global Positioning System (GPS), and collection of spatial data from other sources such as federal, state, or local government agencies, are typically necessary for spatial database construction.

3.2.1 Country Files

Geographical and administrative units of Turkey were included in this study as base layers of GIS. All administrative units (provinces, districts, villages and neighborhoods), lakes, rivers, 3D relief and animal holdings were added to the ESRI ArcMap 9.3 application in shape file format with WGS 84 Lambert Conformal Conic projection.

Turkey data were taken from RSGIS Ltd. Company with the permission of General Command of Mapping (GCM) which is the authority for preparing and supervising the distribution of maps in Turkey. Table 3.4 lists the structure of all layers used as base map whereas Figure 3.1 represents the screenshot. The

‘Animal Holdings’ layer has been achieved from the General Directorate of Protection and Control of Ministry of Agriculture and Rural Affairs.

3.2.2 Digital Elevation Model (DEM)

A Digital Elevation Model (DEM) is a digital representation of ground surface topography or terrain. It is a digital model of altitude retrieved from a set of height values (Heywood et al., 2002). In any geographical analysis, a DEM can be of great use given its capacity to represent elevations or Z values of the entities as well as the locations in horizontal and vertical dimension. Parallel to the developments in satellite imagery DEM provides accurate results for large areas like Turkey. Figure 3.2 shows the DEM of Turkey.

Factors related with elevation which may have effect on the distribution of Avian Influenza disease such as mean altitude and variation of altitude were all derived by the DEM.

3.3 Produced Auxiliary Data

3.3.1 Avian Influenza Case Event Data

Turkey has experienced outbreaks of H5N1 HPAI in domestic poultry every year since October 2005. The initial case was in the northeast of the country in October 2005, affecting a single free range flock of turkeys. From December 2005 to March 2006, an extensive epidemic occurred, starting in the east and then spreading over the whole country, which resulted in 230 outbreaks and 12 human cases, including four fatalities. In February 2007, 19 outbreaks were confined to

Table 3.4 Structure of Base map Layers

LAYER NAME	DESCRIPTION	ATTRIBUTES	GEOMETRY TYPE
Animal Holdings	Point locations of animal holdings	ID, CODE, SETTLEMENT_CODE, TYPE	Point
Villages	Villages center	ID, CODE, NAME	Point
District centers	District centers	ID, CODE, NAME	Point
Province centers	City centers	ID, CODE, NAME	Point
River	River network	ID, NAME	Polyline
Roads	Road network	ID, NAME	Polyline
Wetlands_A	Wetland boundary	ID, NAME	Polygon
Lake	Lake areas	ID, NAME	Polygon
Neighborhood	Neighborhood boundaries	ID, CODE, NAME	Polygon
District	District boundaries	ID, CODE, NAME	Polygon
Provinces	City boundaries	ID, CODE, NAME	Polygon
Regions	Region boundaries	ID, CODE, NAME	Polygon
3D relief of Turkey	3D map of Turkey		Raster

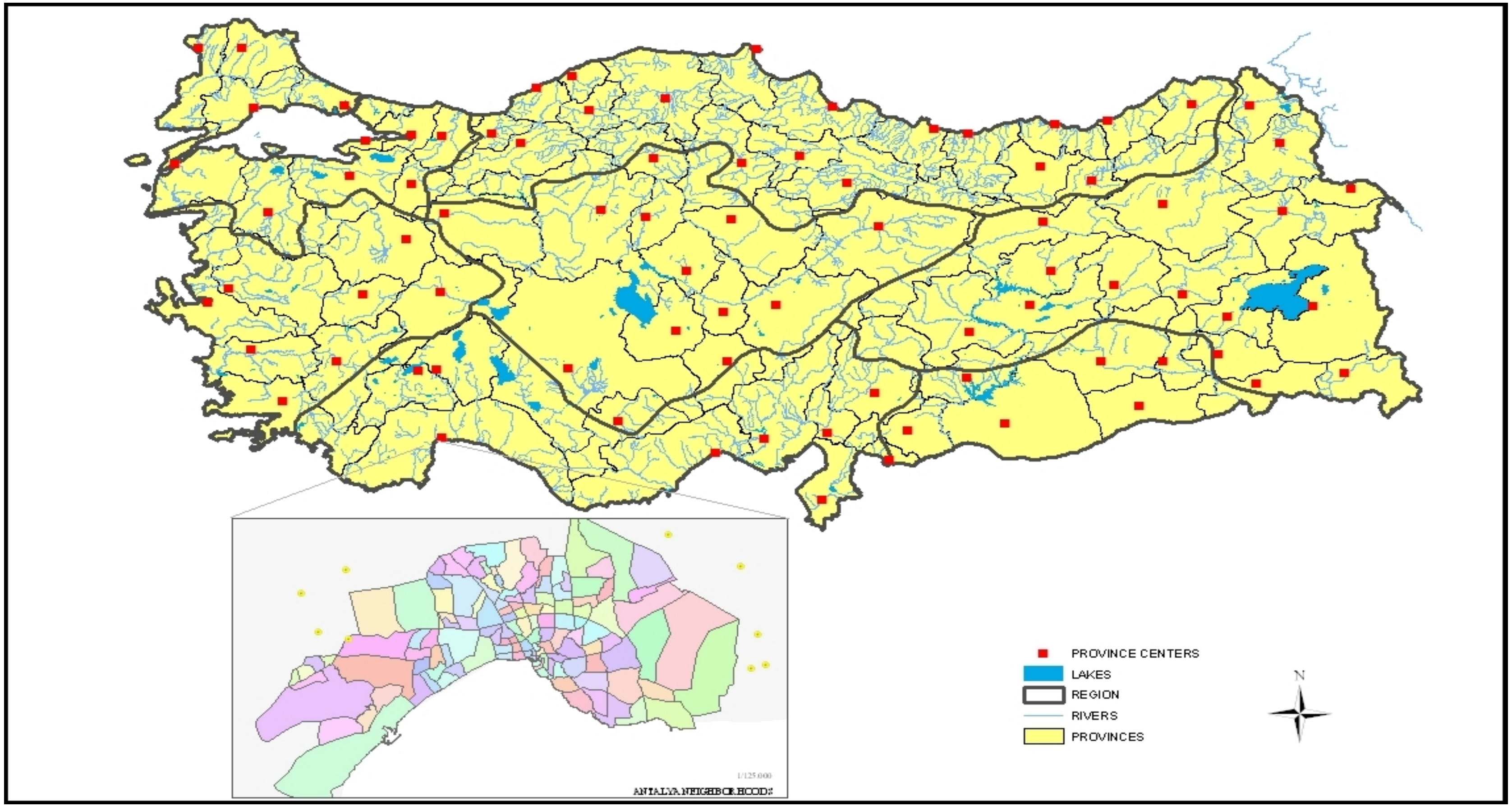

Figure 3.1 Country Layers of Turkey

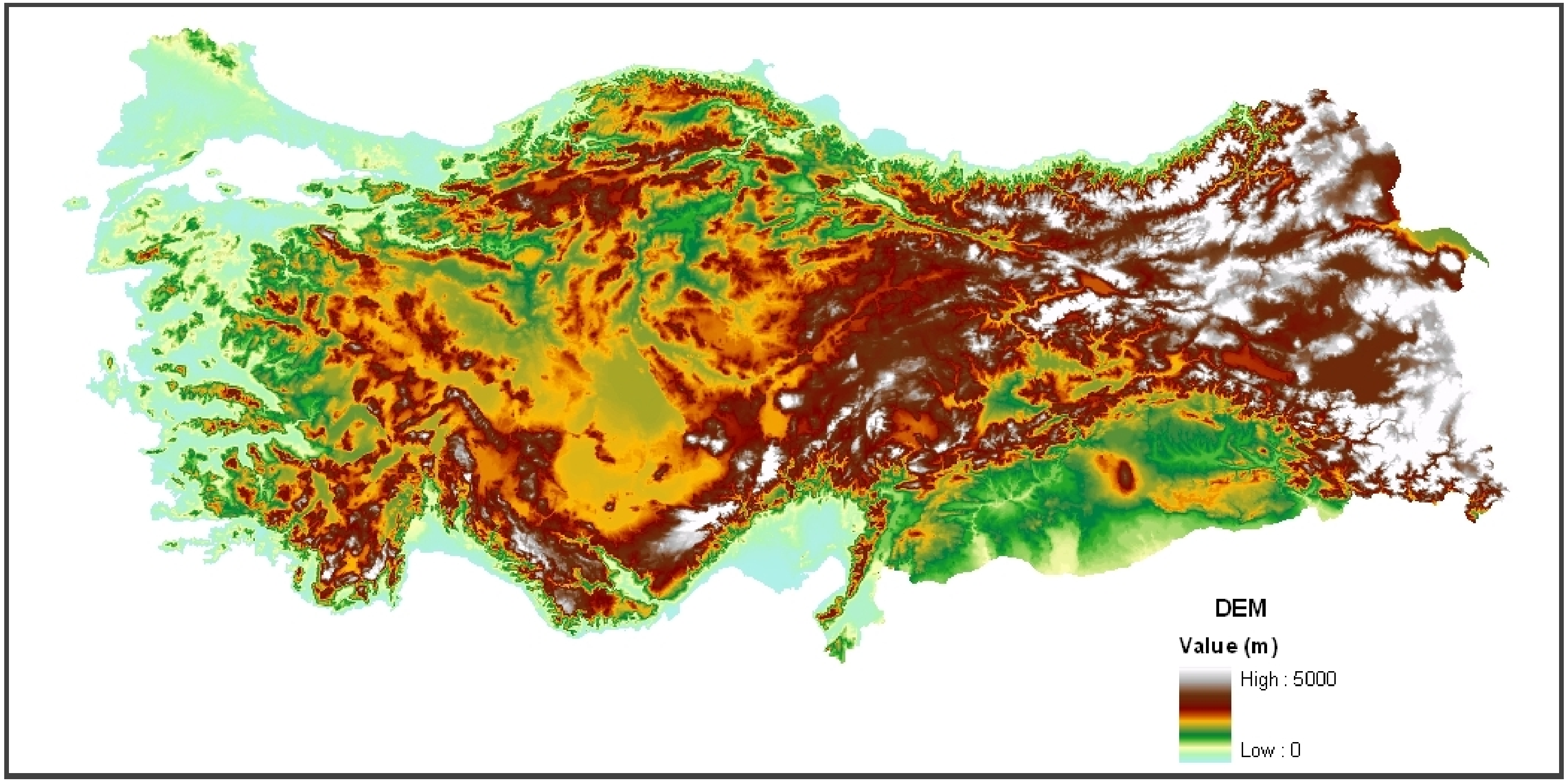

Figure 3.2 DEM of Turkey

southeast Turkey. In January and February 2008, six outbreaks occurred along the Black Sea coast of Turkey (URL 13).Since its first appearance in 2005, highly pathogenic Avian Influenza H5N1 has become a recurrent disease in Turkey. It continues to make yearly and seasonal incursions in poultry, where the severity of its impact depends on the extent of peripheral spread of the virus from initial foci of infection. It is therefore important to improve knowledge about the circulation of avian influenza viruses.

The outbreak site of a disease is called ‘focal point’. It is the point at which a disease first appears or first gets suspicious about. Disease outbreak site has been recorded in terms of a village, city, district or neighborhood. All focal points of infection are kept with event time and location information in the system.

In the context of case event data, this study focused on the 2006 Avian Influenza (AI) outbreaks consisting of 197 cases occurring in Turkey. The list of AI outbreaks in 2006 is available in Appendix A. Description of the disease location includes “Notification Date”, “Confirmation Date” of the disease, “Date of end of Sickness”, Province, District, Village, Neighborhood names for each bird flu outbreak. This list has been derived from the “Diseases” table used in TURKVET Veterinary Information System project on 09/27/2008.

The single most important factor behind the difficulty was the imperfect description of the locations. The point locations of the AI disease could be a village, city center or holding location. To plot disease cases on a map has always been part of epidemiology. Each AI outbreak event has been located as a point feature on the map. For neighborhood, centroids of the polygon features are assumed as the true incident locations.

A point feature class was created named BIRDFLU_2006, which has WGS 1984 Lambert Conformal Conic projection in ArcCatalog 9.3. The attribute fields of the

BIRDFLU_2006 layer are defined as in Table 3.5. Geographical location of each outbreak has been integrated into GIS as point feature on ArcGIS 9.3 environment by using country files as base map according to the list given in Appendix A. Each Avian Influenza event point has been digitized manually with sketch tool in ArcGIS 9.3 environment. Distribution of 2006 Avian Influenza outbreak is displayed in Figure 3.3.

Table 3.5 Structure of the BIRDFLU_2006 layer

FIELD NAME	DATA TYPE	LENGTH	DESCRIPTION
ID	Long Integer	6	Unique identifier number for each case
NOT_DATE	Date	8	Notification date of the outbreak
CON_DATE	Date	8	Conformation date of the outbreak
END_DATE	Date	8	Date of end of sickness
LEVEL_2	Text	30	Province name
LEVEL_3	Text	30	District name
LEVEL_4	Text	30	Focal point (village or neighborhood) name

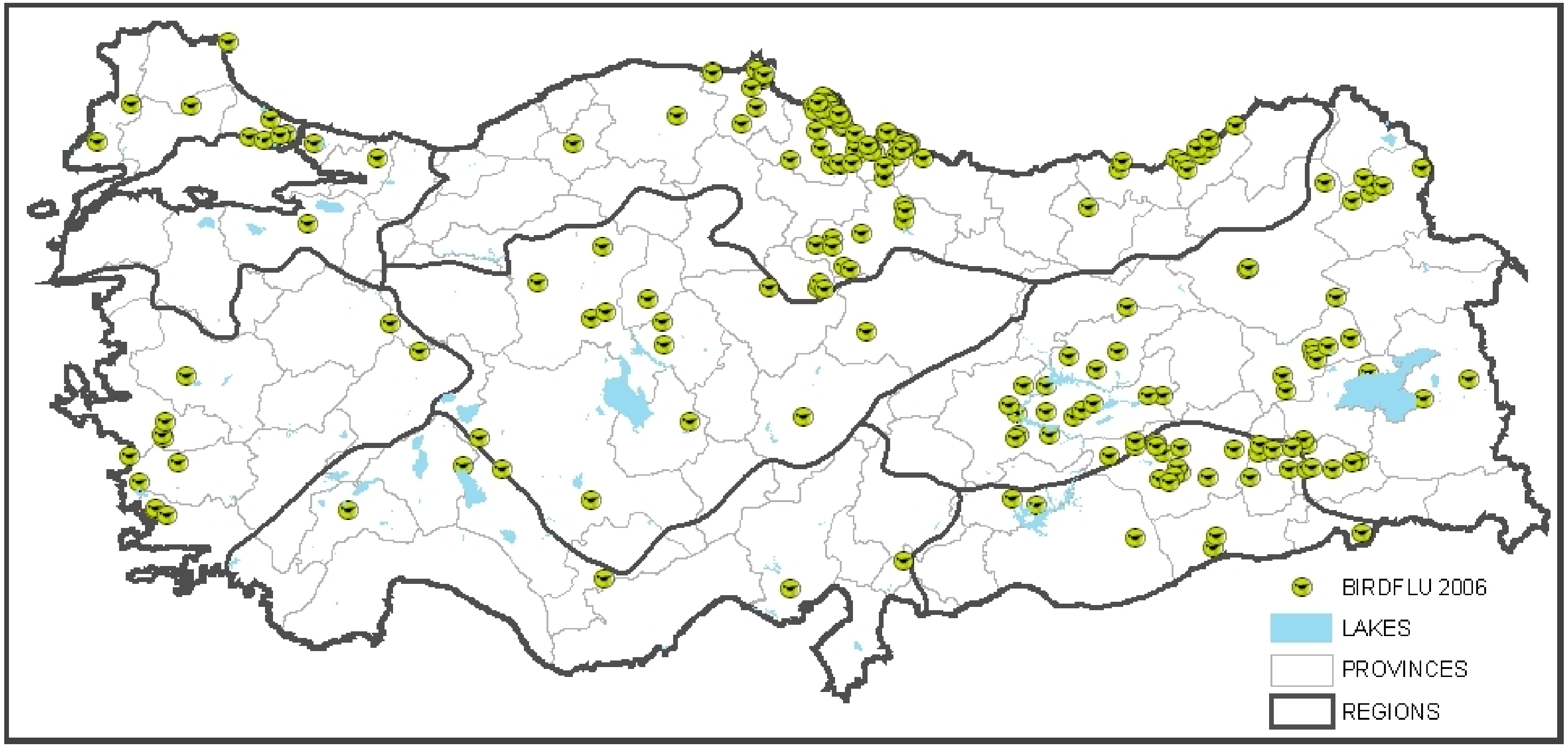

Figure 3.3 Distribution of 2006 Avian Influenza outbreak in Turkey

3.3.2 Wetlands

Avian Influenza outbreaks − both high and low pathogenic − in poultry are often assumed to result from exposure to wild birds. Waterfowl and shorebirds can be infected by all subtypes of influenza A viruses with few or no clinical signs (Ward et al., 2007). It is generally accepted that waterfowl play an important role in the generation, spread, and transmission of Avian Influenza (AI). Wetlands have international importance especially as waterfowl habitat. Under the text of Ramsar Convention (Article 1.1) wetlands are defined as; "areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters". Wetlands are the most important ecosystems, for wild birds, and there are many important examples in Turkey. The list of wetlands of international importance in Turkey is available in Appendix B which was obtained from Department of Natural Protection of Ministry of Environmental and Forestry on 08/05/2008.

Geocoded locations of the wetlands are needed in this thesis to calculate distance from each avian influenza event case to the nearest wetland. So it is possible to evaluate whether the cases occur near water bodies or not. Positions of wetlands were represented in latitude and longitude in geographic coordinate system in degrees and minutes. To add tabular data that contains geographic locations in the form of latitude and longitude coordinates to the map as a layer; ‘Add XY Data’ tool of ArcGIS 9.3 ‘Tools’ menu was used.

To create a point Wetland layer from x, y coordinates, the coordinates need to be in decimal degrees. The following formula was used to convert Degree Minutes Seconds (DMS) data into decimal degrees;

$$\text{Decimal Degrees} = \text{Degrees} + ((\text{Minutes} / 60) + (\text{Seconds} / 3600))$$

WETLANDS point layer with its attribute fields as illustrated in Table 3.6 has been created and its coordinate system has been changed to WGS 84 Lambert Conformal Conic with ArcToolbox, Project (Data Management) utility. Map of wetlands of international importance in terms of waterfowls is illustrated in Figure 3.4.

Table 3.6 Structure of the WETLANDS layer

FIELD NAME	DATA TYPE	LENGTH	DESCRIPTION
ID	Long Integer	6	Unique identifier number for wetland point
NAME	Text	50	Name of the wetland
PROVINCE	Text	30	Name of the province of wetland
X	Double	-	X coordinate value in decimal degree
Y	Double	-	Y coordinate value in Decimal Degree

3.3.3 Terrain

Elevation, slope and aspect may have an effect on Avian Influenza outbreaks. In order to quantify the respective factor, DEM of Turkey was utilized by 3D Analyst extension of ArcGIS 9.3.

Aspect and slope layers in WGS 84 Conformal Conic spatial reference were derived and are shown in Figures 3.5 and 3.6 respectively. Slope dataset has been created by using degree as the measurement unit and 100 cell size of the output raster.

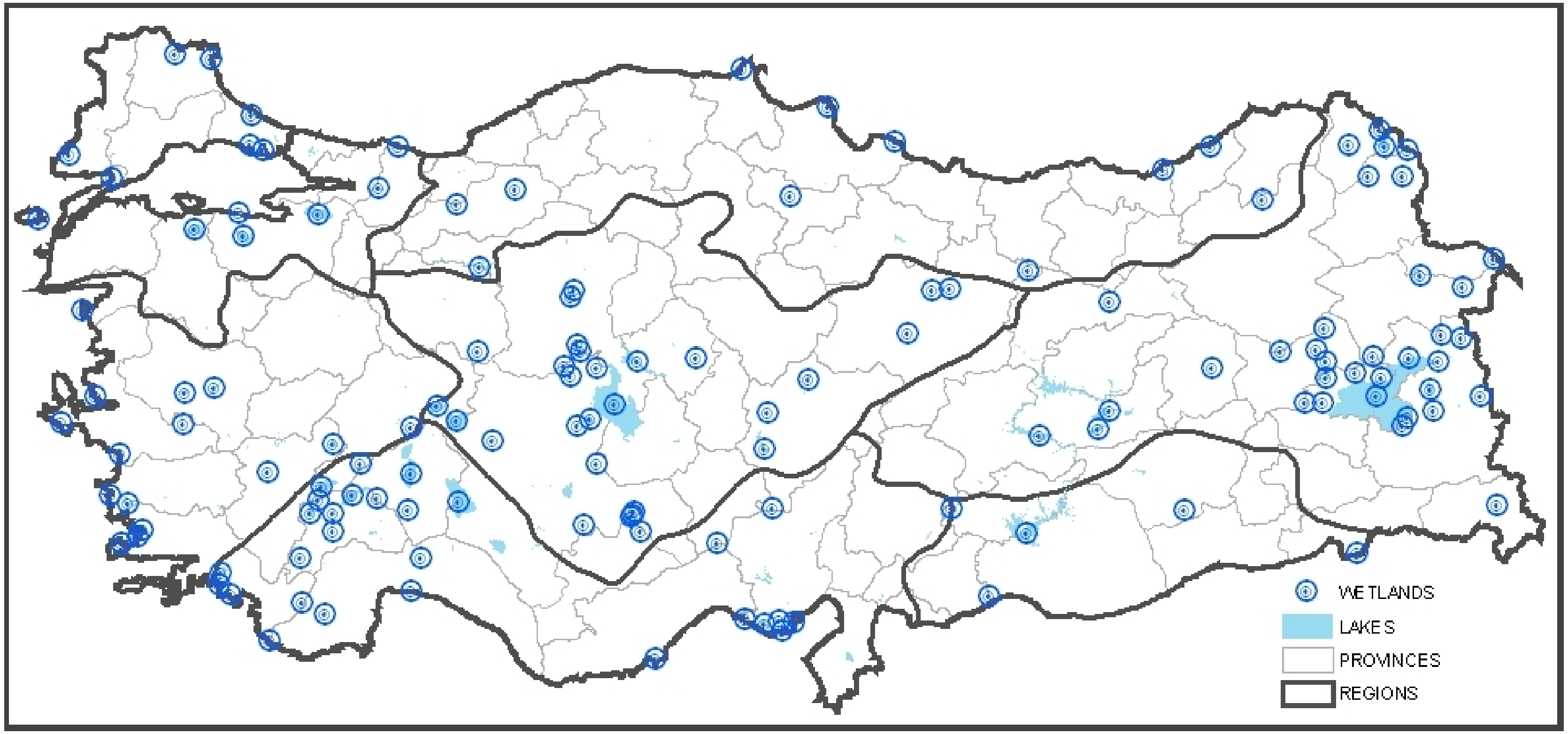

Figure 3.4 Map of wetlands of international importance in Turkey

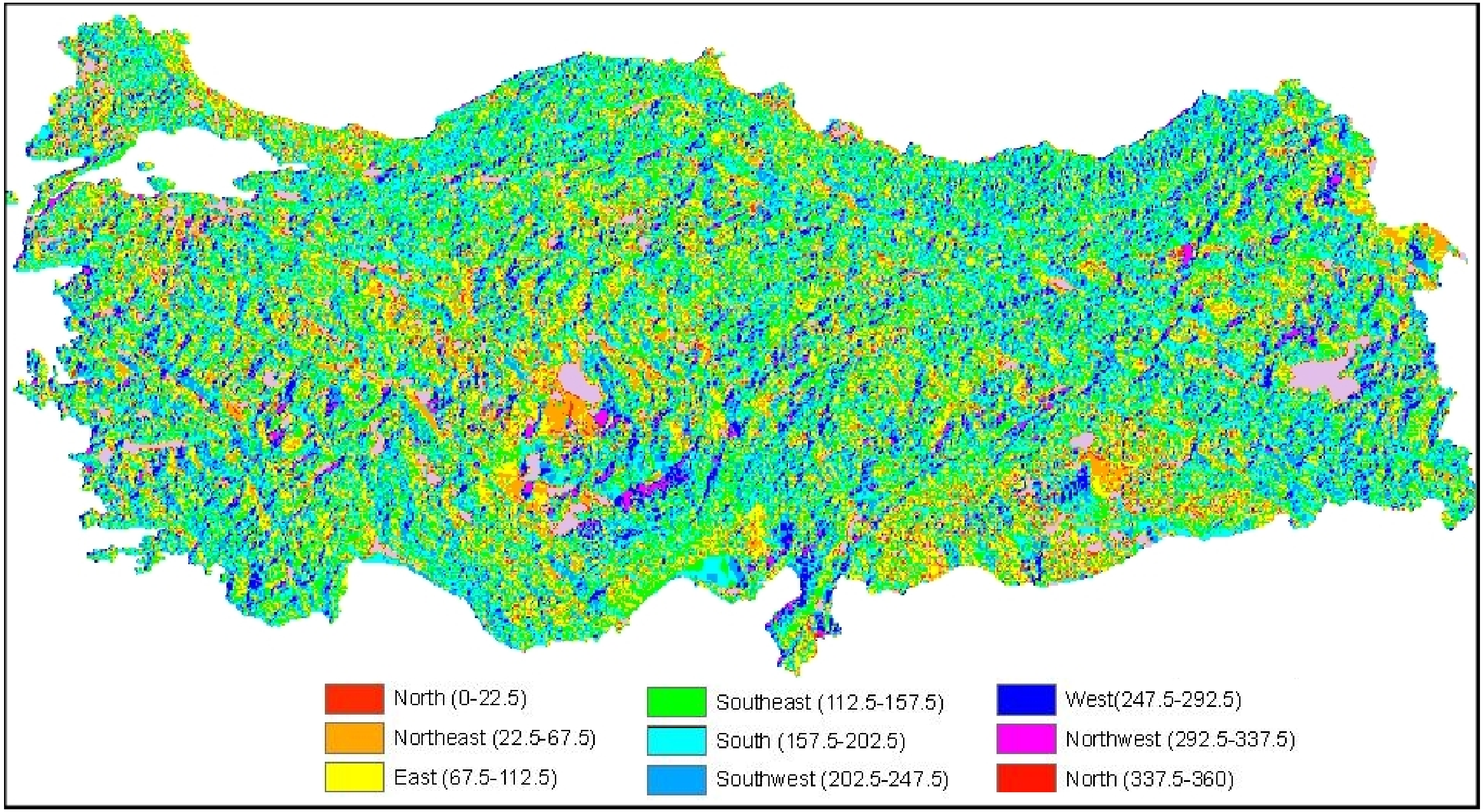

Figure 3.5 Produced aspect raster of Turkey

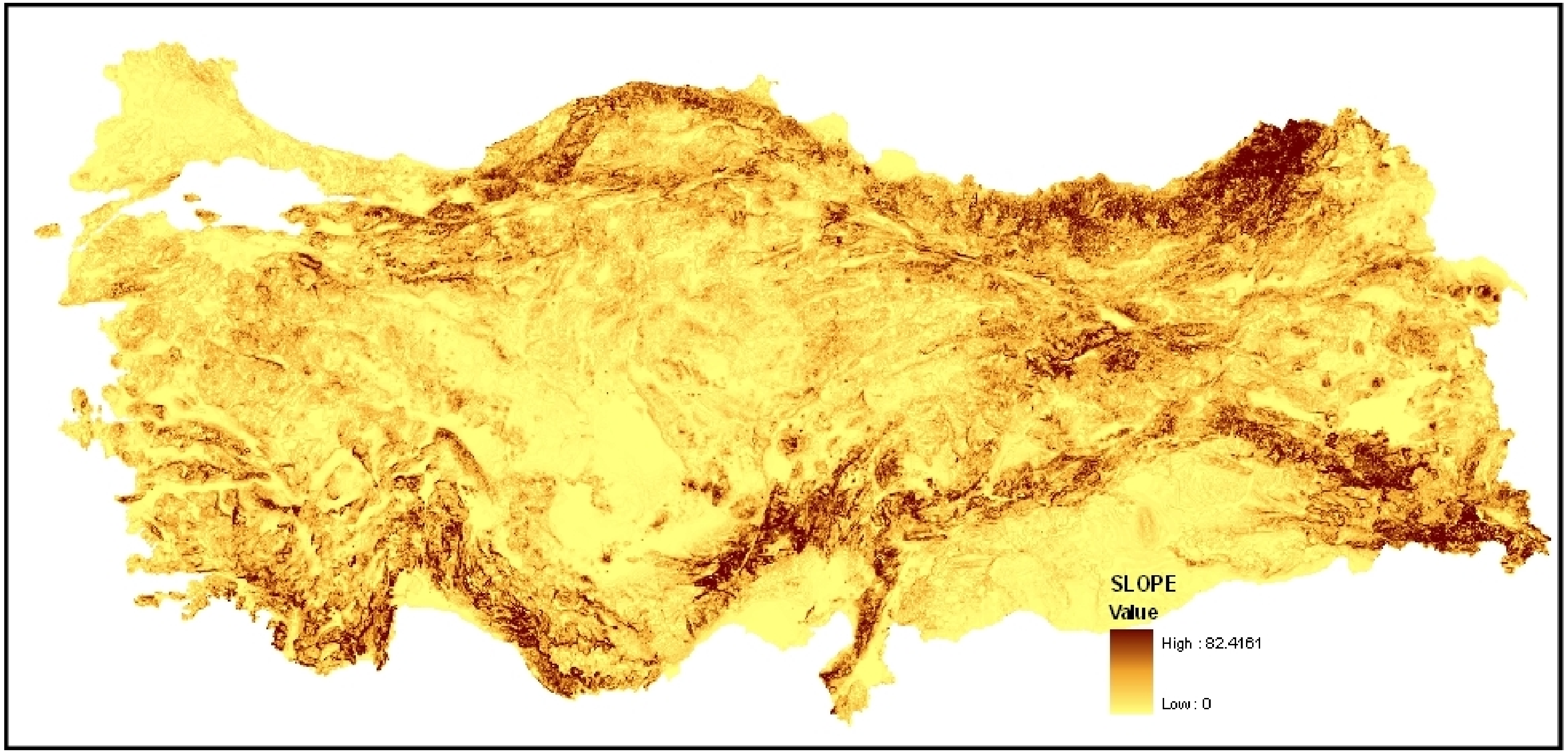

Figure 3.6 Produced slope raster of Turkey in degrees

3.3.4 Temperature

Highly pathogenic viruses can survive for long periods in the environment, especially when temperatures are low. For example, the highly pathogenic H5N1 virus can survive in bird faeces for at least 35 days at low temperature (4^oC). At a much higher temperature (37^oC), H5N1 viruses have been shown to survive, in faecal samples, for six days (URL 14).

In order to express the effect of temperature on bird flu, average temperature values of the notification month for each bird flu case in terms of its location have been procured from State Meteorological Works (SMW). The average temperature values in ^oC unit for each location are available in Appendix A.

3.3.5 Main Routes of Migratory Birds

Avian Influenza is a transboundary disease that affects the entire world due to its epidemiology. The disease agent is carried to the countries located on migratory routes via migratory birds, and occasionally causes outbreaks. The paper map of routes of migratory birds has been achieved from Ministry of Environment and Forestry on October 2008. The image is registered into WGS 1984 Lambert Conformal Conic with Georeferencing Toolbar of ArcMap 9.3.

ROUTES polyline layer has been created and its features-migratory routes have been digitized (Figure 3.7). The way of routes is from north to south direction. Migratory birds are following these routes to reach the wetlands in Turkey.

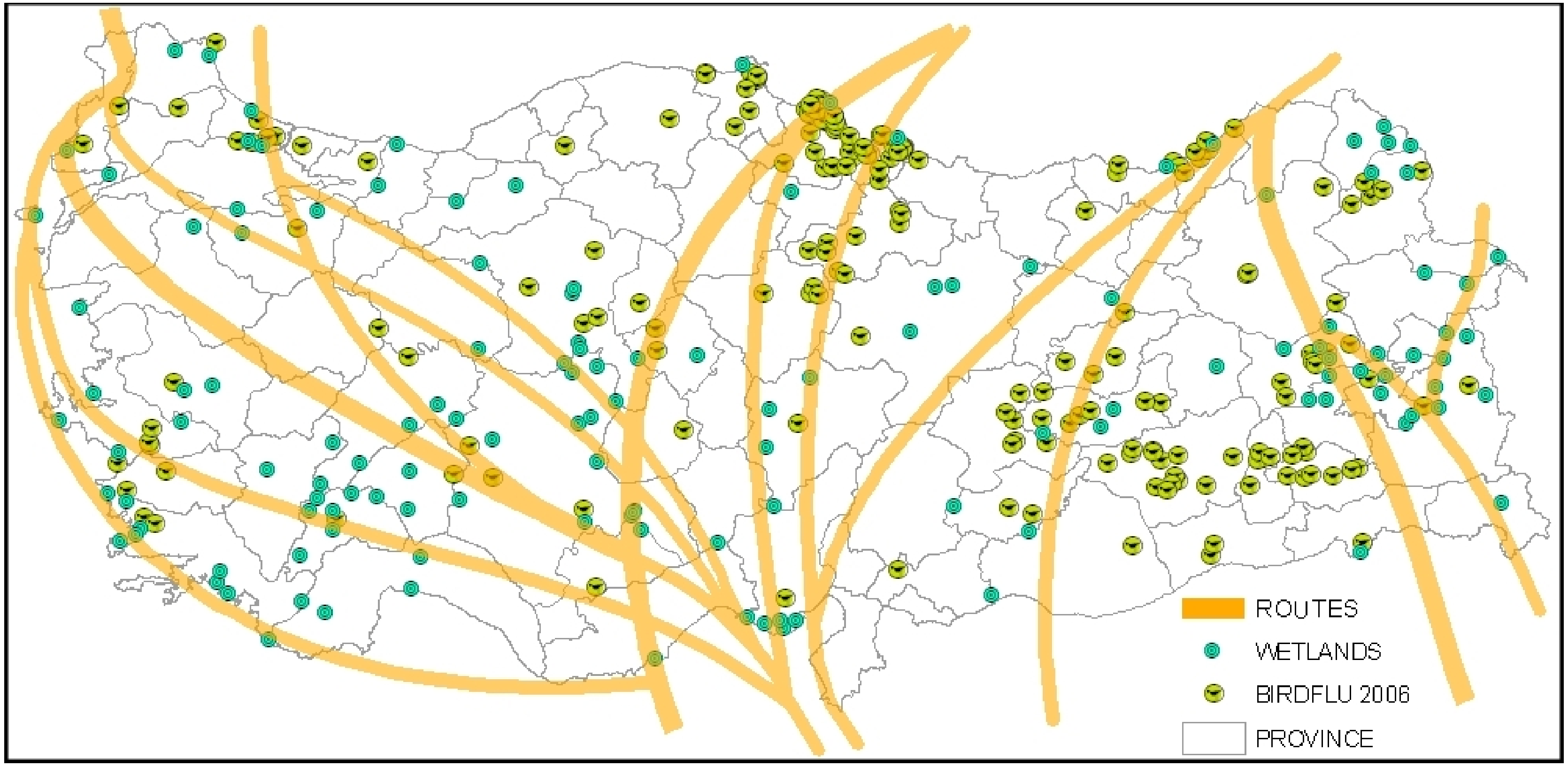

Figure 3.7 Main Routes of Migratory Birds

CHAPTER 4

WEB BASED SYSTEM DESIGN PROCESS

An internet-based or web-based mapping application allows users to utilize spatial data in their work through a Web interface without any extra GIS training or software. With a Web-based interactive mapping service, a user can use spatial data through a familiar internet browser, interact with the data and create a customized output. The advantage for the user is using the functionality of the application without having to purchase or learn any GIS software. Web based mapping supports visualization, analysis and decision-making, just as desktop GIS does.

In this chapter, system design process is evaluated. In this study, two major phases were appraised to form a web based GIS application. These phases are (i) designing of the web based animal diseases surveillance application (ii) associated analysis and evaluation of animal health and surveillance based on the spatial data.

Web based GIS application provides two major user needs;

a. Animal diseases surveillance
b. Emergency preparedness and response

In this chapter, the design of the database of the animal disease surveillance is discussed in section 4.1. Then, system development and components are presented in section 4.2. The research framework of the application in the study is summarized in Figure 4.1.

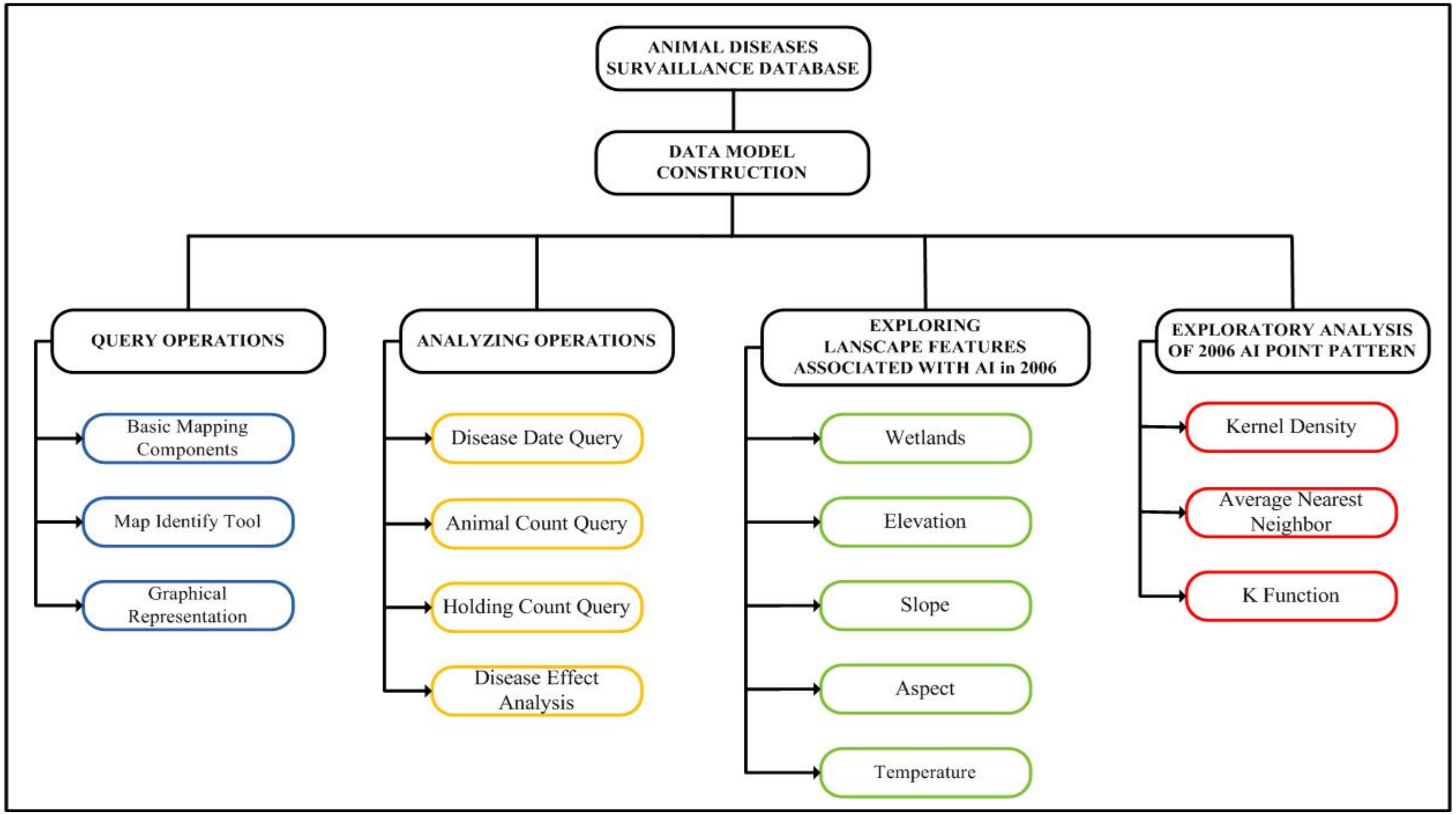

Figure 4.1 Research Framework of the Study

4.1 Database Design and Management for Animal Disease Surveillance

Before designing a database, the strategy of the business should be decided and then the analysis of the problem and the related data should be examined thoroughly. There are three distinct phases of database design (Figure 4.2). The first phase is the determination of data. If the data are not what are really needed in the database model, nothing further will be accomplished. The second phase of database design involves the determination of the relationships inherent in the data. The third phase of database design involves the creation and superimposition of a control system over the database. Finally management of the database system is ended by building the main frames of the system.

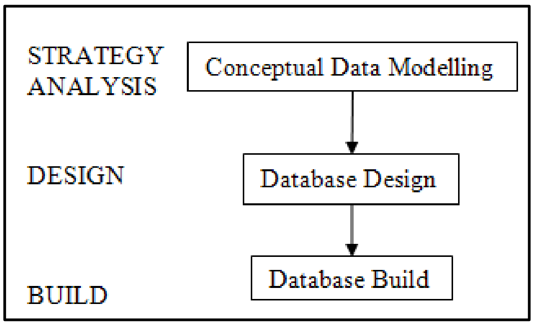

Figure 4.2 Phases of Database Design (Miller and Shaw, 2001)

The data models are composed of three major components;

(i) entity types,

(ii) general integrity rules,

(iii) operators.

Entity types are the basic building blocks for the database. The second component is integrity rules which control the occurrences of entities in the database. The final component of data model includes operators that can be applied to the entities in the database (Miller and Shaw, 2001).

Conceptual data models describe the organization of data at a high level of abstraction, without considering the implementation aspects. The entity-relationship and the extended entity-relationship models are the most widely used conceptual data models. These models provide a series of concepts such as entities, relationships, attributes, capable of describing the data requirements of an application in a manner that is easy to understand and independent of the criteria for managing and organizing data on the system. A logical data model translates the conceptual model into a system-specific data scheme, while low-level physical data models provide the details of physical implementation (file organization and indexes) on a given logical data model (Fisher, 2004).

Web GIS Based Animal Diseases Surveillance Application has two stages in terms of database design; (i) tabular database design and integration of data (ii) integration of spatial database and tabular data.

4.1.1 Tabular Database Design

The source of all the tabular data used in this study is TURKVET Veterinary Information System database of Ministry of Agriculture and Rural Affairs. The database design and table structures of TURKVET database are shown in Figure 4.3. As shown in this figure, the data required for this study are hidden in many tables with many columns in Oracle database. In order to simplify the database and make it suitable for the program, Microsoft SQL Server Management Studio module which comes with SQL 2005 database program was used (Figure 4.4).

When importing data from one database to another, one of the biggest problems that can be faced is data incompatibility. In this study, import process has been

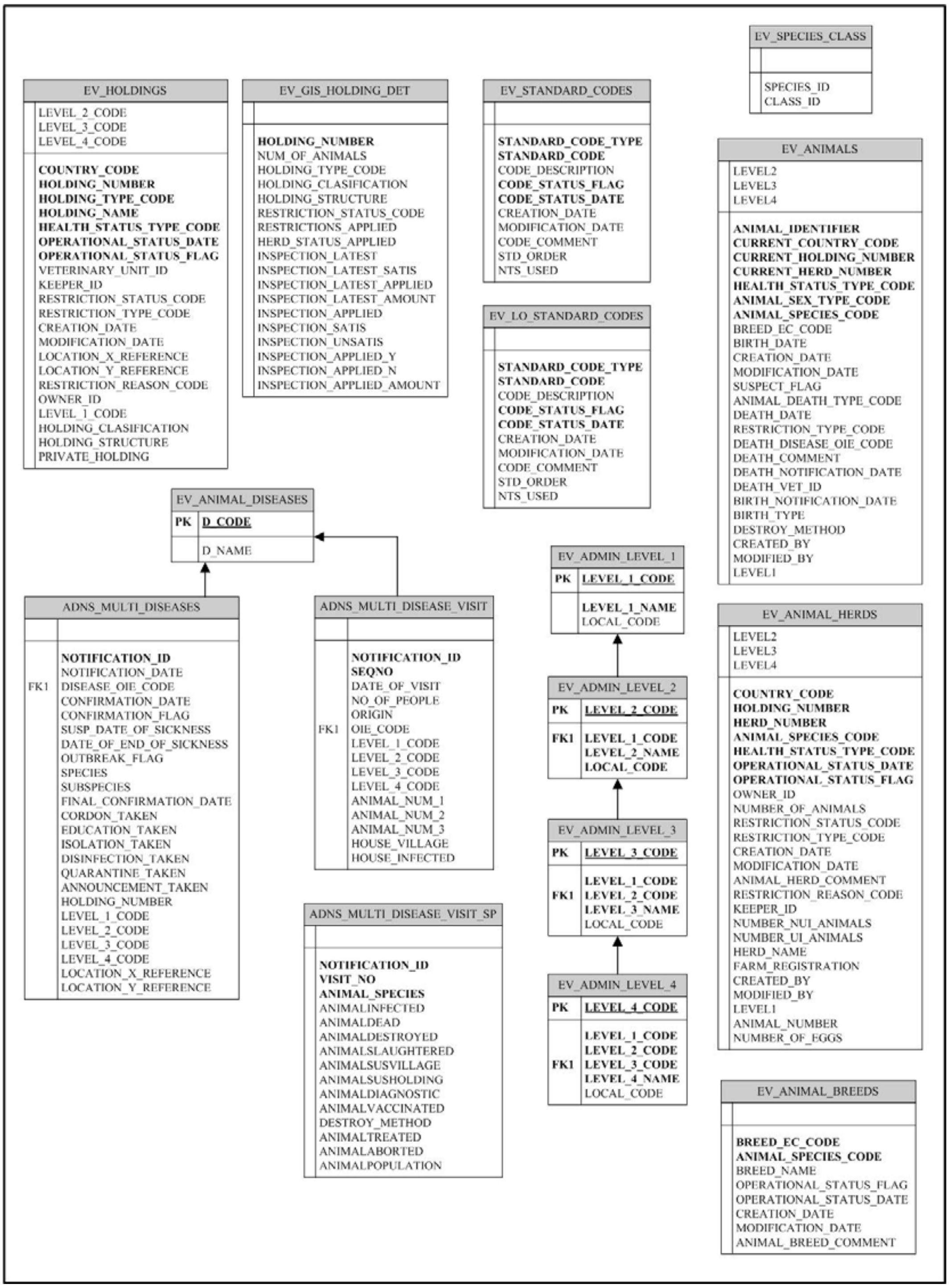

Figure 4.3 Structure of required part of TURKVET database for this study

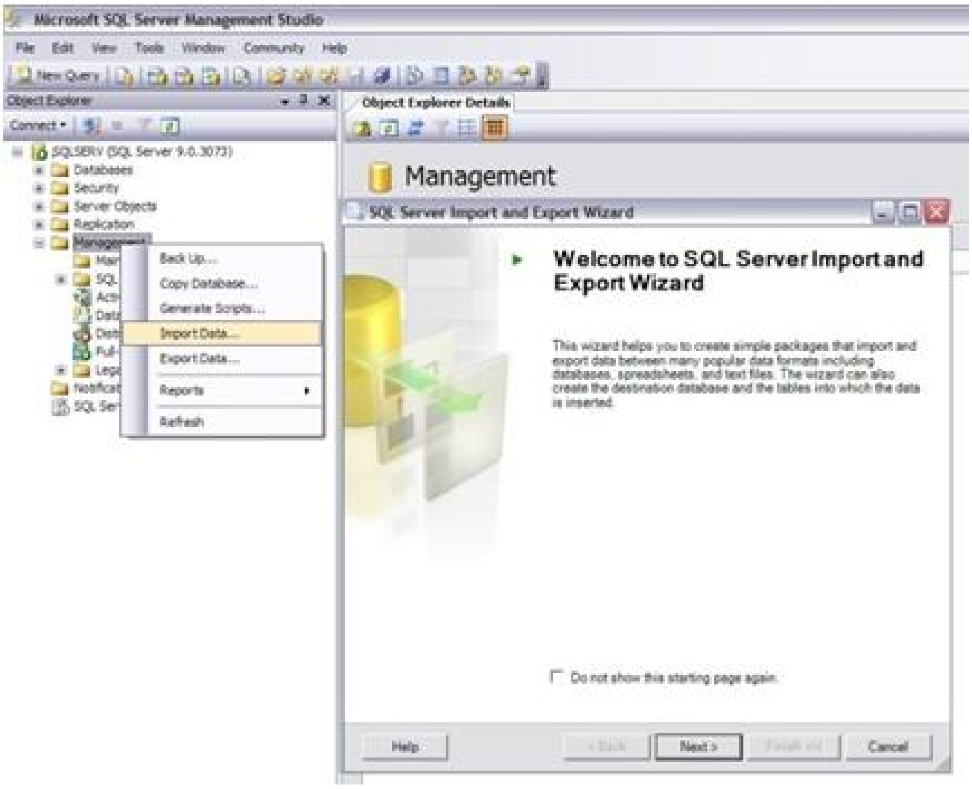

Figure 4.4 Microsoft SQL Server Management Studio page

made with ‘SQL Server Import and Export Wizard Tool’ of ‘Microsoft SQL Server Management Studio’ by setting type mappings. As a result; in the first step a copy of original database has been created within SQL Server 2005 database. In the second step, the columns that are not used in the program have been deleted. The data in different tables have been integrated into a new database, and simple table structures have been created to be used in the program. This situation shortens the query time and makes the program to run faster. Animal health surveillance database may have various members depending on the problem. Animal diseases, animal types, animal counts, holdings can be included in the database. Each data table, which is basically the entities of the database and the attributes which are connected with these entities are showed in Figure 4.5.

DISEASE_DATE Entity Database Schema

Notification_ID	Disease_OIE_Code	Disease_Name	Notification_Date	Confirmation_Date	Date_Of_End_Of_Sickness	Disease_Status_ID

Disease_Status	Level_1_Code	Level_1_Name	Level_2_Code	Level_2_Name	Level_3_Code	Level_3_Name	Level_4_Code	Level_4_Name

EV_ANIMALS Entity Database Schema

Animal_Identifier	Animals_Species_Code	Animals_Species_Name	Animals_Breed_Code	Animals_Breed_Name	Birth_Date	Death_Date

Level1	Level1_Name	Level2	Level2_Name	Level3	Level3_Name	Level4	Level4_Name

EV_HOLDINGS Entity Database Schema

Holding_Number	Holding_Type_Code	Holding_Type_Name	Holding_Subtype_Code	Holding_Subtype_Name

Level_1_Code	Level_1_Name	Level_2_Code	Level_2_Name	Level_3_Code	Level_3_Name	Level_4_Code	Level_4_Name

Figure 4.5 Database Schemas

DISEASE_DATE table includes Notification_ID, Disease_OIE_Code, Disease_Name, Notification_Date, Confirmation_Date, Date_Of_End_Of_Sickness, Disease_Status_ID, Disease_Status, Level_1_Code, Level_1_Name, Level_2_Code , Level_2_Name, Level_3_Code, Level_3_Name, Level_4_Code, Level_4_Name columns, which are explained below.

i. Notification_ID is the primary key for DISEASE_DATE table. It is the unique ID for each disease notification. Diseases are recorded based on a numerated system in terms of notification.
ii. Disease_OIE_Code is the code of the disease which is defined by World Organization for Animal Health (OIE). Each disease has a different code.

iii. Disease_Name is the name of the disease corresponding to each disease code.
iv. Notification_Date is the date of the disease outbreak notification in terms of day, month and year.
v. Confirmation_Date is the date of the disease outbreak confirmation in terms of day, month and year.
vi. Date_Of_End_Of_Sickness is the date which the disease outbreak ends in the format of day, month and year.
vii. Disease_Status_ID is the unique identifier of the status of the disease.
viii. Disease_Status is the activity status of a disease. If a disease is a part of an outbreak then the status of this disease is active; if not its status is called inactive.
ix. Level_1_Code, Level_1_Name, Level_2_Code, Level_2_Name, Level_3 _Code, Level_3_Name, Level_4_Code, Level_4_Name are the codes and names of the regions, provinces, districts and villages of Turkey defined by Minister of Internal Affairs respectively.

EV_ANIMALS table includes Animal_Identifier, Animals_Species_Code, Animals_Species_Name, Animals_Breed_Code, Animals_Breed_Name, Birth_ Date, Death_Date, Level1, Level1_Name, Level2, Level2_Name, Level3, Level3 _Name, Level4, Level4_Name, as explained below.

i. Animal_Identifier is the primary key for EV_ANIMALS table. Each animal has an earring with a unique code.
ii. Animal_Species_Code is the code for species. There are only two codes as cattle and winged animals in this study.
iii. Animals_Breed_Code is the code of the breed which the animal belongs.
iv. Animals_Breed_Name is the name of the breed that the animal comes from.
v. Birth_Date is the birth date of the animal in terms of day, month and year.

vi. Death_Date is the death date of the animal in terms of day, month and year.
vii. Level1, Level1_Name, Level2, Level2_Name, Level3, Level3_Name, Level4 and Level4_Name are the codes and names of the regions, provinces, districts and villages of Turkey defined by Minister of Internal Affairs respectively.

EV_HOLDINGS table includes Holding_Number, Holding_Type_Code, Holding _Type_Name, Level_1_Code, Level_1_Name, Level_2_Code, Level_2_Name, Level_3_Code, Level_3_Name, Level_4_Code, Level_4_ Name columns. They are explained as follows.

i. Holding_Number is the primary key for EV_HOLDINGS table. Each holding has a number uniquely identifying it.
ii. Holding_Type_Code and Holding_Type_Name are the code and name for holdings which define the holding respectively.
iii. Holding_Subtype_Code and Holding_Subtype_Name are the code and name for holdings which define the subtypeholding respectively.
iv. Level_1_Code, Level_1_Name, Level_2_Code, Level_2_Name, Level _3_Code, Level_3_Name, Level_4_Code and Level_4_Name are the codes and names of the regions, provinces, districts and villages of Turkey defined by Minister of Internal Affairs respectively.

4.1.2 Spatial Database Design

ArcSDE technology is a core element of ArcGIS Server. Its primary role is to act as the database access engine to spatial data within a relational database management system (RDBMS). ArcSDE technology provides geospatial behavior, integrity and utility to the underlying records of the geo-database. The geo-database is the primary data storage model for ArcGIS. It sits on top of the

RDBMS and provides a single central location to access and manage spatial data (URL 15). Base map layers, such as Regions, Provinces, Districts, Province Centers, District Centers, Villages, Animal Holdings, 3D relief of Turkey, Birdflu 2006, Wetlands and Routes were all loaded into ESRI ArcSDE 9.3.

4.1.3 Database Model Selection and Normalization

A database can be accepted as a collection of related files. How those files are related depends on the model used. Early models like hierarchical model (where files are related in a parent/child manner, with each child file having at most one parent file) and the network model (where files are related as owners and members, similar to the network model except that each member file can have more than one owner) have often been replaced by relational databases because they are easier to understand and use, even though they are much less efficient.

The relational database model was a huge step forward, as it allowed files to be related by means of a common field. In order to relate any two files, they simply needed to have a common field, which makes the model extremely flexible. A relational database allows the definition of data structures, storage and retrieval operations and integrity constraints. In such a database the data and the relations between them are organized in tables. A table is a collection of records and each record in a table contains the same fields. To achieve the flexibility and extendibility on data storage mechanism, relational database model have been preferred for the system (URL 16).

Although the relational model has these powerful advantages over the ancestor models, there are some rules to be obeyed for improving the flexibility, efficiency and for avoiding bad data integrity. These rules can be defined as data analysis or normalization process of the database (Codd, 1990).

Database normalization, sometimes referred to as canonical synthesis, is a technique for designing relational database tables to minimize duplication of information and, in so doing, to safeguard the database against certain types of logical or structural problems, namely data anomalies. For example, when multiple instances of a given piece of information occur in a table, the possibility exists that these instances will not be kept consistent when the data within the table is updated, leading to a loss of data integrity. Normalization is the term used to describe how a file is broken down into tables to create a database. There are three or four major steps involved known as First Normal Form (1NF), Second Normal Form (2NF), Third Normal Form (3NF) and Boyce-Codd Normal Form (BCNF). There are others but they are rarely if ever used. A database is said to be normalized if it is in 3NF (or ideally in BCNF). So, in the following paragraphs, the conversion process of initial database to a 3NF database will be described (URL 17).

As the first step of the normalization process, all the attributes should be enforced to be atomic which means that any single field should only have a value for one thing. As seen in Figure 4.5, the table scheme of the obtained data suits the 1NF (First Normal Form), because all the entries in the columns are the same type and there is no repeating groups. The next step in normalization is determination of functional dependencies, which are very helpful for splitting the tables into 2NF and 3NF. In Figure 4.6, the resultant functional dependencies for the achieved and reorganized data are shown.

The column named Notification_ID in DISEASE_DATE table is the primary key and all the non-key fields depend on this primary key. In other words all other fields of the table are a function of Notification_ID, since it is defined uniquely to identify and separate the disease notifications that are made in different times and places. This situation agrees with the constraint of 2NF therefore the table is in 2NF. Also there are some non-key fields to non-key field dependencies in the table. To fully convert the table into 3NF, these unwanted dependencies must be reorganized. As a result, all the non-key to non key dependencies are transferred into newly created tables and the fields that contain the unique codes are left in main table as a foreign key.

In the second table (EV_ANIMALS), all animal recordings are kept and to uniquely identify them, the Animal_Identifier field is used. All the animal information that are used in the system is separated from each other by this field. Therefore the table is in the form of 2NF. Species, breeds and level related fields have some non-key dependencies in the table and data of these fields are inserted into new tables created for making the table in the form of 3NF.

Similarly, the last table (EV_HOLDINGS) has a unique primary key named Holding_Number in order to separately number the holdings all around the country. But non-key to non-key dependencies also appear here, and therefore in the resultant table scheme, all the code fields are kept as foreign key and new tables were created to hold the functionally dependent fields together.

After the database normalization of the form 3NF and simplification of field and table names, and defining the foreign keys, the resultant database structure including the relations between them are as shown in Figure 4.7.

The constraints between tables can be examined as:

i. Relation Between Levels: A location can be a Region, a Province, a District or a Village. To keep the simplicity and flexibility, all levels must be coded into a simple table which is named as LOCATIONS as seen in Figure 4.8. LOCATIONS table and the other LEVEL tables are tied with the related level id (L1_CODE, L2_CODE, L3_CODE and L4_CODE).

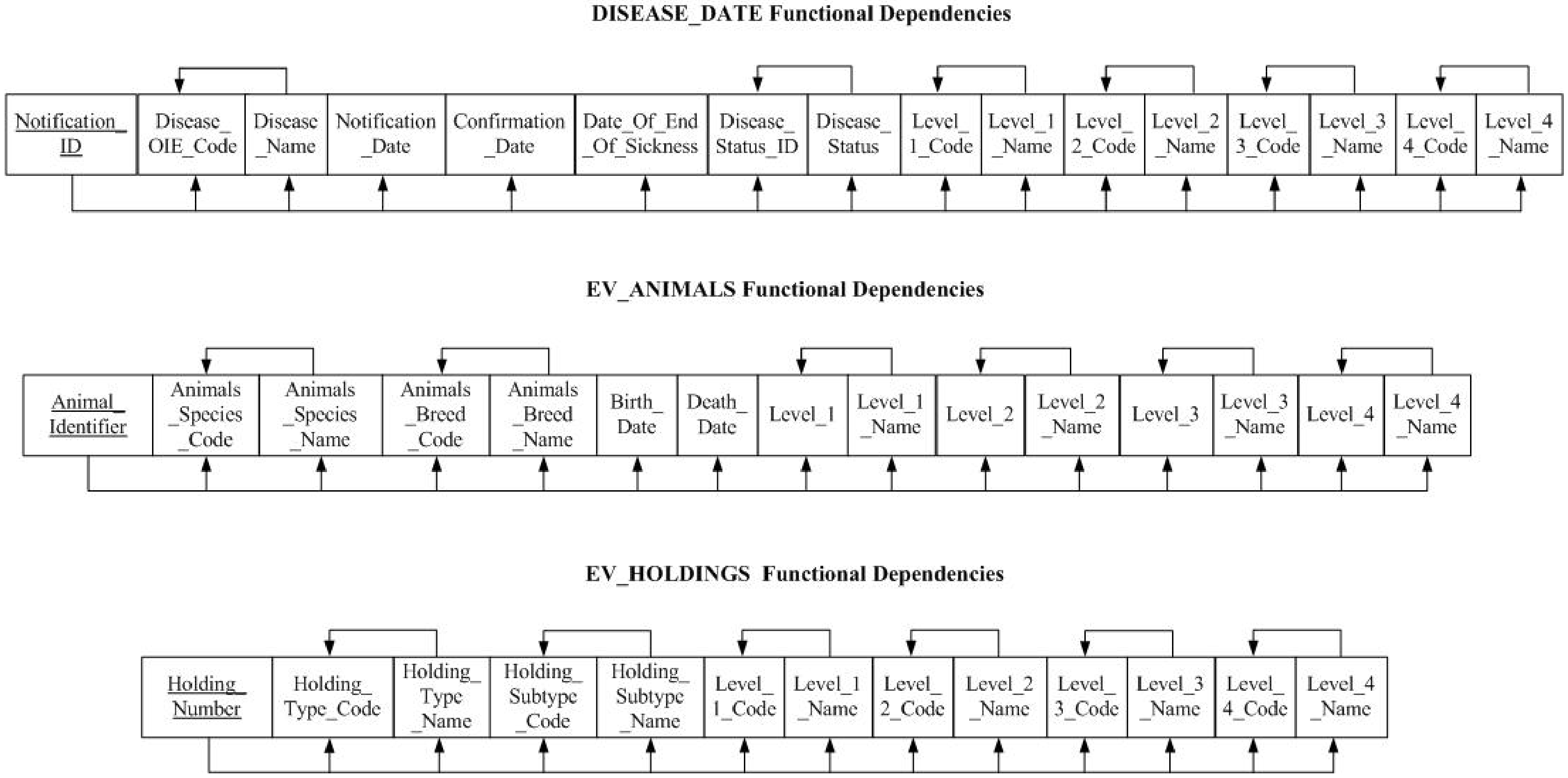

Figure 4.6 Functional Dependencies of Tables

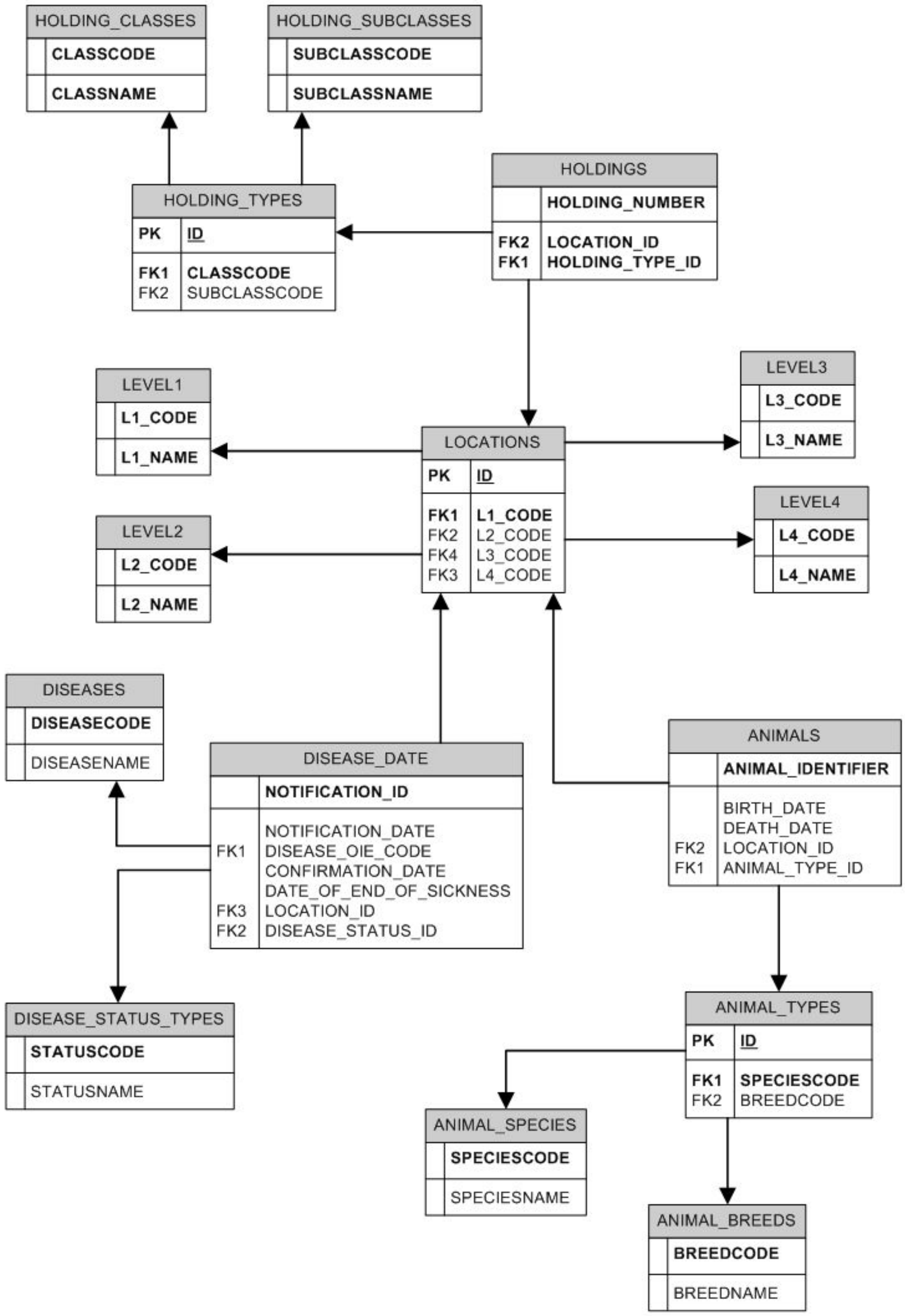

Figure 4.7 Relational Database Structure of the System

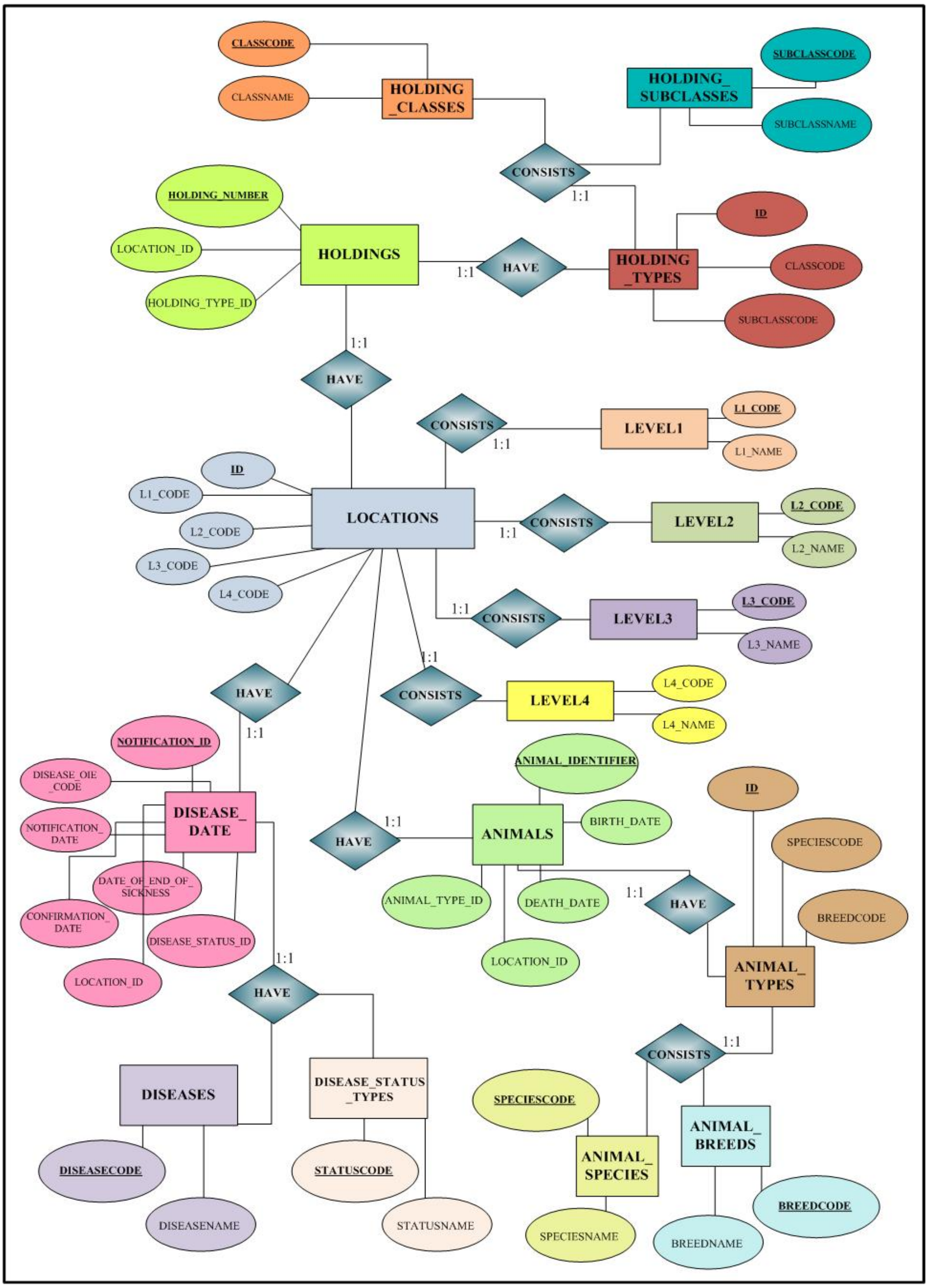

Figure 4.8 E-R Diagram of the Database

ii. Holding Relations: Every holding must have a location and a holding type. However there are two levels of holding types. Again to keep the simplicity, these types are coded into a covering table named HOLDING_TYPES. The relation between holding types, holding classes and holding subclasses established with the CLASSCODE and SUBCLASSCODE.

iii. Disease-Date Relations: DISEASE_DATE table holds the diseases and the sequential dates of these diseases and these data are identified by Notification_Id uniquely. Every disease-date information must also be related with a location. Diseases have unique codes that are determined internationally and named OIE Code.

These codes and their names are separated into DISEASES table to increase the manageability. Outbreaks are coded with some predefined status types. These can be extendible according to different types of diseases and characteristics of future outbreaks. Therefore status types are separated into a DISEASE_STATUS_TYPES table.

iv. Animal Relations: Every animal is classified with their species and breeds. In order to keep both manageability of separated breeds and species, and simplicity of using one foreign key in animals table, breeds and species are coded into a covering table named ANIMAL_TYPES with the foreign keys of SPECIESCODE and BREEDCODE.

4.2 System Development

Appropriate hardware and software must be selected at the beginning of the system development. In this study hardware and software are selected as in Table 4.1.

Table 4.1 System Components

HARDWARE	SOFTWARE
Intel® Xeon (TM) 2 CPU 3.20 GHz 4 GB RAM IBM ServeRAID SCSI Disk Device (136 GB) HP NC7170 Dual Gigabit Server Adapter (Ethernet) RADEON 7000 RADEON VE Family	**Operating System**: Microsoft Windows Server 2003 R2 Standard Edition + Service Pack 2 **Web Server**: Internet Information Services (6.0) **Map Server:** ESRI ArcGIS Server 9.3 **Database:** Microsoft SQL Server 2005 (9.0.3042) **DBMS:** ESRI ArcSDE 9.3 **Web Development:** Microsoft Visual Studio . Net 2005 **Data Preparation and Evaluation in GIS:** ESRI ArcMAP ArcINFO 9.3, ArcCatalog 9.3 **Graphical Representation:** ZedGraph 5.1.2

The map services were created using the Environmental Systems Research Institute (ESRI) internet map server technology (ArcGIS Server™ 9.3); the geographic layers were shaped and are managed with ArcGIS™ Desktop 9.3 and ArcSDE™ 9.3. The geo-database used to collect spatial and epidemiological data is a relational data base management system (RDBMS) based on SQL Server. The Web-GIS system architecture is displayed in Figure 4.9.

Web GIS based animal diseases surveillance system architecture is based mainly on both the medium client and SOA architectures. Since it has the Java Script codes on the client side and the ASP.NET codes on the server side.ArcGIS Server provides a complete server-based GIS system that supports the use of centrally managed spatial data for mapping and analysis. ArcGIS Server has built in functions which are based on SOA. ArcGIS Server has a management tool and .mxd files can be served as services and published as the web sites. And all the web sites communicate with these web services. There are map services so it matches to the definition of SOA.

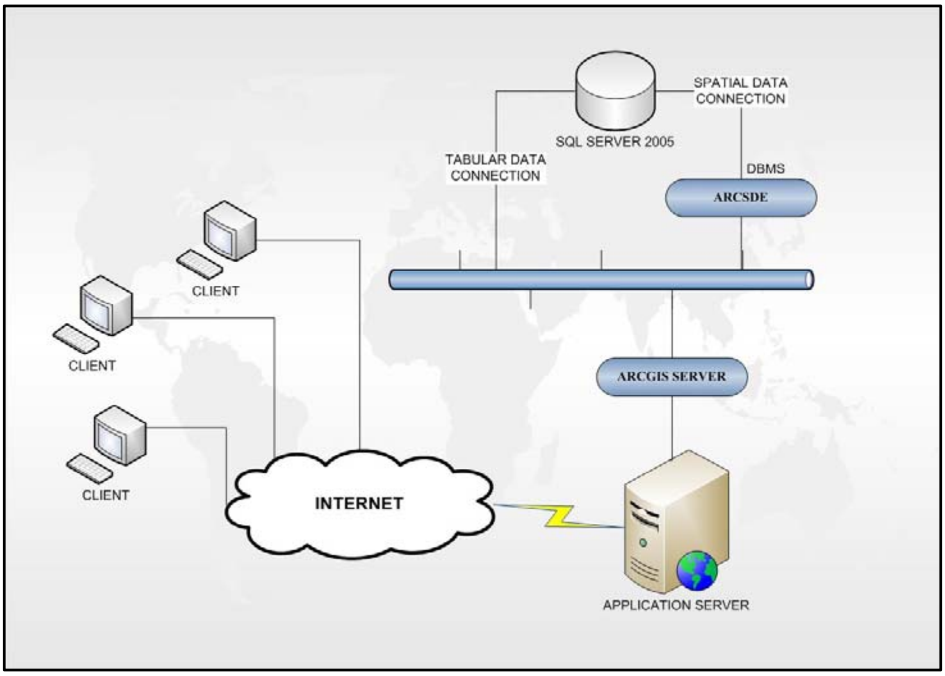

Figure 4.9 Web GIS architecture

4.3 Functions of the System

A program has been developed that provides different administrative levels with a spatial decisional and management tool to assist them in case of epidemics. One of the main features of the system is an interactive and user-friendly web-based

geographic information system. The Web GIS application can be accessed through a generic internet browser with the address http://91.93.128.43/webmap. The system is user-friendly and interactive; users can surf dynamic maps and use system data to perform tailored epidemiological analysis, without having to install any GIS software on their PCs. Screenshot of initial user interface is shown in Figure 4.10. In the program, the interactive thematic maps, standard browsing functions (zoom in, zoom out, pan, full extent, back extent, forward extent, magnifier, identifier, measure...etc.) and query functions are provided.

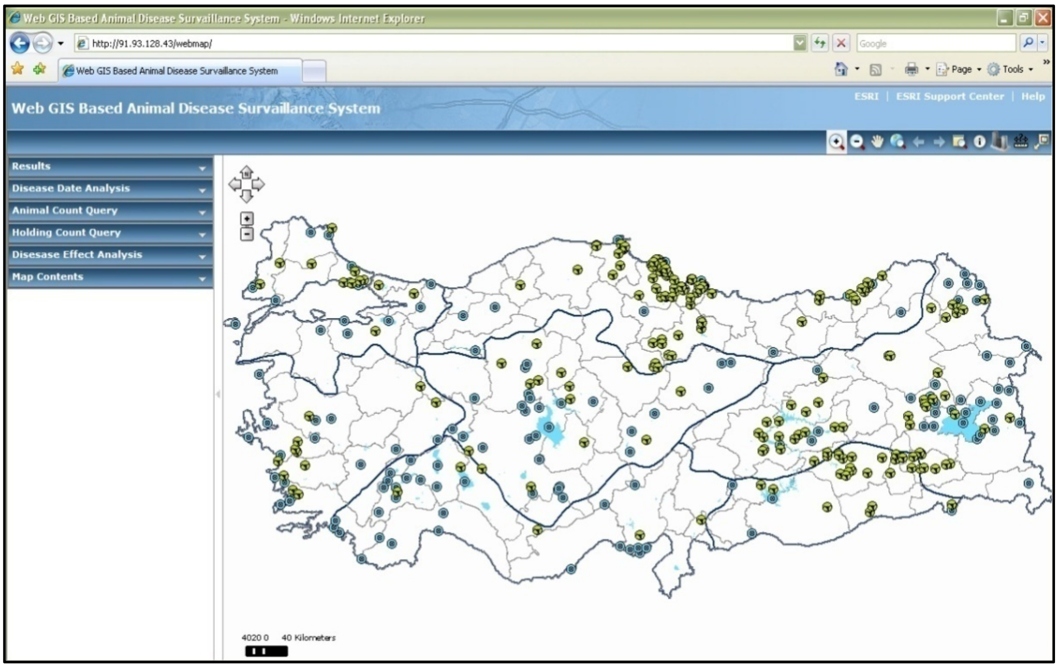

Figure 4.10 Screenshot of client interface

4.3.1 Web Application Functionality Components

Generally, a map visually orients the user to where the features are and what they represent. The basic mapping tools used in this study and their utilization are explained in Table 4.2. These tools are used for map navigation and query within the frame.

4.3.2 Disease Date Query

With the web-based program, users are able to query the disease outbreaks according to confirmation date, type and activity (active or inactive) of the disease. Activity of a disease means that; it's continuing over a period of time. Ten kinds of animal diseases (Avian Influenza, Foot and Mouth Disease, Pest Des Petits Ruminants, Rabies, Sheep-Goat Brucellosis, Sheep and Goat Pox, Cattle

Table 4.2 Basic Mapping Components

Button	Name	Function
	Zoom In	Allows user to zoom in to a geographic window by clicking a point or dragging a box.
	Zoom Out	Allows user to zoom out to a geographic window by clicking a point or dragging a box.
	Pan	Helps to reposition the map without changing the zoom level.
	Full Extent	Allows zooming to the full extent of the map.
	Back Extent	Allows user to go back to the previous extent.
	Forward Extent	Allows user to go forward to the next extent.
	Magnifier Window	Allows seeing a magnified view of a small area without changing the extent of the view.
	Map Identify	Identifies the geographic feature or place on which you click.
	Chart	Shows the graph when you click on the thematic map.
	Measure	Defines point coordinates, measures line distance and can define the perimeter and area of the polygon on the map.
	Show Overview Map	Shows the full extent of the data. A box in the overview window represents the currently displayed area on the map.

Brucellosis, Bovine tuberculosis, Anthrax, Bluetongue) are listed in the diseases menu. Query results are shown as dynamic thematic maps in terms of region, province or districts. Thematic maps depict the results of queries and display spatial pattern of a theme or series of attributes. It is possible to represent disease counts on the map by varying colors, as a choropleth map. It provides an easy way to visualize how the counts vary across the region, province or district. When the features are drawn with graduated colors, the quantitative values are grouped into classes and each class is identified by a particular color. It is possible to select one of the 'Natural Breaks' or 'Equal Interval' data classification methods with five classes through the web based program. Figure 4.11 shows the screenshot of the thematic map example of Avian Influenza disease quantities between the dates 01.01.2006 and 01.01.2007 on provinces according to Natural Breaks data classification method with five classes.

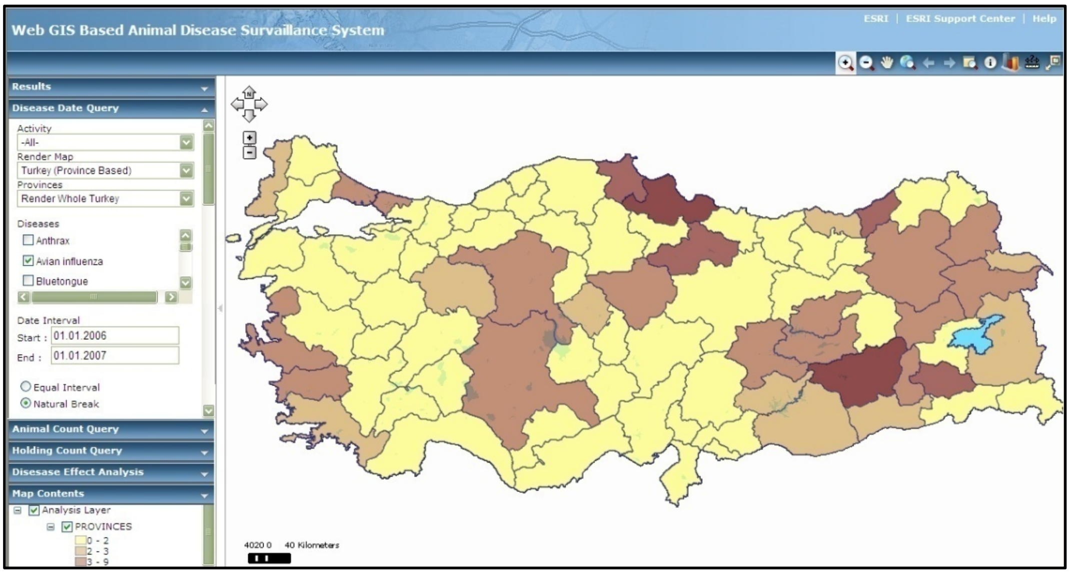

Figure 4.11 Disease Date Query of Avian Influenza Outbreak

4.3.3 Animal Count Query

It is possible to make query about the cattle counts according to the breeds of cattle on Marmara and Aegean geographical regions of Turkey. There are 45 breeds of cattle in the menu. Since there have been approximately more than 25 million dairy cattle in Turkey, this study covered only the cattle data of two regions. This part of the program enables users to represent cattle counts on the map by varying colors as a choropleth map in terms of Marmara or Aegean region, provinces or districts of these regions within a time interval. Time interval covers the period when the animal is alive. Birth and death dates of each animal are kept in the database. It is possible to render the map according to one of the data classifications method; ‘Equal Interval’ or ‘Natural Breaks - jenks’ with five classes.

Equal interval classification scheme divides the range of attribute values into equal-sized sub ranges. For example, if features have attribute values ranging from 0 to 300 and we have three classes, each class represents a range of 100 with class ranges of 0–100, 101–200, and 201–300. This method emphasizes the amount of an attribute value relative to other values, for example, to show that a store is part of the group of stores that made up the top one-third of all sales.

In natural breaks classes are based on natural groupings inherent in the data. It identifies break points by picking the class breaks that best group similar values and maximize the differences between classes. The features are divided into classes whose boundaries are set where there are relatively big jumps in the data values. An example thematic map showing the counts of ‘Angus’ type cattle between the dates 01.01.2004 and 01.01.2007 in terms of provinces is shown in Figure 4.12.

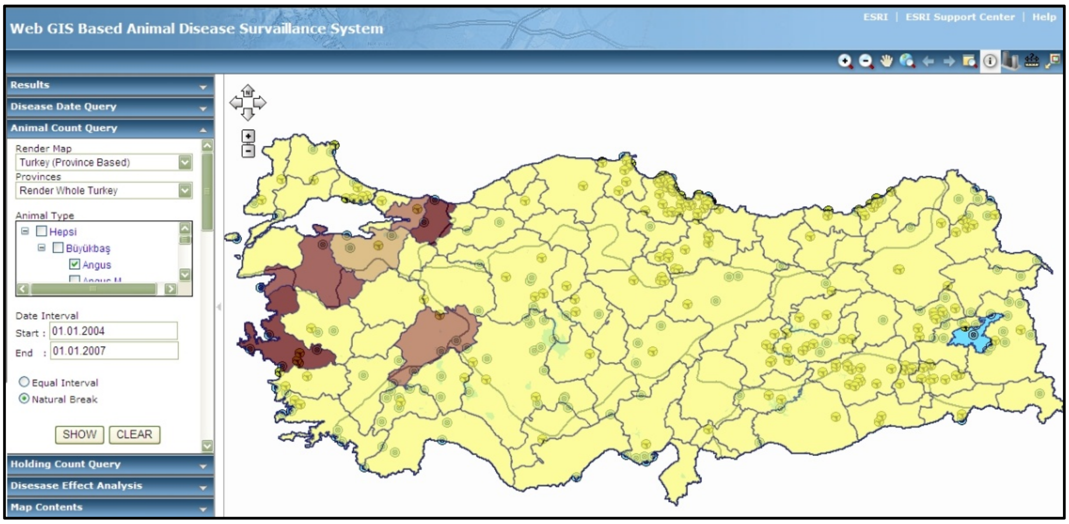

Figure 4.12 Animal Count Query for 'Angus' type cattle

4.3.4 Holding Count Query

It is possible to query the count of animal holdings according to their types. There are five main types of animal holdings (cattle, sheep and goats, wingy, combined, slaughter house) and so many sub-types in the program. Figure 4.13 shows the screenshot of the thematic map of counts of sheep holdings in terms of provinces.

4.3.5 Disease – effect (buffer) analysis

In case of an outbreak of an infectious disease, GIS can provide a tool for identifying the location of the case location and all locations or holdings at risk within a specified area of the outbreak. Buffer zones can be drawn around those locations. The response is needed for an animal disease emergency depending on a number of factors, such as the particular disease, how easily it is spread, the number of animals or locations affected.

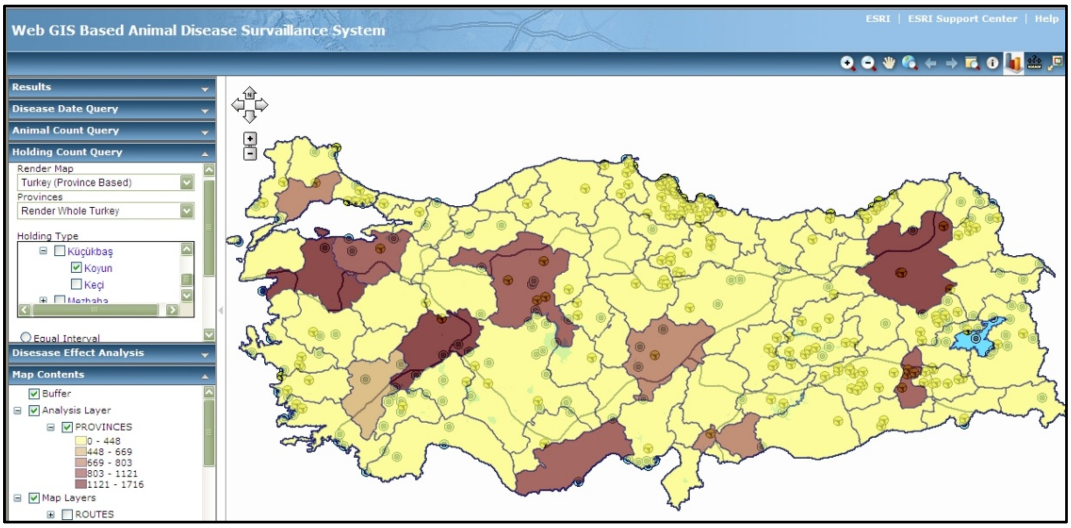

Figure 4.13 Thematic map of count of sheep holdings

The outbreak site of a disease is called 'focal point'. It is the point at which a disease first appears or first gets suspicious about. Disease outbreak site can be a village or holding. Each disease may spread differently according to its characteristics. In this study, the Avian Influenza disease characteristics have been considered in effect analysis. After the Avian Influenza disease which appeared in past years, it is proved that, to take the precautions and to quarantine the affected areas as soon as possible is very important, especially when the possibility of infection of people is considered. Decision makers can draw first, second and third risk areas around the focal point with 'disease effect analyses' tool (Figure 4.14). The risk areas are shown with different colored, same centered circles on the map and animal holdings and villages in each area are listed separately in the result part (Figure 4.15). During a disease outbreak, animal health authorities can easily access risky location data from the program and precautions can be taken rapidly and efficiently. If restrictions are needed to be issued (animal movement restriction, slaughtering restriction) to any or all of the animal holdings which are in quarantine region, decision maker can define these locations easily and response to an animal disease emergency.

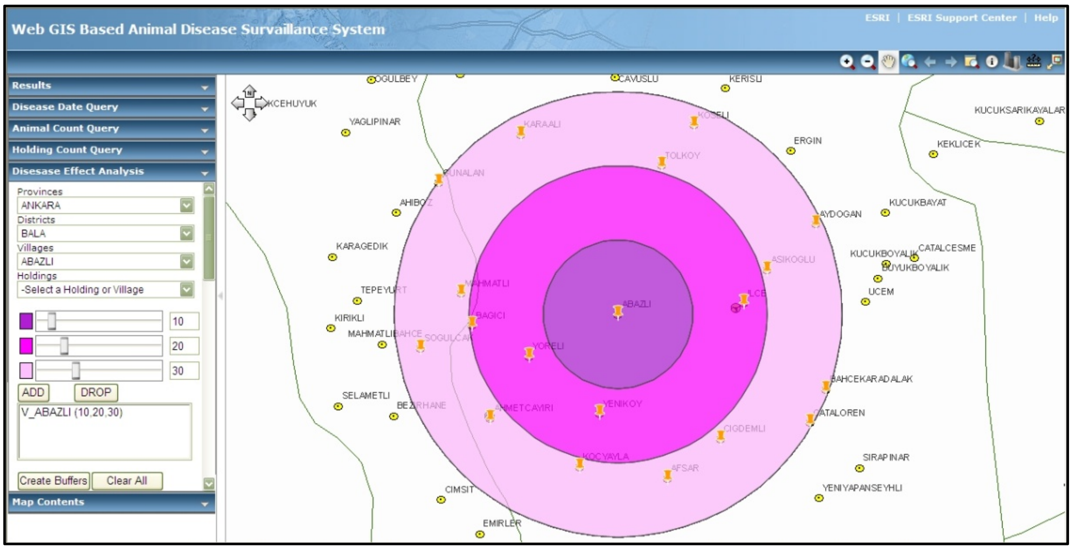

Figure 4.14 A map showing an example of how buffer zones with the distance of 10, 20, and 30 km were created around Ankara, Bala, Abazlı village

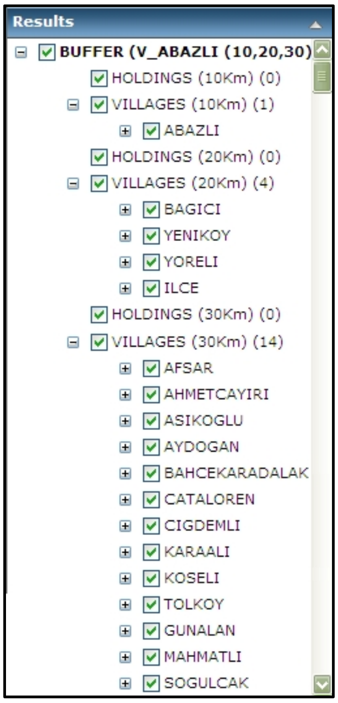

Figure 4.15 List of animal holdings and villages in each risk area

4.3.6 Graphical representation

ZedGraph 5.1.2 software has been used in coding the program in order to show the query results with bar graphics. With ‘chart’ tool, it is possible to get detail count information about the geographical unit with a graph in a pop-up menu when you click it over the thematic map. Figure 4.16 shows the screenshot of the graph about the ‘Anthrax’ and ‘Avian Influenza’ disease counts in Samsun province during the period of 01.01.2006 and 01.01.2007.

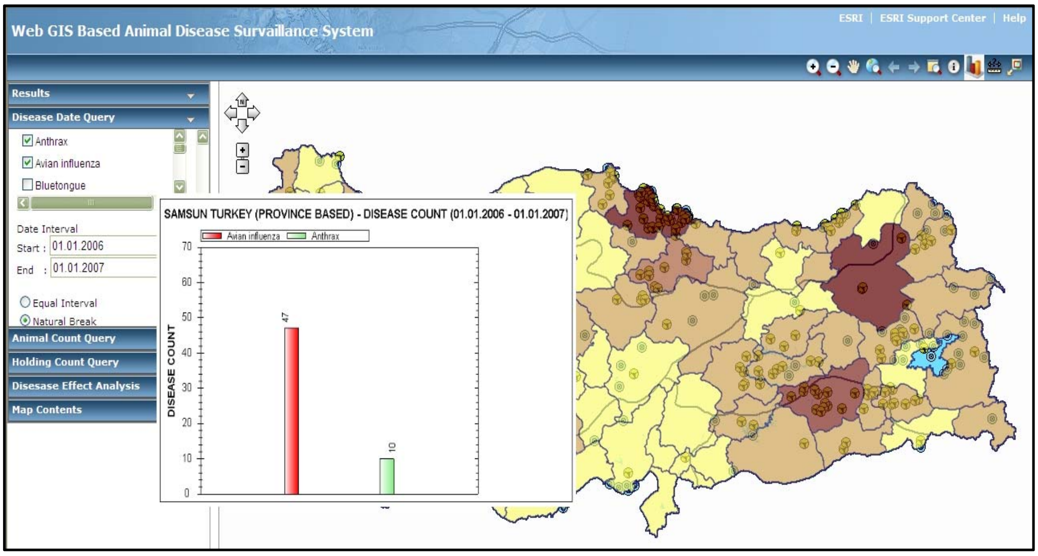

Figure 4.16 Graphical representation of Anthrax and Avian Influenza disease counts in Samsun

4.3.7 Exploring Landscape Features Associated with Avian Influenza 2006

Exploring data is the first step in analyzing the data. By examination of the data, researcher can find the opportunity to derive summary statistics and/or plots, use them in investigating the patterns the dataset has, suggest possible models by modifying hypotheses made before, putting forward new hypotheses and evaluate the appropriateness of the techniques to be utilized.In this study, the landscape features associated with Avian Influenza are explored.

The intent of this part of the study is to give an idea about preliminary landscape epidemiology model, which relates bird flu disease occurrence to environmental factors. In such a model, spatial features like terrain, hydrology and temperature that are characteristic of the disease areas, are defined and may be used to identify areas at risk for new outbreaks.

GIS and spatial analysis methods were applied to individual bird flu case sites to identify landscape features possibly correlated with disease transmission. Terrain and hydrologic factors were analyzed. This study focused on the 2006 Avian Influenza outbreak consisting of 197 cases which occurred in Turkey (Figure 4.17). The outbreak lasted from January to April in 2006.

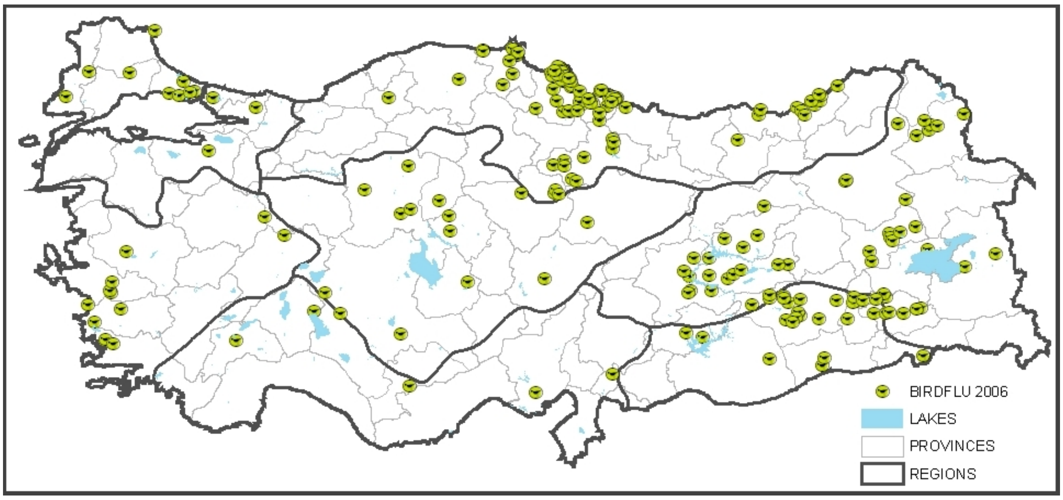

Figure 4.17 Extent of the 2006 AI Outbreak

4.3.7.1 Wetlands

It is generally accepted that waterfowls play an important role in the generation, spread and transmission of Avian Influenza (AI). Wetlands are the most important ecosystems for wild birds. Since water bodies provide habitats for possible vectors of AI, the distance to water features is an important variable. This study only considers wetlands of international importance in terms of waterfowls.

There are 135 such wetlands in Turkey and 197 confirmed Avian Influenza cases which occurred in 2006. Point Distance Analysis Tool of ArcInfo was used to calculate distance from each Avian Influenza case to the nearest wetland point. It determines the distances between point features in the BIRDFLU_2006 layer to all points in the WETLANDS layer (Table 4.3). Figure 4.18 shows the distribution of distances for the Avian Influenza cases. The result shows that the cases are more likely to occur close to the wetlands.

Table 4.3 Frequency distribution of distance values

Group of distance to nearest wetland (km)	Number of Avian Influenza Cases	%
0-29	86	43.7
30-59	57	28.9
60-89	37	18.8
90-119	14	7.1
120-149	1	0.5
150-180	2	1
Total	**197**	**100**

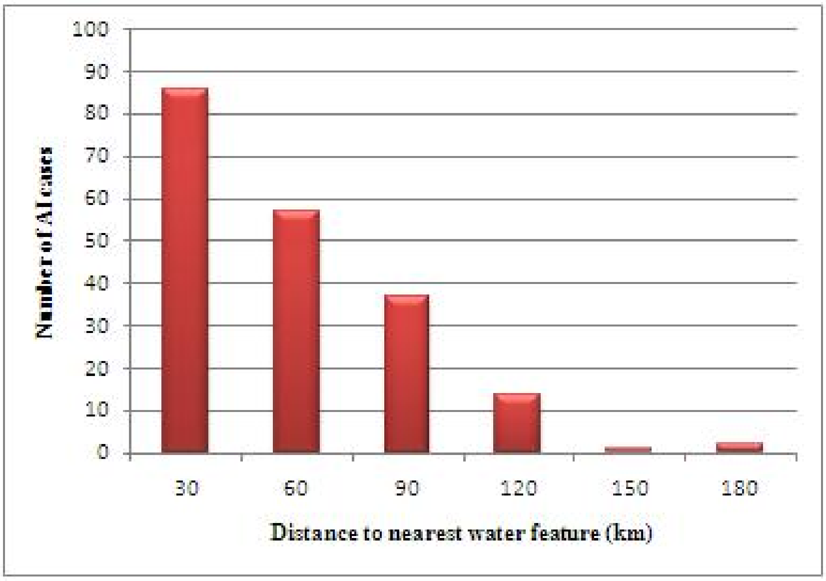

Figure 4.18 Distance in kilometers to nearest wetlands for 2006 AI cases

4.3.7.2 Elevation

Terrain features include elevation, slope, and aspect of each Avian Influenza case. Elevation, slope and aspect may have an effect on Avian Influenza outbreaks. In order to quantify the respective factor, DEM data was utilized by 3D Analyst extension of ArcGIS 9.3. Aspect and slope layers in WGS 84 were also derived. The elevation value of the cell under each Avian Influenza case was exported to a table and the descriptive statistics (minimum, maximum, mean, standard deviation) were calculated for the elevation values in meters by using SPSS program (Table 4.4). Average elevation is 715.78 meters. Histogram of the elevation data set is shown in Figure 4.19. The result shows that number of AI cases is much more at lower places.

Table 4.4 Descriptive statistics for elevation values (meter)

	Count	Minimum	Maximum	Mean	Std. Deviation
ELEVATION	197	4.83	2689.43	715.78	592.58

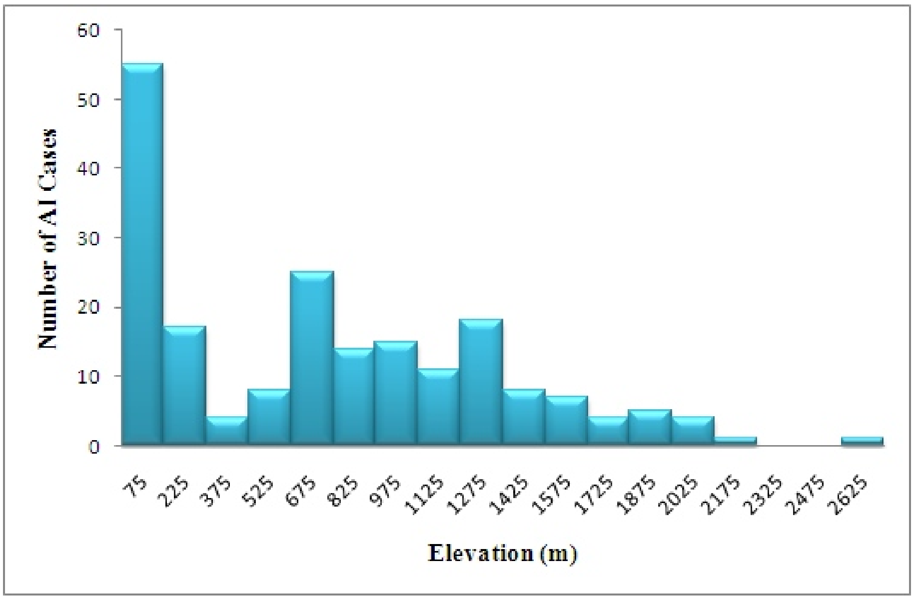

Figure 4.19 Histogram of elevation data set

4.3.7.3 Slope

The slope value of the cell under each Avian Influenza case was exported to a table and the descriptive statistics (minimum, maximum, mode, median, mean, variance, standard deviation) were calculated for the slope values in degrees by using SPSS (Table 4.5). The average slope is 3.8^o with a range of 0^o to 27.7^o Histogram of the slope data set is shown in Figure 4.20. The result shows that AI cases are more likely to occur at flater places.

Table 4.5 Descriptive statistics for slope values (degrees)

	Count	Minimum	Maximum	Mean	Std. Deviation
SLOPE	197	0.00	27.72	3.82	5.21

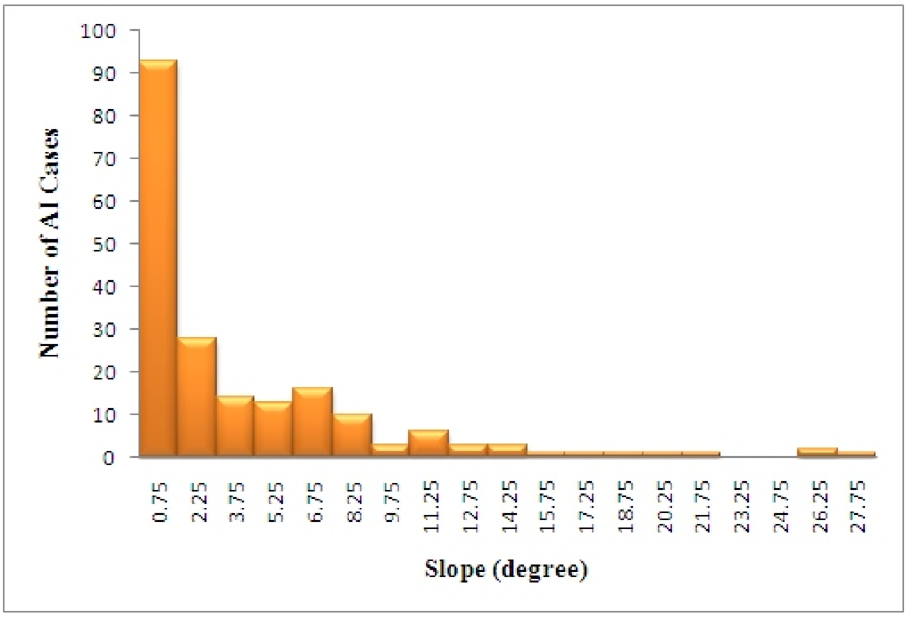

Figure 4.20 Histogram of slope data set

4.3.7.4 Aspect

Aspect identifies the steepest down slope direction from each cell to its neighbors. It can be thought of as slope direction or the compass direction a hill faces. The aspect value (Flat, North, Northeast, East, Southeast, South, Southwest, West and Northwest) for each Avian Influenza case was exported to a table. Numbers of AI cases in terms of categories are listed in Table 4.6. Histogram of the aspect data set is shown in Figure 4.21. The results showed that aspect has no distinct effect on the distribution of the locations of AI cases.

Table 4.6 Description of bird flu cases

Aspect categories	Number of Avian Influenza Cases	%
Flat	41	20.81
North	22	11.17
Northeast	26	13.20
East	20	10.15
Southeast	16	8.12
South	18	9.14
Southwest	13	6.60
West	22	11.17
Northwest	19	9.64
Total	**197**	**100**

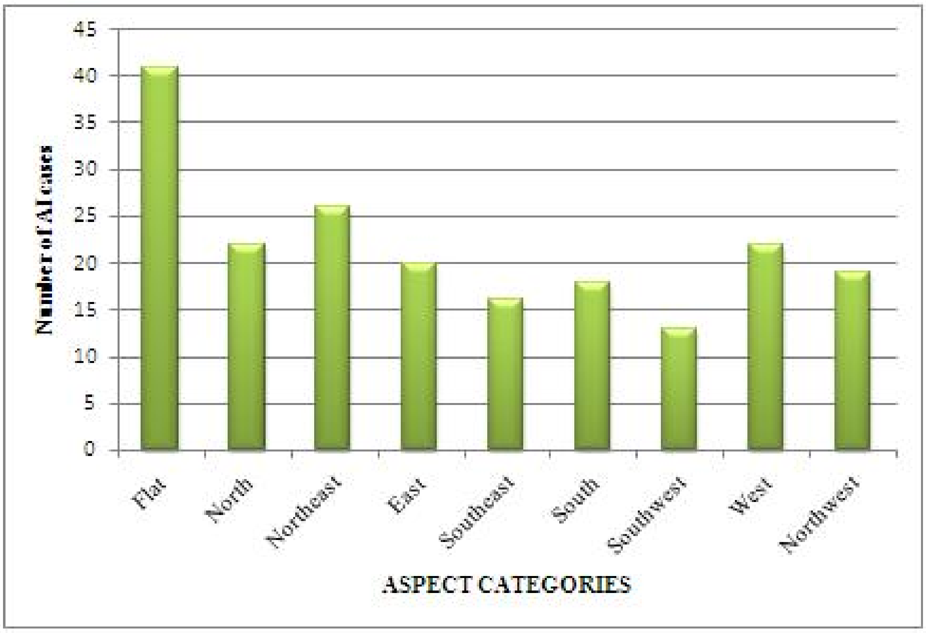

Figure 4.21 Histogram of aspect data set

4.3.7.5 Temperature

H5N1 virus can survive in bird faeces for at least 35 days at low temperature (4^{o}C). At a much higher temperature (37^{o}C), H5N1 viruses have been shown to survive, in faecal samples, for six days (URL 18). The average temperature value in ^{o}C unit for 197 bird flu cases areas in 2006 is; 3.11 ^{o}C. The minimum temperature is -10.1 ^{o}C and maximum temperature is 9.7 ^{o}C.

CHAPTER 5

CONCLUSIONS and RECOMMENDATIONS

5.1 Introduction

Infectious animal diseases such as avian influenza, foot-and-mouth and swine fever spread rapidly through herds and flocks causing public alarm and significant losses to farming and food production. Many animal diseases are zoonotic (transmissible between humans and animals, causing infection in both species), therefore their management and prevention are important to improve public health.

The most efficient and effective way of controlling animal disease can be through an enhanced system of early warning for early detection and rapid reaction. GIS provides a powerful means of managing data related to a disease outbreak, especially in designing surveillance strategies and monitoring spatial-temporal trends. GIS databases offer new analytic opportunities for disease assessment and prevention. GIS enables to improve disaster response efficiency by supplying maps and spatial analysis capabilities. GIS analysis can be done to convert data into information which can be used to assist animal health decision making.

5.2 Conclusions

This thesis is designed to build a GIS web-based animal health surveillance system in Turkey in order to monitor and analyse disease outbreaks. It is possible to geo-visualize the animal health data as a choropleth map, illustrate the results of explored landscape features associated with Avian Influenza, analyse the results of the spatial arrangements of AI points, identify the locations at risk within a specified area of the outbreak. The system basically works as an early response and reporting system, in line with principles of emergency management. This study provides delineation of spatial clusters of AI infectious disease, helps health agencies and epidemiologists to respond more effectively.

This study established a server side web architecture that provides map visualization, query and analyzing operations. Web helps users to utilize GIS more easily than desktop complex system. Web-based applications can be utilized by multiple users at the same time. The clients using the browsers do not install any additional plug in. Web-based system is also cost-efficient. The advantage for the user is using the functionality of the application without having to purchase or learn any GIS software.

In this study three main issues have been accomplished:

i. A web-based GIS program which integrates epidemiological information with the corresponding geographic component was developed.

ii. Landscape features associated with Avian Influenza data of 2006 were explored.

iii. Exploratory spatial analyses of Avian Influenza point data of 2006 were made

The key functions of the web based program are the retrieval and querying of animal diseases, animal counts, animal holdings and disease outbreak data by considering the date and the creation of the interactive maps to visualize them. The system works on a disease basis for ten of the most contagious and common diseases in Turkey. Number of registered animals, holdings and disease events can be queried according to date and activity criteria and thematic maps can be created on the base of region, province and district of Turkey. It is possible to represent quantities on the map by varying colors, as a choropleth map which enables easy visual interpretation of the results.

With disease-effect analysis, it is possible to determine the 1st, 2nd and 3rd degree risk zones of the Avian Influenza disease around its focal point and get the list of villages and animal holdings that fall inside of these buffer areas. In case of an outbreak of an infectious disease, the web GIS program provides an excellent tool for identifying the location of the case and all holdings and villages at risk within a specified area of the outbreak. So decision makers can use this program as a spatial decision support system tool which can be used in crisis management.

Moreover, GIS was utilized to give an idea about preliminary landscape epidemiology model, which relates bird flu disease occurrence in 2006 to environmental factors. There were 197 confirmed AI cases and 12 cumulative confirmed human cases in 2006 in Turkey. Spatial features like terrain, wetlands and temperature that may be characteristic of the disease areas are defined and they may be used to identify areas at risk for new outbreaks.

Distances to wetlands of international importance in terms of waterfowls from each bird flu case location were calculated. Distribution of distances for the Avian Influenza cases was considered. The result showed that the cases are more likely to occur close to the wetlands. In order to examine the effect of elevation, slope and aspect on AI outbreaks, average value of each was derived from the DEM data of Turkey. Average elevation is 715.78 meters. The result showed that number of AI cases is much more at lower places. The average slope is 3.8^{o} with a range of 0^{o} to 27.7^{o} which shows that cases mostly occur at flater places. The average temperature value in ^{o}C unit for 197 bird flu cases areas in 2006 is; 3.11^{o}C. The minimum temperature is -10.1^{o}C and maximum temperature is 9.7^{o}C. Number of Avian Influenza cases in each aspect categories (Flat, North, Northeast, East, Southeast, South, Southwest, West and Northwest) was also evaluated. The number of cases at flat surfaces is much more than the others but it is difficult to cınclude that whether aspect has distinct effect on the distribution of the locations of AI cases or not.

5.3 Recommendations

Since the new era grows with technological improvement, every discipline should adopt itself to the enhancement of the science. GIS technologies can be incredibly powerful and useful tools in aiding animal health research. The principles of GIS are well-suited for the visualization of epidemiological research. The data collected and compiled can be stored, recalled and analyzed using GIS technology.

The web GIS program which is developed with this study only operates on existing data collected via web-based TURKVET Management Information System (MIS) software. This GIS program can be fully integrated to existing TURKVET system at database and user interface level. Users will benefit from MIS-GIS integration because it reduces the cost of development and difficulty in using a software application. The right information can be efficiently extracted and easily understood with the help of maps.

Epidemiologists can use GIS to determine the geographic distribution, analyse spatial and temporal trends, map populations at risk, stratify risk factors and assess resource allocation, plan and target interventions, monitor diseases and interventions over time. In this context, modeling of the spatial data to establish appropriate forecasting models, comparing the distribution of set of disease cases with a set of healthy controls, visualizing and analyzing geographic distribution of diseases through time, thus revealing spatio-temporal trends, patterns, and relationships can be done as future work.

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APPENDIX A

LIST OF 2006 AVIAN INFLUENZA OUTBREAKS IN TURKEY

Table A.1 Avian Influenza Cases Table

	Notification Date	Confir-mation Date	Date of End of Sickness	Province	District	Village Neighborhood	Av. Temp (oC)
1	1/14/2006	2/20/2006	3/27/2006	ADANA	YÜREĞİR	DÜZCE	9.7
2	1/20/2006	1/20/2006	2/16/2006	ADIYAMAN	KAHTA	ÇAYBAŞI	4.7
3	1/20/2006	2/8/2006	2/15/2006	ADIYAMAN	MERKEZ	MERKEZ-ALTINŞEHİR	4.7
4	1/7/2006	1/26/2006	2/14/2006	AKSARAY	MERKEZ	BEBEK	0.4
5	1/27/2006	2/3/2006	3/8/2006	ANKARA	BALA	AHMETÇAYIR	0.4
6	1/27/2006	1/27/2006	3/8/2006	ANKARA	BALA	MERKEZ-MERKEZ	0.4
7	1/27/2006	1/27/2006	2/28/2006	ANKARA	ÇUBUK	SÜNLÜ	0.4
8	1/31/2006	2/8/2006	3/2/2006	ANKARA	POLATLI	GÜREŞ	0.4
9	1/9/2006	1/12/2006	1/30/2006	AYDIN	KUŞADASI	MERKEZ-TÜRKMEN MAH.	8.2
10	1/9/2006	1/12/2006	1/31/2006	AYDIN	MERKEZ	ÇEŞTEPE	8.2
11	1/16/2006	1/26/2006	2/13/2006	AYDIN	SÖKE	SERÇİN	8.2
12	1/11/2006	1/26/2006	2/16/2006	BATMAN	KOZLUK	KAMIŞLI	3.4
13	1/11/2006	1/26/2006	2/16/2006	BATMAN	KOZLUK	ULAŞLI	3.4
14	1/11/2006	1/26/2006	2/16/2006	BATMAN	KOZLUK	UZUNÇAYIR	3.4
15	1/11/2006	1/26/2006	2/16/2006	BATMAN	KOZLUK	YANKILI	3.4
16	1/18/2006	3/9/2006	2/20/2006	BATMAN	MERKEZ	AKÇA	3.4
17	1/2/2006	2/14/2006	3/15/2006	BITLIS	ADİLCEVAZ	EVRENPAŞA MAH.	-2.9
18	1/15/2006	1/27/2006	2/24/2006	BURDUR	MERKEZ	ÇALLICA	2.6
19	1/6/2006	1/8/2006	1/30/2006	BURSA	GÜRSU	KARAHIDIR	5.5
20	1/21/2006	2/3/2006	2/24/2006	DIYARBAKIR	BİSMİL	MERKEZ-KEMBERLİ	2
21	1/16/2006	1/27/2006	2/15/2006	DIYARBAKIR	ÇERMİK	MERKEZ-TEPE MAH.	2
22	1/6/2006	1/27/2006	2/16/2006	DIYARBAKIR	EĞİL	BAHŞİLER	2
23	1/7/2006	1/27/2006	2/16/2006	DIYARBAKIR	EĞİL	BAYSU	2
24	1/6/2006	1/27/2006	2/16/2006	DIYARBAKIR	EĞİL	KIRKKUYU	2
25	1/9/2006	1/26/2006	2/16/2006	DIYARBAKIR	ERGANİ	BONCUKLU	2
26	1/10/2006	2/8/2006	2/22/2006	DIYARBAKIR	ERGANİ	MERKEZ	2
27	1/11/2006	1/26/2006	2/16/2006	DIYARBAKIR	MERKEZ	GÖMMETAŞ	2
28	1/25/2006	2/10/2006	3/3/2006	DIYARBAKIR	MERKEZ	HAVACILAR	2
29	1/12/2006	1/26/2006	2/16/2006	DIYARBAKIR	MERKEZ	KARAÇALI	2
30	1/25/2006	2/10/2006	3/3/2006	DIYARBAKIR	MERKEZ	KÜÇÜKAKÖREN	2
31	1/6/2006	1/22/2006	2/16/2006	DIYARBAKIR	MERKEZ	MERKEZ-MERKEZ	2
32	1/27/2006	2/10/2006	3/3/2006	DIYARBAKIR	MERKEZ	SARIDALLI	2
33	1/18/2006	2/1/2006	2/23/2006	DIYARBAKIR	SİLVAN	MERKEZ	2
34	2/13/2006	2/14/2006	3/10/2006	EDIRNE	UZUNKOPRU	ÖMERBEY	4.2
35	3/7/2006	3/17/2006	4/11/2006	EDIRNE	İPSALA	ESETÇE	7.6
36	1/11/2006	2/8/2006	2/10/2006	ELAZIG	BASKİL	KIZILUŞAĞI	-0.6
37	1/25/2006	3/13/2006	2/20/2006	ELAZIG	KEBAN	DENİZLİ	-0.6
38	2/3/2006	2/10/2006	3/7/2006	ELAZIG	MERKEZ	IŞIKYOLU	0.6
39	1/6/2006	1/22/2006	2/2/2006	ELAZIG	MERKEZ	KARŞIYAKA	-0.6

	Notification Date	Confir-mation Date	Date of End of Sickness	Province	District	Village Neighborhood	Av. Temp (oC)
40	1/11/2006	2/8/2006	2/14/2006	ELAZIG	MERKEZ	YUKARI DEMİRTAŞ	-0.6
41	1/11/2006	1/27/2006	2/8/2006	ELAZIG	PALU	GÜLLÜCE	-0.6
42	1/10/2006	2/8/2006	2/14/2006	ELAZIG	PALU	MERKEZ-YENİMAHALLE	-0.6
43	1/11/2006	1/21/2005	1/27/2006	ERZINCAN	MERKEZ	ÇAĞLAYAN	-2.7
44	1/1/2006	1/22/2006	2/17/2006	ERZURUM	KARAYAZI	SELENLİ	-9.6
45	3/22/2006	3/29/2006	4/27/2006	ERZURUM	MERKEZ	MERKEZ-KAZIM YURDALAN MAH.	-2.9
46	1/2/2006	1/7/2006	2/17/2006	ERZURUM	MERKEZ	MERKEZ-MAKSUT EFENDİ MAH.	-9.6
47	1/2/2006	1/7/2006	2/20/2006	ERZURUM	ŞENKAYA	İĞDELİ	-9.6
48	1/8/2006	1/27/2006	2/13/2006	ESKISEHIR	HAN	GÖKÇEYAYLA	-0.3
49	1/30/2006	2/8/2006	3/9/2006	ESKISEHIR	SEYİTGAZİ	GÖCENOLUK	-0.3
50	1/9/2006	1/26/2006	2/13/2006	GAZIANTEP	NURDAĞI	İÇERİSU	3.4
51	1/6/2006	1/22/2006	3/1/2006	GUMUSHANE	TORUL	MERKEZ-TUĞRULBEY MAH	-1.8
52	1/6/2006	1/22/2006	2/3/2006	ISPARTA	ŞARKIKARA AĞAÇ	KARAYAKA	1.8
53	3/3/2006	3/8/2006	3/28/2006	ISTANBUL	BÜYÜKÇEK MECE	MERKEZ-19 MAYIS MAH.	7.7
54	2/24/2006	2/25/2006	3/20/2006	ISTANBUL	ÇATALCA	BAKLALI	5.9
55	1/6/2006	1/9/2006	1/31/2006	ISTANBUL	GAZİOSMAN PAŞA	MERKEZ-CEBECİ	6.1
56	1/7/2006	1/19/2006	2/1/2006	ISTANBUL	KÜÇÜKÇEK MECE	İKİTELLİ-ZİYA GÖKALP MAH.	6.1
57	2/27/2006	3/1/2006	3/24/2006	ISTANBUL	SİLİVRİ	CELALİYE	5.9
58	1/19/2006	1/22/2006	2/14/2006	ISTANBUL	ÜMRANİYE	ALEMDAR	6.1
59	1/9/2006	1/22/2006	2/22/2006	IZMIR	BAYINDIR	MERKEZ-DEMİRCİLİK	8.9
60	1/6/2006	2/8/2006	3/8/2006	IZMIR	TİRE	AKÇAŞEHİR	8.9
61	2/16/2006	2/28/2006	3/24/2006	IZMIR	TİRE	ALACALI	9.1
62	1/9/2006	1/22/2006	2/1/2006	KARABUK	MERKEZ	MERKEZ-KAYABAŞI	3.1
63	1/9/2006	1/25/2006	2/3/2006	KARAMAN	MERKEZ	CERİT	0.3
64	3/22/2006	3/29/2006	4/21/2006	KARS	AKYAKA	MERKEZ-İSTASYON MAH.	-2.6
65	1/8/2006	1/22/2006	1/30/2006	KARS	MERKEZ	BOZKALE	-10.1
66	1/8/2006	1/22/2006	1/30/2006	KARS	MERKEZ	BÜYÜKBOĞATEPE	-10.1
67	1/9/2006	1/22/2006	1/30/2006	KARS	MERKEZ	ÇAĞLAYAN	-10.1
68	3/24/2006	4/4/2006	4/14/2006	KARS	MERKEZ	HASÇİFTLİK	-2.6
69	1/6/2006	1/22/2006	1/27/2006	KARS	MERKEZ	MERKEZ	-10.1
70	3/24/2006	4/6/2006	4/27/2006	KARS	SELİM	BÖLÜKBAŞ	-2.6
71	1/29/2006	2/3/2006	4/5/2006	KASTAMONU	MERKEZ	KADIOĞLU	-0.7
72	3/3/2006	3/13/2006	3/31/2006	KAYSERI	TALAS	CEBİR	4.6
73	1/29/2006	2/3/2006	3/3/2006	KIRIKKALE	KESKİN	MERKEZ-ALTINTAŞ MAH.	0.6
74	2/8/2006	2/10/2006	3/3/2006	KIRKLARELI	DEMİRKÖY	BEĞENDİK	2.3
75	3/3/2006	3/10/2006	4/11/2006	KIRSEHIR	KAMAN	ÇADIRLIKÖRMEHME T	5.3
76	3/21/2006	3/24/2006	5/1/2006	KIRSEHIR	KAMAN	HAMİT	5.3
77	3/1/2006	3/7/2006	3/31/2006	KOCAELI	KANDIRA	GONCAAYDIN	8.4
78	1/7/2006	1/19/2006	2/20/2006	KONYA	AKŞEHİR	REİS	-0.3
79	1/8/2006	1/19/2006	2/17/2006	KONYA	DERBENT	YASSIÖREN	-0.3
80	1/8/2006	1/19/2006	2/15/2006	KONYA	KARATAY	İSMİL-ÇEŞME	-0.3
81	1/12/2006	1/24/2006	2/10/2006	MALATYA	ARGUVAN	ERMİŞLİ	0.3
82	1/11/2006	1/18/2006	2/6/2006	MALATYA	KALE	BENT	0.3
83	1/12/2006	1/18/2006	2/20/2006	MALATYA	MERKEZ	MERKEZ-MELEKBABA MAH.	0.3
84	1/12/2006	1/18/2006	2/20/2006	MALATYA	MERKEZ	MERKEZ-ÖZALPER	0.3

	Notification Date	Confir-mation Date	Date of End of Sickness	Province	District	Village Neighborhood	Av. Temp (oC)
85	1/12/2006	1/24/2006	2/9/2006	MALATYA	YAZIHAN	AMBARCIK	0.3
86	1/12/2006	1/19/2006	2/7/2006	MALATYA	YAZIHAN	KARACA	0.3
87	2/13/2006	2/22/2006	3/20/2006	MANISA	GÖLMARMA RA	KAYAALTI	7.6
88	1/14/2006	2/13/2006	3/10/2006	MARDIN	KIZILTEPE	EKİNLİK	3.2
89	1/16/2006	3/13/2006	3/23/2006	MARDIN	MERKEZ	MERKEZ-İSTASYON	3.2
90	1/23/2006	1/26/2006	2/27/2006	MUGLA	MİLAS	HİSARCIK	5.5
91	1/23/2006	1/26/2006	2/27/2006	MUGLA	MİLAS	MERKEZ-BURGAZ	5.5
92	2/15/2006	2/24/2006	3/8/2006	MUS	BULANIK	BİNGÖLDEK	-6
93	1/30/2006	2/23/2006	2/21/2006	MUS	BULANIK	ERENTEPE	-7.1
94	2/14/2006	2/24/2006	3/7/2006	MUS	BULANIK	MERKEZ-CUMHURİYET MAH.	-6
95	1/30/2006	2/23/2006	2/21/2006	MUS	BULANIK	YEMİŞEN	-7.1
96	1/12/2006	1/12/2006	2/16/2006	MUS	HASKÖY	MERKEZ-KÜLTÜR MAH.	-7.1
97	1/5/2006	3/1/2006	2/27/2006	MUS	MALAZGİRT	MERKEZ-SELÇUKLU MAH .	-7.1
98	1/22/2006	1/24/2006	2/16/2006	MUS	MERKEZ	KIRKÖY	-7.1
99	2/22/2006	3/22/2006	3/29/2006	ORDU	ÜNYE	AYDINTEPE	6.5
100	2/3/2006	3/1/2006	3/10/2006	RIZE	ÇAYELİ	MADENLİ-MERKEZ	6.2
101	2/22/2006	3/23/2006	3/22/2006	RIZE	ÇAYELİ	MERKEZ-LİMANKÖY	6.2
102	2/15/2006	3/20/2006	3/24/2006	RIZE	FINDIKLI	DERBENT	6.2
103	2/2/2006	2/27/2006	3/17/2006	RIZE	MERKEZ	ÇAYCILAR	6.2
104	2/21/2006	3/22/2006	3/22/2006	RIZE	MERKEZ	KÖMÜRCÜLER	6.2
105	2/1/2006	2/1/2006	3/17/2006	RIZE	MERKEZ	KÜÇÜKÇAYIR	6.2
106	2/21/2006	3/23/2006	3/30/2006	RIZE	PAZAR	BAŞKÖY	6.2
107	2/19/2006	3/24/2006	3/30/2006	RIZE	PAZAR	MERKEZ-KİRAZLIK	6.2
108	2/22/2006	3/23/2006	3/30/2006	RIZE	PAZAR	OCAK	6.2
109	2/9/2006	3/21/2006	3/21/2006	SAMSUN	ALAÇAM	YUKARIELMA	6.6
110	1/18/2006	3/2/2006	3/9/2006	SAMSUN	ASARCIK	MERKEZ-BİÇİNCİK	7.1
111	2/18/2006	3/22/2006	3/27/2006	SAMSUN	AYVACIK	ÇAMALAN	6.6
112	1/6/2006	3/3/2006	3/15/2006	SAMSUN	AYVACIK	ORTAKÖY	7.1
113	2/17/2006	3/20/2006	4/3/2006	SAMSUN	BAFRA	ÇETİNKAYA	6.6
114	2/11/2006	2/11/2006	3/24/2006	SAMSUN	BAFRA	DOĞANCA	6.6
115	1/6/2006	1/6/2006	2/4/2006	SAMSUN	BAFRA	GÖKÇEAĞAÇ	7.1
116	1/8/2006	3/21/2006	3/9/2006	SAMSUN	BAFRA	KAPIKAYA	7.1
117	2/22/2006	3/27/2006	3/25/2006	SAMSUN	BAFRA	KAYGUSUZ	6.6
118	2/20/2006	3/27/2006	3/25/2006	SAMSUN	BAFRA	KORULUK	6.6
119	2/2/2006	3/24/2006	3/1/2006	SAMSUN	BAFRA	KÖSELİ	6.6
120	2/14/2006	2/14/2006	3/25/2006	SAMSUN	BAFRA	KUŞÇULAR	6.6
121	2/25/2006	3/27/2006	4/11/2006	SAMSUN	BAFRA	SAHİLKENT	6.6
122	2/4/2006	3/24/2006	3/9/2006	SAMSUN	BAFRA	SARIKÖY	6.6
123	2/8/2006	3/24/2006	3/9/2006	SAMSUN	BAFRA	SÜRMELİ	6.6
124	2/15/2006	2/15/2006	3/25/2006	SAMSUN	BAFRA	ŞİRİNKÖY	6.6
125	2/10/2006	2/10/2006	3/25/2006	SAMSUN	BAFRA	ÜÇPINAR	6.6
126	2/2/2006	3/8/2006	3/14/2006	SAMSUN	ÇARŞAMBA	DURUSU	6.6
127	2/19/2006	4/3/2006	3/28/2006	SAMSUN	ÇARŞAMBA	HÜRRİYET-SİVASLILAR	6.6
128	2/3/2006	3/13/2006	3/14/2006	SAMSUN	ÇARŞAMBA	KUMTEPE	6.6
129	1/6/2006	3/27/2006	4/10/2006	SAMSUN	HAVZA	YAYLAÇATI	7.1
130	3/7/2006	3/29/2006	4/11/2006	SAMSUN	KAVAK	BELALAN	7.8
131	2/10/2006	3/29/2006	3/14/2006	SAMSUN	KAVAK	ILICA	6.6
132	2/21/2006	4/6/2006	4/24/2006	SAMSUN	KAVAK	KÖSELLİ	6.6

	Notification Date	Confir-mation Date	Date of End of Sickness	Province	District	Village Neighborhood	Av. Temp (oC)
133	2/6/2006	3/2/2006	3/8/2006	SAMSUN	MERKEZ	ATAKUM	6.6
134	1/6/2006	3/1/2006	3/8/2006	SAMSUN	MERKEZ	BAŞALAN	7.1
135	2/24/2006	3/22/2006	3/30/2006	SAMSUN	MERKEZ	ÇATALÇAM-YEŞİLYURT	6.6
136	2/4/2006	3/2/2006	3/16/2006	SAMSUN	MERKEZ	DERELER	6.6
137	2/18/2006	3/21/2006	3/30/2006	SAMSUN	MERKEZ	TAFLAN-CAMİ	6.6
138	2/24/2006	3/20/2006	3/29/2006	SAMSUN	MERKEZ	ÜÇPINAR	6.6
139	1/12/2006	3/13/2006	3/3/2006	SAMSUN	SALIPAZARI	KOCALAR	7.1
140	2/3/2006	2/12/2006	3/16/2006	SAMSUN	TEKKEKÖY	ANTYERİ	6.6
141	1/31/2006	3/17/2006	3/16/2006	SAMSUN	TEKKEKÖY	AŞAĞIÇİNİK	7.1
142	2/3/2006	3/17/2006	3/16/2006	SAMSUN	TEKKEKÖY	BALCALI	6.6
143	2/7/2006	3/17/2006	3/16/2006	SAMSUN	TEKKEKÖY	BÜYÜKLÜ	6.6
144	1/31/2006	3/17/2006	3/16/2006	SAMSUN	TEKKEKÖY	MERKEZ-SELYERİ MAH.	7.1
145	1/7/2006	3/2/2006	3/20/2006	SAMSUN	TERME	AKBUCAK	7.1
146	2/3/2006	3/14/2006	3/20/2006	SAMSUN	TERME	ÇANGALLAR	6.6
147	2/3/2006	2/6/2006	3/20/2006	SAMSUN	TERME	GÖLYAZI	6.6
148	2/3/2006	3/14/2006	3/20/2006	SAMSUN	TERME	KARACALI	6.6
149	1/5/2006	3/2/2006	3/20/2006	SAMSUN	TERME	MERKEZ-ELMALIK MAH.	7.1
150	2/2/2006	3/14/2006	3/20/2006	SAMSUN	TERME	MERKEZ-YENİMAHALLE	6.6
151	2/3/2006	3/14/2006	3/20/2006	SAMSUN	TERME	UZUNGAZİ	6.6
152	3/6/2006	2/4/2006	3/21/2006	SAMSUN	VEZİRKÖPRÜ	TEPEÖREN	6.6
153	2/16/2006	3/22/2006	3/27/2006	SAMSUN	19 MAYIS	ENGİZ	6.6
154	2/3/2006	3/13/2006	3/6/2006	SAMSUN	19 MAYIS	YÖRÜKLER-GELERİÇ MAH.	6.6
155	3/6/2006	3/28/2006	4/7/2006	SAMSUN	19 MAYIS	YÖRÜKLER-TATLIELMA MAH.	7.8
156	1/6/2006	1/26/2006	2/16/2006	SANLIURFA	VİRANŞEHİR	ÜÇGÜL	5.8
157	1/11/2006	2/15/2006	3/8/2006	SIIRT	BAYKAN	KASIMLI	2.9
158	1/11/2006	2/15/2006	3/8/2006	SIIRT	BAYKAN	YARIMCA	2.9
159	1/12/2006	2/15/2006	3/8/2006	SIIRT	BAYKAN	ZİYARET-ATATÜRK MAH.	2.9
160	3/7/2006	3/7/2006	3/28/2006	SIIRT	KURTALAN	GÜRGÖZE	8.2
161	1/20/2006	1/20/2006	3/1/2006	SIIRT	MERKEZ	GÖKÇEBAĞ	2.9
162	2/15/2006	2/15/2006	3/8/2006	SIIRT	MERKEZ	MERKEZ-ALGÜL MAH.	4.1
163	2/21/2006	2/22/2006	3/27/2006	SIIRT	PERVARİ	GÜLEÇLER	4.1
164	1/20/2006	1/23/2006	3/1/2006	SIIRT	PERVARİ	ORMANDALI	2.9
165	2/21/2006	2/21/2006	3/27/2006	SIIRT	PERVARİ	PALAMUTLU	4.1
166	2/16/2006	3/16/2006	4/10/2006	SINOP	BOYABAT	DOĞUCA	6.3
167	2/2/2006	2/16/2006	3/21/2006	SINOP	BOYABAT	KOZKULE	6.3
168	2/8/2006	2/16/2006	3/20/2006	SINOP	MERKEZ	BEKTAŞAĞA	6.3
169	2/21/2006	3/16/2006	4/12/2006	SINOP	GERZE	ÇAKILDAK	6.3
170	3/16/2006	3/20/2006	4/12/2006	SINOP	MERKEZ	KABALI	7.4
171	2/16/2006	3/16/2006	4/12/2006	SINOP	MERKEZ	LALA	6.3
172	3/13/2006	3/22/2006	4/19/2006	SINOP	MERKEZ	YALI	7.4
173	2/7/2006	2/16/2006	3/21/2007	SINOP	TÜRKELİ	DÜZKÖY	6.3
174	2/7/2006	2/27/2006	3/21/2007	SINOP	TÜRKELİ	KARABEY	6.3
175	2/1/2006	2/10/2006	3/6/2006	SIRNAK	SİLOPİ	ÖZGEN	3.5
176	2/14/2006	3/16/2006	3/30/2006	SIVAS	ŞARKIŞLA	ÇATALYOL	-2.2
177	1/15/2006	1/19/2006	2/16/2006	TEKIRDAG	ÇORLU	MISINLI	5.0
178	2/11/2006	3/16/2006	4/3/2006	TOKAT	MERKEZ	BÜYÜKYILDIZ	3.2
179	2/20/2006	3/16/2006	4/10/2006	TOKAT	NİKSAR	ARIPINARI	3.2

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180	1/6/2006	2/9/2006	3/24/2006	TOKAT	NİKSAR	ÇİMENÖZÜ	2.0
181	1/9/2006	2/9/2006	3/7/2006	TOKAT	NİKSAR	MERKEZ-İSMETPAŞA MAH.	2.0
182	2/17/2006	3/16/2006	4/10/2006	TOKAT	YEŞİLYURT	ÇIKRIK	3.2
183	1/23/2006	2/23/2006	3/9/2006	TOKAT	YEŞİLYURT	MERKEZ-YÜZÜNCÜYIL MAH.	2.0
184	1/6/2006	2/9/2006	3/10/2006	TOKAT	ZİLE	KIRLAR	2.0
185	1/6/2006	2/9/2006	3/10/2006	TOKAT	ZİLE	KÜÇÜKKARAYÜN	2.0
186	2/8/2006	2/23/2006	3/10/2006	TOKAT	ZİLE	SÖĞÜTÖZÜ	3.2
187	1/6/2006	2/9/2006	2/11/2006	TRABZON	MERKEZ	AKOLUK	7.4
188	1/6/2006	2/9/2006	2/11/2006	TRABZON	MERKEZ	MERKEZ-DEĞİRMENDERE MAH.	7.4
189	2/3/2006	2/10/2006	3/2/2006	TUNCELI	ÇEMİŞGEZEK	GÖZLÜÇAYIR	-0.2
190	1/13/2006	2/14/2006	2/15/2006	TUNCELI	MERKEZ	GÜLEÇ	-1.6
191	1/12/2006	2/14/2006	2/10/2006	TUNCELI	PERTEK	DERE	-1.6
192	1/5/2006	1/17/2006	2/10/2006	VAN	MERKEZ	MERKEZ-VALİMİTHATBEY MAH.	-3.2
193	1/5/2006	1/9/2006	2/10/2006	VAN	ÖZALP	MERKEZ-CUMHURIYET MAH.	-3.2
194	1/2/2006	1/7/2006	1/30/2006	YOZGAT	AKDAĞMADENİ	ALTILI	-1.9
195	3/19/2006	3/24/2006	4/17/2006	YOZGAT	AKDAĞMADENİ	BAHÇECİK	2.6
196	3/28/2006	4/6/2006	4/26/2006	YOZGAT	AKDAĞMADENİ	BULGURLU	2.6
197	1/8/2006	1/12/2006	1/31/2006	YOZGAT	SORGUN	MERKEZ-AGAHEFENDİ MAH.	-1.9

APPENDIX B

LIST OF WETLANDS OF INTERNATIONAL IMPORTANCE IN TURKEY

Table B.1 List of Wetlands

	WETLANDS NAME	PROVINCE	AREA (ha)	LATITUDE (...º ...')	LONGITUDE (...º ...')
1	Abant Lake	Bolu	1,200		
2	Acıgöl-YPH-2005	Afyon Denizli	21,000	37 49	29 48
3	Ağyatan Lake	Adana	2,200	36 36	35 31
4	Akdoğan Lake	Muş	2,000	39 07	41 48
5	Akşehir Lake-YPH-2005	Konya	25,500	38 32	31 28
6	Aksu Delta	Antalya	16,500	36 52	30 58
7	Aktaş Lake	Ardahan	1,400	41 12	43 12
8	Akyatan Lake	Adana	14,000	36 37	35 16
9	Alaçatı coastal ecosystem	İzmir	55,740	38 12	26 31
10	Aras / Karasu Taşkınları	Iğdır	65,130	39 52	44 31
11	Atatürk Baraj Lake	Şanlıurfa	81,700		
12	Avlan Lake	Antalya	850		
13	Aygır Lake	Kars	2,941	40 45	43 00
14	Ayvalık coastal ecosystem	Balıkesir	25,810	39 19	26 38
15	Bafa Lake	Aydın,Muğla	12,281	37 30	27 26
16	Balık Lake	Ağrı	3,400	39 47	43 33
17	Balıkdamı Lake	Eskişehir	1,470	39 12	31 39
18	Batmış Lake	Bitlis	3,400	38 53	42 40
19	Bendimahi Delta	Van	370		
20	Beyşehir Lake	Isparta Konya	73,000	37 45	31 30
21	Bolluk Lake	Konya	3,800	38 32	32 56
22	Bulanık Wetlands	Muş	8,000	39 10	42 14
23	Burdur Lake	Burdur	25,000	37 44	30 12
24	Büyükçekmece Lake	İstanbul	2,850	41 03	28 34
25	Büyükmenderes Delta	Aydın	9,800	37 34	27 12
26	Çaldıran Ovası Wetlands	Van	2,000	39 07	44 02
27	Çalı Lake	Kars	18,670	40 60	43 32
28	Çavuşçu Lake	Konya	1,200	38 21	31 53
29	Çelebibağı Marshy Places	Van	990		
30	Çiçekli Lake	Ağrı	1,736	39 09	43 44
31	Çıldır Lake	Ardahan	14,000	41 03	43 15
32	Çimenova Lakes	Van	9,580	38 34	44 12
33	Çıralı Katavothre	Konya			
34	Cizre Wetlands	Şırnak	7,000	37 15	42 21
35	Çöl Lake and Çalıkdüzü	Ankara	1,500	39 19	32 51
36	Çorak Lake	Burdur	1,150	37 41	29 46
37	Dalaman Wetlands	Muğla	28,400	36 42	28 45
38	Dalyan Wetlands Ecosystem	Muğla			
39	Doğubeyazıt Marshy Places	Ağrı	8,750	39 38	44 06

	WETLANDS NAME	PROVINCE	AREA (ha)	LATITUDE (...º ...')	LONGITUDE (...º ...')
40	Dönemeç Delta	Van	300		
41	Dupnisa Cave	Kırklareli			
42	Eber Lake	Afyon	6,400	38 40	31 12
43	Edremit Marshy Places	Van	1,300		
44	Eğirdir Lake	Isparta	47,250	38 00	30 54
45	Ekşisu Marshy Places	Erzincan	2,371	39 42	39 36
46	Erçek Lake	Van	9,520	38 40	43 35
47	Ereğli Marshy Places	Konya Karaman Niğde	5,000	37 32	33 45
48	Fırtına Deresi	Rize			
49	Gediz Delta	İzmir	20,400	38 30	26 55
50	Girdev Lake	Muğla	900	36 34	39 37
51	Gökçeada Fish Trap	Çanakkale	6,883	40 10	26 00
52	Gökdere	Karaman	10,400	36 95	33 03
53	Göksu Delta	Mersin-KB-2004	14,480	36 18	33 58
54	Gölbaşı Lakes	Adıyaman	7,000	37 47	37 37
55	Gölcük Lake	Isparta	6,684	37 73	30 49
56	Gölcük Lake	İzmir	432	37 73	30 49
57	Gölhisar Lake	Burdur	600		
58	Gölköy	Muğla	14,870	37 00	27 15
59	Gölova Lake	Erzincan	5		
60	Güllük Delta	Muğla	2,500	37 15	27 38
61	Güney Keban Dam	Elazığ	100,000	38 37	39 35
62	Haçlı Lake	Muş	2,500	39 01	42 18
63	Hafik Lake	Sivas			
64	Hazar Lake	Elazığ	9,200	38 28	39 23
65	Hirfanlı Dam	Ankara	26,300	39 10	33 39
66	Hörmetçi Marshy Place	Kayseri	9,590	38 71	35 34
67	İğneada Deep Spot	Kırklareli	3,000	41 52	27 57
68	İron Marshy Place	Muş	16,090	38 37	42 01
69	Işıklı Lake	Denizli	7,300	38 14	29 55
70	İznik Lake	Bursa	29,830	40 26	29 32
71	Kapuzbaşı Sources	Kayseri			
72	Karadere	Rize			
73	Karagöl and Çinili lake	Adana	500	37 07	34 09
74	Karakaya Dam	Malatya	9,148	38 25	38 40
75	Karakuyu Marshy Places	Afyon, Burdur	1,581	38 02	30 14
76	Karamık Marshy Places	Afyon	4,500	38 26	30 50
77	Karataş Lake	Burdur	1,190	37 23	29 58
78	Karkamış Flood Plain	Şanlıurfa	10,470	36 92	38 00
79	Kaz Lake	Van	200	39 20	42 19
80	Kesik Lake	Adana			
81	Kızılırmak Delta	Samsun	21,700	41 36	36 05
82	Kızören Obruk Lale	Konya	2		
83	Kocaçay Delta	Bursa	4,200	40 23	28 29
84	Konya Acıgöl	Konya			
85	Kovada Lake	Isparta	2,534	37 37	30 52
86	Köyceğiz Lake	Muğla	8,000	36 54	28 38
87	Kozanlı Gökgöl	Konya	650	39 00	32 49
88	Küçükçekmece Lake	İstanbul	1,500	41 00	28 45
89	Küçükmenderes Delta	İzmir	1,500	37 59	27 18
90	Kulu Lake	Konya	1,800	39 05	33 09

	WETLANDS NAME	PROVINCE	AREA (ha)	LATITUDE (...º ...')	LONGITUDE (...º ...')
91	Kuş Lake	Balıkesir-KB-2003	16,000	40 11	27 58
92	Kuyucuk Lake	Kars	389	40 74	43 45
93	Marmara Lake	Manisa	6,800	38 37	28 00
94	Meke Maarı	Konya	314		
95	Meriç Delta	Edirne	7,000	40 47	26 14
96	Metruk Tuzlası	Muğla-KB-2004			
97	Meyil Obruk Lake	Konya	20		
98	Mogan Lake	Ankara	1,500	39 42	32 46
99	Nazik Lake	Bitlis			
100	Nemrut Lake	Bitlis	4,500	38 37	42 14
101	Olukköprü Sources	Antalya		37 19	31 07
102	Palas Lake	Kayseri	2,720	39 02	35 49
103	Pamukkale	Denizli	2,000		
104	Patara coastal ecosystem	Antalya	11,910	36 16	29 17
105	Putka Lake	Ardahan	2,500	41 08	42 46
106	Sakarya Delta	Sakarya	33,270	41 05	30 28
107	Salda Lake	Burdur	4,370	37 33	29 40
108	Samsam Lake	Konya	830	39 06	32 45
109	Sapanca Lake	Sakarya Kocaeli	4,700	40 42	30 15
110	Sarıkum Lake	Sinop	785	42 01	34 55
111	Sarısu Plain Wetlands	Ağrı	4,800	39 03	42 54
112	Sarıyar Dam	Ankara	8,400	40 02	31 38
113	Saroz Körfezi	Çanakkale	1,000	40 37	26 50
114	Seyfe Lake	Kırşehir	19,500	39 12	34 25
115	Sodalı Lake	Bitlis	4,387	38 80	42 98
116	SultanMarshy Place	Kayseri	39,000	38 20	35 16
117	Terkos Lake	İstanbul, Kırklareli	5,850	41 25	28 21
118	Tersakan Lake	Konya	11,000	38 35	33 06
119	Tödürge Lake	Sivas	750	39 48	37 23
120	Tortum Lake	Erzurum	350	40 38	41 38
121	Turna Lake	Van	700	38 25	43 26
122	Tuz Lake	Aksaray Ank. Konya	533,000	38 45	33 23
123	Tuzla Lake	Adana	2,800	36 42	35 03
124	Ulas Lakes	Sivas	12,820	39 26	37 00
125	Uluabat Lake	Bursa-KB-2003	13,500	40 10	28 35
126	Uyuz Lake	Konya	15	39 15	32 57
127	Van Lake	Van, Bitlis	366,715	38 40	42 55
128	Yarışlı Lake	Burdur	1,400	37 34	29 58
129	Yedikır Dam	Amasya	593	40 48	35 34
130	Yeniçağa Lake	Bolu	1,492	40 78	32 01
131	Yeşilırmak Delta	Samsun	3,000	41 18	36 55
132	Yüksekova Marshy Places	Hakkari	24,900	37 30	44 18
133	Yumurtalık Lagoon	Adana	16,430	36 44	35 41
134	Yüzenada Wetland	Bingöl			
135	Zamantı River	Kayseri			

APPENDIX C

SAMPLE CODE

Default.aspx.vb

```
Imports System.Collections.Generic
Imports ESRI.ArcGIS.ADF.Web
Imports ESRI.ArcGIS.ADF.Web.UI.WebControls
Imports ESRI.ArcGIS.ADF.Web.DataSources
Imports ESRI.ArcGIS.ADF.Connection.AGS
Imports ESRI.ArcGIS.Server
Imports ESRI.ArcGIS.ADF.ArcGISServer
Imports ESRI.ArcGIS.ADF.Web.DataSources.ArcGISServer
Imports ESRI.ArcGIS.Geodatabase
Imports ESRI.ArcGIS.Geometry
Imports ESRI.ArcGIS.GeoAnalyst
Imports ESRI.ArcGIS.DataSourcesRaster
Imports ESRI.ArcGIS.esriSystem

Public Class BufferRing
    Public Radius As Integer = 10
    Public InnerRadius As Integer = 0
    Public RingColor As System.Drawing.Color = Drawing.Color.Yellow
    Public RingTransparency As Double = 70.0
End Class

Public Class Buffer
    Public CenterLyr As String = "VILLAGES"
    Public CenterLyrExpr As String = ""
    Public CenterPt As ESRI.ArcGIS.ADF.Web.Geometry.Point
    Public CenterStr As String = ""
    Public CenterVal As String = ""
    Public Radius As New ArrayList(3)
End Class

Partial Class WebMapApplication
    Inherits System.Web.UI.Page
    Implements System.Web.UI.ICallbackEventHandler

    Dim grResourceIndex As Integer = 1
    Dim mapResourceIndex As Integer = 2

    Dim mapstring As String
    Public sCallBackPageInvocation As String
    Public sCallBackMapInvocation As String

    Protected Sub Page_Load(ByVal sender As Object, ByVal e As EventArgs)
Handles MyBase.Load
        If Not Page.IsCallback And Not Page.IsPostBack Then
            If Map1.MapResourceManager Is Nothing Or
Map1.MapResourceManager.Length = 0 Then
                callErrorPage("No MapResourceManager defined for the
map.", Nothing)
```

```
            End If
            If MapResourceManager1.ResourceItems.Count = 0 Then
                callErrorPage("The MapResourceManager does not have a
valid ResouceItem Definition.", Nothing)
            ElseIf MapResourceManager1.ResourceItems(0) Is Nothing Then
                callErrorPage("The MapResourceManager does not have a
valid ResouceItem Definition.", Nothing)
            End If

            FillInitialCombos()
            AddControlEvents()

            'Map1.Extent = Functions.getLayerExtent(Map1, "PROVINCES")

            ResetInitials()

            Functions.initLayerGraphicDataSets(Map1, Toc1,
mapResourceIndex, grResourceIndex)

            'If Toc1.Nodes.Count > 0 Then
            '    Dim nods As
ESRI.ArcGIS.ADF.Web.UI.WebControls.TreeViewPlusNodeCollection =
Toc1.Nodes(0).Nodes()
            '    nods.Clear()

            '    Toc1.Refresh()
            'End If

            Dim charttool As ESRI.ArcGIS.ADF.Web.UI.WebControls.Tool =
Toolbar1.ToolbarItems(8)
            charttool.Disabled = True

            Results_Panel_Header.Attributes.Add("ondblclick",
"toggleConsolePanel('Results_Panel')")
            divHT_Header.Attributes.Add("ondblclick",
"toggleConsolePanel('divHT')")
            divHE_Header.Attributes.Add("ondblclick",
"toggleConsolePanel('divHE')")
            divHS_Header.Attributes.Add("ondblclick",
"toggleConsolePanel('divHS')")
            divIS_Header.Attributes.Add("ondblclick",
"toggleConsolePanel('divIS')")
        End If

        'sCallBackPageInvocation =
Page.ClientScript.GetCallbackEventReference(Me, "argument",
"processCallbackResult", "context", "postBackError", True)
    End Sub 'Page_Load

    Protected Sub Page_PreRenderComplete(ByVal sender As Object, ByVal e
As EventArgs) Handles MyBase.PreRenderComplete
        ' check to see if any of the resource items are non-pooled
        If Not Page.IsCallback Or Not Page.IsPostBack Then
            If TaskMenu.Items.Count > 1 Then
                Dim i As Integer
                For i = 0 To TaskMenu.Items.Count - 2
                    TaskMenu.Items(i).SeparatorImageUrl =
"images/separator.gif"
                Next
            End If
```

```
            CloseHyperLink.Visible =
(GISDataSourceLocal.HasNonPooledServices(MapResourceManager1) Or
GISDataSourceLocal.HasNonPooledServices(GeocodeResourceManager1) Or
GISDataSourceLocal.HasNonPooledServices(GeoprocessingResourceManager1))

            If User.Identity.AuthenticationType = "Forms" AndAlso
User.Identity.IsAuthenticated Then
                'Set visibility using style instead of the Visible
property because using the Visible property corrupts ViewState under
certain circumstances
                LoginStatus1.Style(HtmlTextWriterStyle.Visibility) =
"visible"
                CloseHyperLink.Visible = False
            Else
                LoginStatus1.Style(HtmlTextWriterStyle.Visibility) =
"hidden"
            End If

            ' Remove the overview toggle it overviewmap doesn't exist,
and identify if none of the resources support it.
            Dim ov As OverviewMap = Page.FindControl("OverviewMap1")
            Dim supportsIdentify As Boolean =
MapIdentify1.SupportsIdentify()
            Dim tb As Toolbar = Page.FindControl("Toolbar1")
            If Not (tb Is Nothing) Then
                Dim t As Integer
                For t = tb.ToolbarItems.Count - 1 To 0 Step -1
                    Dim item As ToolbarItem = tb.ToolbarItems(t)
                    If item.Name = "OverviewMapToggle" And ov Is Nothing
Then
                        tb.ToolbarItems.Remove(item)
                    End If
                    If item.Name = "MapIdentify" And Not supportsIdentify
Then
                        tb.ToolbarItems.Remove(item)
                    End If
                Next t
            End If
        End If
    End Sub 'Page_PreRenderComplete

       Private Sub Page_Init(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles MyBase.Init
             ' Enforce SSL requirement.
             Dim requireSSL As Boolean
             If (Not Page.IsPostBack() And
ConfigurationManager.AppSettings("RequireSSL") <> Nothing) Then

       Boolean.TryParse(ConfigurationManager.AppSettings("RequireSSL"),
requireSSL)
                    If (requireSSL And Not Request.IsSecureConnection)
Then

       Response.Redirect(Request.Url.ToString().Replace("http://",
"https://"))
                           Return
                    End If
             End If
    End Sub
```

```
    Protected Sub Page_PreInit(ByVal sender As Object, ByVal e As
System.EventArgs) Handles Me.PreInit
        If (Request.QueryString("resetSession") = "true") Then
            ' Allows client applications (such as Manager) to pass in a
query string
            ' to clear out session state for ADF controls.
            Session.RemoveAll()
            Response.Redirect("~/default.aspx")
        End If
    End Sub

    '/ <summary>
    '/ Default method for catching errors that have no programmed catch
point
    '/ </summary>
    Private Sub Page_Error(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles MyBase.Error
        Dim exception As Exception = Server.GetLastError()
        Server.ClearError()
        callErrorPage("Page_Error", exception)

    End Sub

    '/ <summary>
    '/ Common method for calling error page, passing specific parameters
and messages
    '/ </summary>
    Private Sub callErrorPage(ByVal errorMessage As String, ByVal
exception As Exception)
        Session("ErrorMessage") = errorMessage
        Session("Error") = exception
        Page.Response.Redirect("ErrorPage.aspx", True)
    End Sub 'callErrorPage

    Protected Sub ResourceManager_ResourcesInit(ByVal sender As Object,
ByVal e As EventArgs) Handles MapResourceManager1.ResourcesInit,
GeocodeResourceManager1.ResourcesInit,
GeoprocessingResourceManager1.ResourcesInit,
MapResourceManager2.ResourceInit
        If DesignMode Then
            Return
        End If
        Dim manager As ResourceManager = sender '
        If Not manager.FailureOnInitialize Then
            Return
        End If
        If TypeOf manager Is MapResourceManager Then
            Dim mapManager As MapResourceManager = manager '
            Dim i As Integer
            For i = 0 To mapManager.ResourceItems.Count - 1
                Dim item As MapResourceItem = mapManager.ResourceItems(i)
                If Not (item Is Nothing) Then
                    If item.FailedToInitialize Then
                        mapManager.ResourceItems(i) = Nothing
                    End If
                End If
            Next i
        Else
            If TypeOf manager Is GeocodeResourceManager Then
                Dim gcManager As GeocodeResourceManager = manager '
                Dim i As Integer
```

```
                For i = 0 To gcManager.ResourceItems.Count - 1
                    Dim item As GeocodeResourceItem =
gcManager.ResourceItems(i)
                    If Not (item Is Nothing) Then
                        If item.FailedToInitialize Then
                            gcManager.ResourceItems(i) = Nothing
                        End If
                    End If
                Next i
            Else
                If TypeOf manager Is GeoprocessingResourceManager Then
                    Dim gpManager As GeoprocessingResourceManager =
manager '
                    Dim i As Integer
                    For i = 0 To gpManager.ResourceItems.Count - 1
                        Dim item As GeoprocessingResourceItem =
gpManager.ResourceItems(i)
                        If Not (item Is Nothing) Then
                            If item.FailedToInitialize Then
                                gpManager.ResourceItems(i) = Nothing
                            End If
                        End If
                    Next i
                End If
            End If
        End If
    End Sub 'ResourceManager_ResourcesInit

    '/ <summary>
    '/ Handles call from client to clean up session.
    '/ </summary>
    <System.Web.Services.WebMethod()> Public Shared Function
CleanUp(ByVal randomNumber As String) As String
        Dim cleanUpResponse As String =
ConfigurationManager.AppSettings("CloseOutUrl")
        If cleanUpResponse Is Nothing Then
            cleanUpResponse = "ApplicationClosed.aspx"
        ElseIf cleanUpResponse.Length = 0 Then
            cleanUpResponse = "ApplicationClosed.aspx"
        End If
        Try

GISDataSourceLocal.ReleaseNonPooledContexts(HttpContext.Current.Session)
            HttpContext.Current.Session.RemoveAll()
        Catch
        End Try
        Return cleanUpResponse
    End Function 'CleanUp


    Public Function GetCallbackResult1() As String Implements
System.Web.UI.ICallbackEventHandler.GetCallbackResult
        Return mapstring
    End Function

    Public Sub RaiseCallbackEvent(ByVal eventArgs As String) Implements
System.Web.UI.ICallbackEventHandler.RaiseCallbackEvent
        Map1.Refresh()
        mapstring = Map1.CallbackResults.ToString()
    End Sub
```

```
    Protected Sub ddlMapRender_SelectedIndexChanged(ByVal sender As
Object, ByVal e As System.EventArgs) Handles
ddlHTMapRender.SelectedIndexChanged, ddlHSMapRender.SelectedIndexChanged
        Dim ddl As DropDownList = CType(sender, DropDownList)

        Dim tmp As String = ddl.ID
        Dim partname As String = tmp.Replace("MapRender",
"").Replace("ddl", "")

        Dim ddlIller As DropDownList = ddl.Parent.FindControl("ddl" +
partname + "Iller")

        If ddl.SelectedValue = "-1" Then
            SetVisibility(partname + "Iller", True)
            Functions.FillCombo(ddlIller, "FILL_PROVINCES", 0, "Render
Whole Turkey")
            Map1.Extent = Map1.GetFullExtent()
        ElseIf ddl.SelectedValue = "0" Then
            SetVisibility(partname + "Iller", False)
            Map1.Extent = Map1.GetFullExtent()
        Else
            SetVisibility(partname + "Iller", True)
            Functions.FillCombo(ddlIller, "FILL_PROVINCES_BY_REGION",
Integer.Parse(ddl.SelectedValue), "Render Whole Region")
            Functions.clearAllSelection(Map1, mapResourceIndex)
            Functions.zoomToFeature(Map1, mapResourceIndex, "REGIONS",
"BOLGENUM=" + ddl.SelectedValue, ddl.SelectedItem.Text)
        End If

        Toc1.Refresh()

        Dim sJava As String = ""
        sJava = sJava + "RefreshPage();"

        If Not
ClientScript.IsClientScriptBlockRegistered("UniqueID_127756") Then
            ScriptManager.RegisterClientScriptBlock(Me, GetType(Page),
"UniqueID_127756", sJava, True)
        End If

        ' mpeProgress.Hide()
    End Sub

    Protected Sub ddlIller_SelectedIndexChanged(ByVal sender As Object,
ByVal e As System.EventArgs) Handles ddlHTIller.SelectedIndexChanged,
ddlHSIller.SelectedIndexChanged, ddlHEIller.SelectedIndexChanged
        Dim ddl As DropDownList = CType(sender, DropDownList)
        Dim val As Integer = Integer.Parse(ddl.SelectedValue)

        Dim tmp As String = ddl.ID
        Dim partname As String = tmp.Replace("Iller", "").Replace("ddl",
"")

        Dim ddlIlceler As DropDownList = ddl.Parent.FindControl("ddl" +
partname + "Ilceler")

        If val > 0 Then
            SetVisibility(partname + "Ilceler", True)
            If partname = "HE" Then
                Functions.FillCombo(ddlIlceler, "FILL_DISTRICTS", val, "-
Select District")
```

```
            Else
                Functions.FillCombo(ddlIlceler, "FILL_DISTRICTS", val)
            End If
            ClearBuffer()
            Functions.clearAllSelection(Map1, mapResourceIndex)
            Functions.zoomToFeature(Map1, mapResourceIndex, "PROVINCES",
"ILKODNUM=" + ddl.SelectedValue, ddl.SelectedItem.Text)
        Else
            SetVisibility(partname + "Ilceler", False)
        End If

        Toc1.Refresh()

        Dim sJava As String = ""
        sJava = sJava + "RefreshPage();"

        If Not
ClientScript.IsClientScriptBlockRegistered("UniqueID_129956") Then
            ScriptManager.RegisterClientScriptBlock(Me, GetType(Page),
"UniqueID_129956", sJava, True)
        End If
    End Sub

    Protected Sub ddlHEIlceler_SelectedIndexChanged(ByVal sender As
Object, ByVal e As System.EventArgs) Handles
ddlHEIlceler.SelectedIndexChanged
        Dim ddl As DropDownList = CType(sender, DropDownList)
        Dim val As Integer = Integer.Parse(ddl.SelectedValue)

        If val > 0 Then
            SetVisibility("HEKoyler", True)
            SetVisibility("HEHoldings", True)
            Functions.FillCombo(ddlHEKoyler, "FILL_VILLAGES", val, "-
Select a Village or Holding")
            Functions.FillCombo(ddlHEHoldings, "FILL_HOLDINGS", val, "-
Select a Holding or Village")
            ClearBuffer()
            Functions.clearAllSelection(Map1, mapResourceIndex)
            Functions.zoomToFeature(Map1, mapResourceIndex, "DISTRICTS",
"ILILCENUM=" + ddl.SelectedValue, ddl.SelectedItem.Text)
        Else
            SetVisibility("HEKoyler", False)
            SetVisibility("HEHoldings", False)
        End If

        Toc1.Refresh()

        Dim sJava As String = ""
        sJava = sJava + "RefreshPage();"

        If Not
ClientScript.IsClientScriptBlockRegistered("UniqueID_17416") Then
            ScriptManager.RegisterClientScriptBlock(Me, GetType(Page),
"UniqueID_17416", sJava, True)
        End If

    End Sub

    Protected Sub AddControlEvents()
        ddlHTMapRender.Attributes.Add("onchange", "showProgress(true)")
        ddlHTIller.Attributes.Add("onchange", "showProgress(true)")
```

```
        btnHTRender.Attributes.Add("onclick", "showProgress(true)")

        ddlHSMapRender.Attributes.Add("onchange", "showProgress(true)")
        ddlHSIller.Attributes.Add("onchange", "showProgress(true)")
        btnHSRender.Attributes.Add("onclick", "showProgress(true)")

        ddlHEIller.Attributes.Add("onchange", "showProgress(true)")
        ddlHEIlceler.Attributes.Add("onchange", "showProgress(true)")

        btnAddMihrak.Attributes.Add("onclick", "showProgress(true)")
        btnDropMihrak.Attributes.Add("onclick", "showProgress(true)")
        btnCreateBuffers.Attributes.Add("onclick", "showProgress(true)")
    End Sub

    Protected Sub FillInitialCombos()
        Functions.FillCombo(cblHTDiseases, "FILL_DISEASES")
        Functions.FillTree(treHSAnimalType, "FILL_ANIMAL_TYPES")
        Functions.FillCombo(ddlHEIller, "FILL_PROVINCES", 0, "-Select
Province")
        Functions.FillTree(treISHoldingType, "FILL_HOLDINGS_TYPES")

        Functions.FillCombo(ddlHTIller, "FILL_PROVINCES", 0, "Render
Whole Turkey")
        Functions.FillCombo(ddlHSIller, "FILL_PROVINCES", 0, "Render
Whole Turkey")
        Functions.FillCombo(ddlISIller, "FILL_PROVINCES", 0, "Render
Whole Turkey")
    End Sub

    Protected Sub ResetInitials()
        SetVisibility("HTIller", True)
        SetVisibility("HTIlceler", False)

        SetVisibility("HSIller", True)
        SetVisibility("HSIlceler", False)

        SetVisibility("ISIller", True)
        SetVisibility("ISIlceler", False)

        SetVisibility("HEIlceler", False)
        SetVisibility("HEKoyler", False)
        SetVisibility("HEHoldings", False)
    End Sub

    Protected Sub SetVisibility(ByVal whichpart As String, Optional ByVal
isVisible As Boolean = True)
        'Dim divcontrol As FloatingPanel = Me.FindControl("div" +
whichpart.Substring(0, 2))
        Dim lblcontrol As HtmlControl = Me.FindControl("lbl" + whichpart)
        Functions.setVisibility(lblcontrol, isVisible)

        Dim ddlcontrol As WebControls.WebControl = Me.FindControl("ddl" +
whichpart)
        Functions.setVisibility(ddlcontrol, isVisible)
    End Sub

    Protected Sub btnRender_Click(ByVal sender As Object, ByVal e As
System.EventArgs) Handles btnHTRender.Click, btnHSRender.Click,
btnISRender.Click
        Dim btn As Button = CType(sender, Button)
        Dim tmp As String = btn.ID
```

```
        Dim partname As String = tmp.Replace("btn", "").Replace("Render",
"")

        Dim ddlRender As DropDownList = btn.Parent.FindControl("ddl" +
partname + "MapRender")
        Dim ddlIller As DropDownList = btn.Parent.FindControl("ddl" +
partname + "Iller")
        Dim ddlIlceler As DropDownList = btn.Parent.FindControl("ddl" +
partname + "Ilceler")

        Dim lyrName As String = ""
        Dim groupByLevel As Integer = 0
        Dim upLevel As Integer = 0
        Dim lyrColumn As String = ""
        Dim lyrColumnTxt As String = ""
        Dim datStart As String = ""
        Dim datEnd As String = ""
        Dim sql As String = ""
        Dim mainTitle As String = ""
        Dim xTitle As String = ""
        Dim yTitle As String = ""

        mainTitle = ddlRender.SelectedItem.Text.ToUpper().Replace("İ",
"I").Replace("Ö", "O").Replace("Ü", "U")

        If ddlRender.SelectedValue = "0" Then
            lyrName = "REGIONS"
            lyrColumn = "BOLGENUM"
            lyrColumnTxt = "BOLGE"
            groupByLevel = 1
        Else
            If ddlIller.SelectedValue = "0" Then
                lyrName = "PROVINCES"
                lyrColumn = "ILKODNUM"
                lyrColumnTxt = "IL"
                groupByLevel = 2
                If ddlRender.SelectedValue <> "-1" Then
                    upLevel = CInt(ddlRender.SelectedValue)
                End If
            Else
                lyrName = "DISTRICTS"
                lyrColumn = "ILILCENUM"
                lyrColumnTxt = "ILCE"
                groupByLevel = 3
                upLevel = CInt(ddlIller.SelectedValue)
                mainTitle =
ddlIller.SelectedItem.Text.ToUpper().Replace("İ", "I").Replace("Ö",
"O").Replace("Ü", "U") + " by DISTRICTS"
            End If
        End If

        Dim lyr As Display.Graphics.FeatureGraphicsLayer = Nothing

        lyr = Functions.getLayerGraphicDataSet(Map1, grResourceIndex,
lyrName)
        If Not lyr Is Nothing Then
            Functions.addToGraphics(Map1, lyr, grResourceIndex)
        End If

        Dim params As New ArrayList()   'Data.SqlClient.SqlParameter
```

```
        If partname = "HT" Then
            params.Add(New Data.SqlClient.SqlParameter("@DT1",
txtHTStart.Text))
            params.Add(New Data.SqlClient.SqlParameter("@DT2",
txtHTEnd.Text))
            params.Add(New Data.SqlClient.SqlParameter("@AKTIFLIK",
CInt(ddlHTAktiflik.SelectedValue)))

            datStart = txtHTStart.Text
            datEnd = txtHTEnd.Text

            mainTitle += " - DISEASE COUNT (" + datStart + " - " + datEnd
+ ")"
            xTitle = "DISEASES"
            yTitle = "DISEASE COUNT"

            Dim diseases As String = ""
            For i As Integer = 0 To cblHTDiseases.Items.Count - 1
                If cblHTDiseases.Items(i).Selected Then
                    If diseases = "" Then
                        diseases = cblHTDiseases.Items(i).Value
                    Else
                        diseases += "," + cblHTDiseases.Items(i).Value
                    End If
                End If
            Next
            params.Add(New Data.SqlClient.SqlParameter("@HASTALIK",
diseases))
            params.Add(New Data.SqlClient.SqlParameter("@LEVELUP",
upLevel))
            params.Add(New Data.SqlClient.SqlParameter("@LEVEL",
groupByLevel))

            sql = "GET_DISEASES"
        ElseIf partname = "HS" Then
            params.Add(New Data.SqlClient.SqlParameter("@DT1",
txtHSStart.Text))
            params.Add(New Data.SqlClient.SqlParameter("@DT2",
txtHSEnd.Text))

            datStart = txtHSStart.Text
            datEnd = txtHSEnd.Text

            mainTitle += " - ANIMAL COUNT (" + datStart + " - " + datEnd
+ ")"
            xTitle = "ANIMAL TYPE"
            yTitle = "ANIMAL COUNT"

            If treHSAnimalType.CheckedNodes.Count > 0 Then
                If Not treHSAnimalType.CheckedNodes(0).Value = "0" Then
                    If treHSAnimalType.CheckedNodes(0).Parent.Value = "0"
Then
                        params.Add(New
Data.SqlClient.SqlParameter("@SPECIE",
treHSAnimalType.CheckedNodes(0).Value.Substring(1)))
                        params.Add(New
Data.SqlClient.SqlParameter("@BREED", DBNull.Value))
                    Else
                        params.Add(New
Data.SqlClient.SqlParameter("@SPECIE",
treHSAnimalType.CheckedNodes(0).Parent.Value.Substring(1)))
```

```
                        params.Add(New
Data.SqlClient.SqlParameter("@BREED",
treHSAnimalType.CheckedNodes(0).Value.Substring(1)))
                    End If
                Else
                    params.Add(New Data.SqlClient.SqlParameter("@SPECIE",
DBNull.Value))
                    params.Add(New Data.SqlClient.SqlParameter("@BREED",
DBNull.Value))
                End If
            Else
                params.Add(New Data.SqlClient.SqlParameter("@SPECIE",
DBNull.Value))
                params.Add(New Data.SqlClient.SqlParameter("@BREED",
DBNull.Value))
            End If

            params.Add(New Data.SqlClient.SqlParameter("@LEVELUP",
upLevel))
            params.Add(New Data.SqlClient.SqlParameter("@LEVEL",
groupByLevel))

            sql = "GET_ANIMALS"
        ElseIf partname = "IS" Then
            mainTitle += " - HOLDING COUNT"
            xTitle = "HOLDING TYPE"
            yTitle = "HOLDING COUNT"

            If treISHoldingType.CheckedNodes.Count > 0 Then
                If Not treISHoldingType.CheckedNodes(0).Value = "0" Then
                    If treISHoldingType.CheckedNodes(0).Parent.Value =
"0" Then
                        params.Add(New
Data.SqlClient.SqlParameter("@HOLDTYPE",
treISHoldingType.CheckedNodes(0).Value.Substring(1)))
                        params.Add(New
Data.SqlClient.SqlParameter("@HOLDCLASS", DBNull.Value))
                    Else
                        params.Add(New
Data.SqlClient.SqlParameter("@HOLDTYPE",
treISHoldingType.CheckedNodes(0).Parent.Value.Substring(1)))
                        params.Add(New
Data.SqlClient.SqlParameter("@HOLDCLASS",
treISHoldingType.CheckedNodes(0).Value.Substring(1)))
                    End If
                Else
                    params.Add(New
Data.SqlClient.SqlParameter("@HOLDTYPE", DBNull.Value))
                    params.Add(New
Data.SqlClient.SqlParameter("@HOLDCLASS", DBNull.Value))
                End If
            Else
                params.Add(New Data.SqlClient.SqlParameter("@HOLDTYPE",
DBNull.Value))
                params.Add(New Data.SqlClient.SqlParameter("@HOLDCLASS",
DBNull.Value))
            End If

            params.Add(New Data.SqlClient.SqlParameter("@LEVELUP",
upLevel))
```

```
            params.Add(New Data.SqlClient.SqlParameter("@LEVEL",
groupByLevel))

            sql = "GET_HOLDINGS"
        End If
        Dim ds As Data.DataSet = Functions.doQuery(sql,
params.ToArray(GetType(Data.SqlClient.SqlParameter)))

        If Not lyr Is Nothing Then
            Functions.addRelate(lyr, lyrColumn, ds)
        End If

        Dim classification As String = "EqualInterval"
        Dim rad As RadioButton = btn.Parent.FindControl("rad" + partname
+ "Classification2")
        If rad.Checked Then
            classification = "Natural"
        End If

        ClearBuffer()
        Functions.clearAllSelection(Map1, mapResourceIndex)

        Dim ids() As String = Nothing
        Dim lyrs() As String = Nothing

        Dim mapFunctionality As
ESRI.ArcGIS.ADF.Web.DataSources.ArcGISServer.MapFunctionality =
CType(Map1.GetFunctionality(mapResourceIndex),
ESRI.ArcGIS.ADF.Web.DataSources.ArcGISServer.MapFunctionality)
        mapFunctionality.GetLayers(ids, lyrs)

        Dim j As Integer = 0
        For j = 0 To ids.Length - 1
            If lyrs(j) = lyrName Then
                Exit For
            End If
        Next

        mapFunctionality.SetLayerVisibility(ids(j), True)
        Toc1.Refresh()
        Map1.Refresh()

        RenderMap(lyr, ds, classification)
        Session("ACTIVELYR") = lyrName
        Session("ACTIVELYRCOL") = lyrColumn
        Session("ACTIVELYRCOLTXT") = lyrColumnTxt
        Session("SQL") = sql
        Session("PARAMS") = params

        Session("ANALYSIS") = partname

        Session("MAINTITLE") = mainTitle
        Session("XTITLE") = xTitle
        Session("YTITLE") = yTitle

        Dim charttool As ESRI.ArcGIS.ADF.Web.UI.WebControls.Tool =
Toolbar1.ToolbarItems(8)
        charttool.Disabled = False
    End Sub
```

```
    Protected Sub RenderMap(ByRef lyr As
Display.Graphics.FeatureGraphicsLayer, ByVal ds As Data.DataSet, ByVal
classification As String)
        Dim values() As Double = Functions.getUniqueValues(ds, 5,
classification)
        If values Is Nothing Then
            Exit Sub
        End If

        Dim colorStart As System.Drawing.Color =
System.Drawing.Color.FromArgb(0, 255, 255, 128)
        Dim colorEnd As System.Drawing.Color =
System.Drawing.Color.FromArgb(0, 107, 0, 0)

        Dim icolorStart As ESRI.ArcGIS.Display.IColor = New
ESRI.ArcGIS.Display.RgbColor
        Dim icolorEnd As ESRI.ArcGIS.Display.IColor = New
ESRI.ArcGIS.Display.RgbColor
        icolorStart.RGB = colorStart.ToArgb()
        icolorEnd.RGB = colorEnd.ToArgb()

        Dim ramp As ESRI.ArcGIS.Display.IAlgorithmicColorRamp = New
ESRI.ArcGIS.Display.AlgorithmicColorRamp
        ramp.FromColor = icolorStart
        ramp.ToColor = icolorEnd
        ramp.Algorithm =
ESRI.ArcGIS.Display.esriColorRampAlgorithm.esriCIELabAlgorithm
        ramp.Size = values.Length - 1
        Dim bResult As Boolean = False
        ramp.CreateRamp(bResult)

        Dim colors As New ArrayList()
        Dim i As Integer = 0
        If bResult Then
            Dim cols As ESRI.ArcGIS.Display.IEnumColors
            cols = ramp.Colors
            cols.Reset()

            For i = 0 To values.Length - 2
                Dim iColorTmp As ESRI.ArcGIS.Display.IColor = New
ESRI.ArcGIS.Display.RgbColor
                iColorTmp.UseWindowsDithering = True
                iColorTmp = cols.Next
                iColorTmp.UseWindowsDithering = True

                Dim iTmp As ESRI.ArcGIS.Display.IRgbColor = New
ESRI.ArcGIS.Display.RgbColor
                colors.Add(System.Drawing.Color.FromArgb(iColorTmp.RGB))
            Next
        Else
            Dim color1 As System.Drawing.Color =
System.Drawing.Color.FromArgb(0, 250, 209, 85)
            Dim color2 As System.Drawing.Color =
System.Drawing.Color.FromArgb(0, 242, 167, 46)
            Dim color3 As System.Drawing.Color =
System.Drawing.Color.FromArgb(0, 173, 83, 19)

            colors.Add(colorStart)
            colors.Add(color1)
            colors.Add(color2)
            colors.Add(color3)
```

```
            colors.Add(colorEnd)
        End If

        Dim symbols() As Display.Symbol.SimpleFillSymbol =
Functions.createSymbols(colors, values.Length)

        lyr.Renderer = Functions.createValueMapRenderer(values, symbols,
"TOTAL")

        Dim ids() As String = Nothing
        Dim lyrs() As String = Nothing

        Dim mapGrFunctionality As
ESRI.ArcGIS.ADF.Web.DataSources.Graphics.MapFunctionality =
CType(Map1.GetFunctionality(grResourceIndex),
ESRI.ArcGIS.ADF.Web.DataSources.Graphics.MapFunctionality)
        mapGrFunctionality.GetLayers(ids, lyrs)

        i = 0
        For Each nod As
ESRI.ArcGIS.ADF.Web.UI.WebControls.TreeViewPlusNode In
Toc1.Nodes(0).Nodes
            If lyrs(i) = nod.Text Then
                Exit For
            End If
            i = i + 1
        Next

        mapGrFunctionality.SetLayerVisibility(ids(i), True)

        Toc1.Refresh()
        Map1.Refresh()
    End Sub

    Protected Sub btnCreateBuffers_Click(ByVal sender As Object, ByVal e
As System.EventArgs) Handles btnCreateBuffers.Click
        If lstMihraks.Items.Count = 0 Then
            Exit Sub
        End If

        Dim i As Integer
        Dim buffers As New Collection()

        Dim isFirst As Boolean = True
        Dim UnionEnv As ESRI.ArcGIS.ADF.Web.Geometry.Envelope = Nothing

        ClearBuffer()

        For i = 0 To lstMihraks.Items.Count - 1
            Dim bufval As String = lstMihraks.Items(i).Value
            Dim bufstr As String = lstMihraks.Items(i).Text

            Dim ary As String() = bufval.Split("_")
            Dim buf As New Buffer()

            buf.CenterVal = ary(1)
            buf.CenterStr = bufstr.Split("_")(1)

            If ary(0) = "V" Then
                buf.CenterLyr = "VILLAGES"
```

```
                buf.CenterLyrExpr = String.Format("KOYNUM={0}",
buf.CenterVal)
            ElseIf ary(0) = "H" Then
                buf.CenterLyr = "HOLDINGS"
                buf.CenterLyrExpr = String.Format("ISLETME_NO='{0}'",
buf.CenterVal)
            End If

            Dim tmp As String() = ary(2).Split(",")
            Dim tmpi As Integer() = System.Array.ConvertAll(tmp, New
System.Converter(Of String, Integer)(AddressOf Integer.Parse))
            System.Array.Sort(tmpi)

            For j As Integer = 0 To tmpi.Length - 1
                Dim ring As New BufferRing()
                ring.Radius = tmpi(j) * 1000
                If j > 0 Then
                    ring.InnerRadius = tmpi(j - 1) * 1000
                End If

                Dim pic As TextBox =
CType(lstMihraks.Parent.FindControl("picRadius" + (j + 1).ToString()),
TextBox)
                ring.RingColor = pic.BackColor
                ring.RingTransparency = 70 - (20 * j)   ' or    30 + (20
* j)
                buf.Radius.Add(ring)
            Next

            buf.CenterPt = Functions.doQueryFromMap(Map1,
mapResourceIndex, buf.CenterLyr, buf.CenterLyrExpr)
            Functions.clearAllSelection(Map1, mapResourceIndex)

            Dim gds As New
ESRI.ArcGIS.ADF.Web.Display.Graphics.GraphicsDataSet()
            gds.DataSetName = "BUFFER (" + bufstr + ")"

            For j As Integer = 0 To buf.Radius.Count - 1
                If CType(buf.Radius(j), BufferRing).Radius > 0 Then
                    Dim env As ESRI.ArcGIS.ADF.Web.Geometry.Envelope =
Drawbuffer2(CType(buf.Radius(j), BufferRing), buf.CenterPt, gds)
                    If Not env Is Nothing Then
                        If isFirst Then
                            UnionEnv = env
                            isFirst = False
                        Else
                            UnionEnv.Union(env)
                        End If
                    End If
                End If
            Next

            TaskResults1.DisplayResults(Nothing, Nothing, Nothing, gds)
            TaskResults1.ShowClearAllButton = True
        Next

        If Not UnionEnv Is Nothing Then
            UnionEnv = UnionEnv.Expand(5)

Map1.CenterAt(ESRI.ArcGIS.ADF.Web.Geometry.Envelope.GetCenterPoint(UnionE
nv))
```

```
            Map1.Extent = UnionEnv
        End If

        TaskResults1.Refresh()
        Map1.CallbackResults.AddRange(TaskResults1.CallbackResults)

        Toc1.Refresh()
        Map1.Refresh()
        Session("ANALYSIS") = ""
    End Sub

    Protected Sub btnAddMihrak_Click(ByVal sender As Object, ByVal e As
System.EventArgs) Handles btnAddMihrak.Click
        If (ddlHEHoldings.SelectedIndex < 1) And
(ddlHEKoyler.SelectedIndex < 1) Then
            alertMessage("Please choose a Village or a Holding and the
radius values to add a focal point to the list")
            Exit Sub
        End If

        Dim r1 As String = Slider1.Text
        Dim r2 As String = Slider2.Text
        Dim r3 As String = Slider3.Text
        Dim item As String = ""
        Dim value As String = ""

        If (ddlHEKoyler.SelectedIndex > 0) Then
            item = "V_" + ddlHEKoyler.SelectedItem.Text + " (" + r1 + ","
+ r2 + "," + r3 + ")"
            value = "V_" + ddlHEKoyler.SelectedValue + "_" + r1 + "," +
r2 + "," + r3
        End If

        If (ddlHEHoldings.SelectedIndex > 0) Then
            item = "H_" + ddlHEHoldings.SelectedItem.Text + " (" + r1 +
"," + r2 + "," + r3 + ")"
            value = "H_" + ddlHEHoldings.SelectedValue + "_" + r1 + "," +
r2 + "," + r3
        End If

        lstMihraks.Items.Add(New ListItem(item, value))
    End Sub

    Protected Sub btnDropMihrak_Click(ByVal sender As Object, ByVal e As
System.EventArgs) Handles btnDropMihrak.Click
        If lstMihraks.SelectedIndex < 0 Then
            alertMessage("Please select the focus to drop from the list")
            Exit Sub
        End If

        lstMihraks.Items.RemoveAt(lstMihraks.SelectedIndex)
    End Sub

    Protected Sub alertMessage(ByVal message As String)
        Dim sJava As String = ""
        sJava = sJava + "alert('" + message + "');"

        Dim uid As String = DateTime.Now.ToString("yyyyMMddHHmmss")
        If Not ClientScript.IsClientScriptBlockRegistered("UID_" + uid)
Then
```

```
            ScriptManager.RegisterClientScriptBlock(Me, GetType(Page),
"UID_" + uid, sJava, False)
        End If
    End Sub

    Public Sub ClearBuffer()
        Dim gfc As IEnumerable = Map1.GetFunctionalities()
        Dim gResource As
ESRI.ArcGIS.ADF.Web.DataSources.Graphics.MapResource = Nothing
        Dim gfunc As IGISFunctionality
        For Each gfunc In gfc
            If gfunc.Resource.Name = "Buffer" Then
                gResource = CType(gfunc.Resource,
ESRI.ArcGIS.ADF.Web.DataSources.Graphics.MapResource)
                gResource.Graphics.Tables.Clear()
            End If
        Next gfunc

        TaskResults1.Nodes.Clear()
        TaskResults1.Refresh()

        Dim i As Integer
        For i = MapResourceManager1.ResourceItems.Count - 1 To 0 Step -1
            If
MapResourceManager1.ResourceItems(i).Resource.Name.StartsWith("TaskResult
s1") Then
                MapResourceManager1.ResourceItems.RemoveAt(i)
                'Exit For
            End If
        Next

        Map1.Refresh()
        Toc1.Refresh()
    End Sub

    Public Function Drawbuffer2(ByVal bufring As BufferRing, ByVal
CenterPt As ESRI.ArcGIS.ADF.Web.Geometry.Point, ByRef gds As
ESRI.ArcGIS.ADF.Web.Display.Graphics.GraphicsDataSet) As
ESRI.ArcGIS.ADF.Web.Geometry.Envelope
        Try
            Dim gpath As New System.Drawing.Drawing2D.GraphicsPath()
            gpath.AddEllipse(CSng(CenterPt.X) - CSng(bufring.Radius) / 2,
CSng(CenterPt.Y) - CSng(bufring.Radius) / 2, CSng(bufring.Radius),
CSng(bufring.Radius))

            Dim translateMatrix As New System.Drawing.Drawing2D.Matrix()
            translateMatrix.Translate(0, 0)
            Dim flattening As Single = bufring.Radius / 1000 '0.005F;
//decimal degrees  ---  100F; //meters,feet
            gpath.Flatten(translateMatrix, flattening)

            Dim pc As New ESRI.ArcGIS.ADF.Web.Geometry.PointCollection()
            Dim dpnt As System.Drawing.PointF
            For Each dpnt In gpath.PathPoints
                pc.Add(New ESRI.ArcGIS.ADF.Web.Geometry.Point(dpnt.X,
dpnt.Y))
            Next dpnt

            Dim ring As New ESRI.ArcGIS.ADF.Web.Geometry.Ring()
            ring.Points = pc
            If bufring.InnerRadius > 0 Then
```

```
                Dim gpath_in As New
System.Drawing.Drawing2D.GraphicsPath()
                gpath_in.AddEllipse(CSng(CenterPt.X) -
CSng(bufring.InnerRadius) / 2, CSng(CenterPt.Y) -
CSng(bufring.InnerRadius) / 2, CSng(bufring.InnerRadius),
CSng(bufring.InnerRadius))

                Dim translateMatrix_in As New
System.Drawing.Drawing2D.Matrix()
                translateMatrix_in.Translate(0, 0)
                Dim flattening_in As Single = bufring.InnerRadius / 1000
'0.005F; //decimal degrees  ---  100F; //meters,feet
                gpath_in.Flatten(translateMatrix_in, flattening_in)

                Dim pc_in As New
ESRI.ArcGIS.ADF.Web.Geometry.PointCollection()
                Dim dpnt_in As System.Drawing.PointF
                For Each dpnt_in In gpath_in.PathPoints
                    pc_in.Add(New
ESRI.ArcGIS.ADF.Web.Geometry.Point(dpnt_in.X, dpnt_in.Y))
                Next dpnt_in

                Dim hole As New ESRI.ArcGIS.ADF.Web.Geometry.Hole()
                hole.Points = pc_in
                ring.Holes.Add(hole)
            End If

            Dim rings As New
ESRI.ArcGIS.ADF.Web.Geometry.RingCollection()
            rings.Add(ring)

            Dim mappoly As New ESRI.ArcGIS.ADF.Web.Geometry.Polygon()
            mappoly.Rings = rings

            Dim gfc As IEnumerable = Map1.GetFunctionalities()
            Dim gResource As
ESRI.ArcGIS.ADF.Web.DataSources.Graphics.MapResource = Nothing
            Dim gfunc As IGISFunctionality
            For Each gfunc In gfc
                If gfunc.Resource.Name = "Buffer" Then
                    gResource = CType(gfunc.Resource,
ESRI.ArcGIS.ADF.Web.DataSources.Graphics.MapResource)
                End If
            Next gfunc

            If gResource Is Nothing Then
                Throw New Exception("Buffer Graphics layer not in
MapResourceManager")
            End If

            Dim glayerRings As
ESRI.ArcGIS.ADF.Web.Display.Graphics.ElementGraphicsLayer = Nothing

            Dim dt As System.Data.DataTable
            For Each dt In gResource.Graphics.Tables
                If dt.TableName = "Rings" + bufring.Radius.ToString()
Then
                    glayerRings = CType(dt,
ESRI.ArcGIS.ADF.Web.Display.Graphics.ElementGraphicsLayer)
                End If
            Next dt
```

```
            If glayerRings Is Nothing Then
                glayerRings = New
ESRI.ArcGIS.ADF.Web.Display.Graphics.ElementGraphicsLayer()
                glayerRings.TableName = "Rings" +
bufring.Radius.ToString()
                gResource.Graphics.Tables.Add(glayerRings)
            End If

            Dim geom As ESRI.ArcGIS.ADF.Web.Geometry.Geometry =
CType(mappoly, ESRI.ArcGIS.ADF.Web.Geometry.Geometry)
            Dim ge As New
ESRI.ArcGIS.ADF.Web.Display.Graphics.GraphicElement(geom,
bufring.RingColor)
            ge.Symbol.Transparency = bufring.RingTransparency
            glayerRings.Add(ge)

            Dim glayerHold As
ESRI.ArcGIS.ADF.Web.Display.Graphics.GraphicsLayer = Nothing
            Dim glayerVil As
ESRI.ArcGIS.ADF.Web.Display.Graphics.GraphicsLayer = Nothing

            ' Construct selection layer
            Dim targetlayername As String = "HOLDINGS"
            Dim targetlayername2 As String = "VILLAGES"

            Dim layer_index As Integer = 0
            Dim layer_index2 As Integer = 0

            Dim mf As ESRI.ArcGIS.ADF.Web.DataSources.IMapFunctionality =
CType(Map1.GetFunctionality(mapResourceIndex),
ESRI.ArcGIS.ADF.Web.DataSources.IMapFunctionality)

            Dim gisresource As
ESRI.ArcGIS.ADF.Web.DataSources.IGISResource = mf.Resource
            Dim supported As Boolean =
gisresource.SupportsFunctionality(GetType(ESRI.ArcGIS.ADF.Web.DataSources
.IQueryFunctionality))

            If supported Then
                Dim qfunc As
ESRI.ArcGIS.ADF.Web.DataSources.IQueryFunctionality =
CType(gisresource.CreateFunctionality(GetType(ESRI.ArcGIS.ADF.Web.DataSou
rces.IQueryFunctionality), Nothing),
ESRI.ArcGIS.ADF.Web.DataSources.IQueryFunctionality)

                Dim lids() As Object = Nothing
                Dim lnames() As String = Nothing
                qfunc.GetQueryableLayers(Nothing, lids, lnames)

                Dim i As Integer
                For i = 0 To lnames.Length - 1
                    If lnames(i) = targetlayername Then
                        layer_index = i
                    End If
                    If lnames(i) = targetlayername2 Then
                        layer_index2 = i
                    End If
                Next i
```

```
                Dim spatialfilter As New
ESRI.ArcGIS.ADF.Web.SpatialFilter()
                spatialfilter.ReturnADFGeometries = True
                spatialfilter.MaxRecords = 1000
                spatialfilter.Geometry = mappoly

                Dim spatialfilter2 As New
ESRI.ArcGIS.ADF.Web.SpatialFilter()
                spatialfilter2.ReturnADFGeometries = True
                spatialfilter2.MaxRecords = 1000
                spatialfilter2.Geometry = mappoly

                ' Return all fields (must be specified for ArcGIS Server)
                Dim flds As String() = qfunc.GetFields(Nothing,
lids(layer_index))
                Dim scoll As New ESRI.ArcGIS.ADF.StringCollection(flds)
                spatialfilter.SubFields = scoll

                ' Return all fields (must be specified for ArcGIS Server)
                Dim flds2 As String() = qfunc.GetFields(Nothing,
lids(layer_index2))
                Dim scoll2 As New ESRI.ArcGIS.ADF.StringCollection(flds2)
                spatialfilter2.SubFields = scoll2

                glayerHold =
ESRI.ArcGIS.ADF.Web.Converter.ToGraphicsLayer(qfunc.Query(Nothing,
lids(layer_index), spatialfilter), Drawing.Color.Empty,
Drawing.Color.Yellow, Drawing.Color.YellowGreen, True)
                glayerVil =
ESRI.ArcGIS.ADF.Web.Converter.ToGraphicsLayer(qfunc.Query(Nothing,
lids(layer_index2), spatialfilter2), Drawing.Color.Empty,
Drawing.Color.Orange, Drawing.Color.OrangeRed, True)

                If Not glayerHold Is Nothing Then
                    glayerHold.TableName = "HOLDINGS (" + (bufring.Radius
/ 1000).ToString() + "Km)"
                    gds.Tables.Add(glayerHold)
                End If

                If Not glayerVil Is Nothing Then
                    glayerVil.TableName = "VILLAGES (" + (bufring.Radius
/ 1000).ToString() + "Km)"
                    gds.Tables.Add(glayerVil)
                End If


            End If '***/

            Return
ESRI.ArcGIS.ADF.Web.Geometry.Envelope.GetMinimumEnclosingEnvelope(mappoly
)
        Catch e As Exception
            Map1.Refresh()
            'System.Diagnostics.Debug.WriteLine(("Exception: " +
e.Message))
            Return Nothing
        End Try
    End Function
```

```
    Protected Sub btnClear_Click(ByVal sender As Object, ByVal e As
System.EventArgs) Handles btnHTClear.Click, btnHSClear.Click,
btnISClear.Click
        Dim btn As Button = CType(sender, Button)
        Dim tmp As String = btn.ID
        Dim partname As String = tmp.Replace("btn", "").Replace("Render",
"")

        Dim lyr As Display.Graphics.FeatureGraphicsLayer = Nothing

        Dim gisRes As IGISResource =
MapResourceManager1.ResourceItems(grResourceIndex).Resource
'GetFunctionality(resource).Resource
        Dim resource As DataSources.Graphics.MapResource = CType(gisRes,
DataSources.Graphics.MapResource)

        For i As Integer = 0 To resource.Graphics.Tables.Count - 1
            lyr = resource.Graphics.Tables(i)
            lyr.Renderer = Nothing
        Next

        Toc1.Refresh()
        Session("ANALYSIS") = ""
    End Sub

    Protected Sub btnClearBuffer_Click(ByVal sender As Object, ByVal e As
System.EventArgs) Handles btnClearBuffer.Click
        ClearBuffer()
    End Sub
End Class
```