WEB GIS BASED ANIMAL DISEASES SURVEILLANCE SYSTEM

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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

Arikan, Funda

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

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


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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 (avian 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

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<tbody>
<tr>
<td>1</td>
<td>Cattle plague</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>Foot and mouth disease</td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>Bovine tuberculosis</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>Cattle brucellosis</td>
<td>21</td>
</tr>
<tr>
<td>5</td>
<td>Bovine spongiform encephalopathy</td>
<td>22</td>
</tr>
<tr>
<td>6</td>
<td>Anthrax</td>
<td>23</td>
</tr>
<tr>
<td>7</td>
<td>Rabies</td>
<td>24</td>
</tr>
<tr>
<td>8</td>
<td>Sheep- goat pox</td>
<td>25</td>
</tr>
<tr>
<td>9</td>
<td>Sheep and goat brucellosis</td>
<td>26</td>
</tr>
<tr>
<td>10</td>
<td>Pest des petits ruminants</td>
<td>27</td>
</tr>
<tr>
<td>11</td>
<td>Bluetongue</td>
<td>28</td>
</tr>
<tr>
<td>12</td>
<td>Horse pest</td>
<td>29</td>
</tr>
<tr>
<td>13</td>
<td>Ruam</td>
<td>30</td>
</tr>
<tr>
<td>14</td>
<td>Durin</td>
<td>31</td>
</tr>
<tr>
<td>15</td>
<td>Equine infectious anemia</td>
<td>32</td>
</tr>
<tr>
<td>16</td>
<td>Vesicular stomatitis</td>
<td>33</td>
</tr>
<tr>
<td>17</td>
<td>Equine encephalomyelitis</td>
<td></td>
</tr>
</tbody>
</table>

**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°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, Balikesir province in a turkey farm, where the birds were raised outdoors. A second outbreak was reported in November 2005 in Aralik 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

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<td><strong>28</strong></td>
<td><strong>387</strong></td>
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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).
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 vesicular 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 database management system (RDBMS) based on Oracle® 8.1.7. (Savini et al., 2007).

![Figure 2.2 Pig density in Abruzzo by administrative unit](image-url)
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 asymptptomatically 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
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).
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.
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.

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.

![Medium Client Architecture](image)

**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.

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)
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

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<td>Code of district</td>
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</tbody>
</table>

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

<table>
<thead>
<tr>
<th>FIELD NAME</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANIMAL_IDENTIFIER</td>
<td>Unique ID for each animal</td>
</tr>
<tr>
<td>ANIMAL_SPECIES_CODE</td>
<td>Animal type information</td>
</tr>
<tr>
<td>BIRTH_DATE</td>
<td>Birth date of the animal</td>
</tr>
<tr>
<td>DEATH_DATE</td>
<td>Death date of the animal</td>
</tr>
<tr>
<td>LEVEL1</td>
<td>Code of regions of Turkey</td>
</tr>
<tr>
<td>LEVEL2</td>
<td>Code of province</td>
</tr>
<tr>
<td>LEVEL3</td>
<td>Code of district</td>
</tr>
<tr>
<td>LEVEL4</td>
<td>Code of village</td>
</tr>
</tbody>
</table>

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).
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

Table 3.3 Structure of EV_HOLDINGS Table

<table>
<thead>
<tr>
<th>FIELD NAME</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOLDING_NUMBER</td>
<td>Unique ID for each animal holding</td>
</tr>
<tr>
<td>HOLDING_TYPE_CODE</td>
<td>Code which defines type of holding</td>
</tr>
<tr>
<td>HOLDING_SUBTYPE_CODE</td>
<td>Code which defines subtype of holding</td>
</tr>
<tr>
<td>LEVEL_1_CODE</td>
<td>Code of regions of Turkey</td>
</tr>
<tr>
<td>LEVEL_2_CODE</td>
<td>Code of province</td>
</tr>
<tr>
<td>LEVEL_3_CODE</td>
<td>Code of district</td>
</tr>
<tr>
<td>LEVEL_4_CODE</td>
<td>Code of village</td>
</tr>
</tbody>
</table>

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‘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

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

<table>
<thead>
<tr>
<th>FIELD NAME</th>
<th>DATA TYPE</th>
<th>LENGTH</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>Long Integer</td>
<td>6</td>
<td>Unique identifier number for each case</td>
</tr>
<tr>
<td>NOT_DATE</td>
<td>Date</td>
<td>8</td>
<td>Notification date of the outbreak</td>
</tr>
<tr>
<td>CON_DATE</td>
<td>Date</td>
<td>8</td>
<td>Confirmation date of the outbreak</td>
</tr>
<tr>
<td>END_DATE</td>
<td>Date</td>
<td>8</td>
<td>Date of end of sickness</td>
</tr>
<tr>
<td>LEVEL_2</td>
<td>Text</td>
<td>30</td>
<td>Province name</td>
</tr>
<tr>
<td>LEVEL_3</td>
<td>Text</td>
<td>30</td>
<td>District name</td>
</tr>
<tr>
<td>LEVEL_4</td>
<td>Text</td>
<td>30</td>
<td>Focal point (village or neighborhood) name</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>FIELD NAME</th>
<th>DATA TYPE</th>
<th>LENGTH</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>Long Integer</td>
<td>6</td>
<td>Unique identifier number for wetland point</td>
</tr>
<tr>
<td>NAME</td>
<td>Text</td>
<td>50</td>
<td>Name of the wetland</td>
</tr>
<tr>
<td>PROVINCE</td>
<td>Text</td>
<td>30</td>
<td>Name of the province of wetland</td>
</tr>
<tr>
<td>X</td>
<td>Double</td>
<td>-</td>
<td>X coordinate value in Decimal Degree</td>
</tr>
<tr>
<td>Y</td>
<td>Double</td>
<td>-</td>
<td>Y coordinate value in Decimal Degree</td>
</tr>
</tbody>
</table>

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°C). At a much higher temperature (37°C), 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 °C 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)](image)

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
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

<table>
<thead>
<tr>
<th>Notification_ID</th>
<th>Disease_OIE_Code</th>
<th>Disease_Name</th>
<th>Notification_Date</th>
<th>Confirmation_Date</th>
<th>Date_Of_End_Of_Sickness</th>
<th>Disease_Status_ID</th>
</tr>
</thead>
</table>

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

<table>
<thead>
<tr>
<th>Animal_Identifier</th>
<th>Animals_Species_Code</th>
<th>Animals_Species_Name</th>
<th>Animals_Breed_Code</th>
<th>Animals_Breed_Name</th>
<th>Birth_Date</th>
<th>Death_Date</th>
</tr>
</thead>
</table>

Level1 | Level1_Name | Level2 | Level2_Name | Level3 | Level3_Name | Level4 | Level4_Name |

EV_HOLDINGS Entity Database Schema

<table>
<thead>
<tr>
<th>Holding_Number</th>
<th>Holding_Type_Code</th>
<th>Holding_Type_Name</th>
<th>Holding_Subtype_Code</th>
<th>Holding_Subtype_Name</th>
</tr>
</thead>
</table>

Level1 | Level1_Code | Level1_Name | Level2 | Level2_Code | Level2_Name | Level3 | Level3_Code | Level3_Name | Level4 | Level4_Code | Level4_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 CLASCODE 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

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

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.
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.
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

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

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](image)

### 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.
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.
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 4.13 Thematic map of count of sheep holdings
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

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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

<table>
<thead>
<tr>
<th>Group of distance to nearest wetland (km)</th>
<th>Number of Avian Influenza Cases</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-29</td>
<td>86</td>
<td>43.7</td>
</tr>
<tr>
<td>30-59</td>
<td>57</td>
<td>28.9</td>
</tr>
<tr>
<td>60-89</td>
<td>37</td>
<td>18.8</td>
</tr>
<tr>
<td>90-119</td>
<td>14</td>
<td>7.1</td>
</tr>
<tr>
<td>120-149</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>150-180</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>197</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

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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.

Figure 4.18 Distance in kilometers to nearest wetlands for 2006 AI cases
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° with a range of 0° to 27.7°. 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)

<table>
<thead>
<tr>
<th></th>
<th>Count</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLOPE</td>
<td>197</td>
<td>0.00</td>
<td>27.72</td>
<td>3.82</td>
<td>5.21</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Aspect categories</th>
<th>Number of Avian Influenza Cases</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>41</td>
<td>20.81</td>
</tr>
<tr>
<td>North</td>
<td>22</td>
<td>11.17</td>
</tr>
<tr>
<td>Northeast</td>
<td>26</td>
<td>13.20</td>
</tr>
<tr>
<td>East</td>
<td>20</td>
<td>10.15</td>
</tr>
<tr>
<td>Southeast</td>
<td>16</td>
<td>8.12</td>
</tr>
<tr>
<td>South</td>
<td>18</td>
<td>9.14</td>
</tr>
<tr>
<td>Southwest</td>
<td>13</td>
<td>6.60</td>
</tr>
<tr>
<td>West</td>
<td>22</td>
<td>11.17</td>
</tr>
<tr>
<td>Northwest</td>
<td>19</td>
<td>9.64</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>197</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

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°C). At a much higher temperature (37°C), H5N1 viruses have been shown to survive, in faecal samples, for six days (URL 18). The average temperature value in °C unit for 197 bird flu cases areas in 2006 is; 3.11 °C. The minimum temperature is -10.1 °C and maximum temperature is 9.7°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° with a range of 0° to 27.7° which shows that cases mostly occur at flater places. The average temperature value in °C unit for 197 bird flu cases areas in 2006 is; 3.11°C. The minimum temperature is -10.1°C and maximum temperature is 9.7°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 conclude 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.
REFERENCES


Internet Sources


URL 9: General Directorate of Protection and Control, Avian Influenza Project, Date of access: 05/08/2008, http://www.aiproject.org/English/start.htm


URL 16: http://wwwunixspace.com/context/databases.html, Date of access: 28/12/2008

URL 17: http://en.wikipedia.org/wiki/Database_models, Date of access: 10/01/2009

APPENDIX A

LIST OF 2006 AVIAN INFLUENZA OUTBREAKS IN TURKEY

Table A.1 Avian Influenza Cases Table

<table>
<thead>
<tr>
<th>Notification Date</th>
<th>Confirmation Date</th>
<th>Date of End of Sickness</th>
<th>Province</th>
<th>District</th>
<th>Village Neighborhood</th>
<th>Av. Temp (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/7/2006</td>
<td>1/24/2006</td>
<td>2/14/2006</td>
<td>AKSARAY</td>
<td>MERKEZ</td>
<td>BEBEK</td>
<td>0.4</td>
</tr>
<tr>
<td>1/27/2006</td>
<td>2/28/2006</td>
<td>2/28/2006</td>
<td>ANKARA</td>
<td>CUBUK</td>
<td>SÜNÜ</td>
<td>0.4</td>
</tr>
<tr>
<td>1/31/2006</td>
<td>3/2/2006</td>
<td>3/2/2006</td>
<td>ANKARA</td>
<td>POLATLI</td>
<td>GÜREŞ</td>
<td>0.4</td>
</tr>
<tr>
<td>1/9/2006</td>
<td>1/30/2006</td>
<td>1/30/2006</td>
<td>AYDIN</td>
<td>KUSADASI</td>
<td>MERKEZ-TURKMEN MAH.</td>
<td>8.2</td>
</tr>
<tr>
<td>1/9/2006</td>
<td>1/31/2006</td>
<td>1/31/2006</td>
<td>AYDIN</td>
<td>MERKEZ</td>
<td>CEŞTEPE</td>
<td>8.2</td>
</tr>
<tr>
<td>1/16/2006</td>
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APPENDIX B

LIST OF WETLANDS OF INTERNATIONAL IMPORTANCE IN TURKEY

Table B.1 List of Wetlands

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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.ADF.ArcGISServer
Imports ESRI.ArcGIS.ADF.ArcGISServer.DataSources
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 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
    End Sub

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

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
    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"
Else
CloseHyperLink.Visible = False
Else
LoginStatus1.Style(HtmlTextWriterStyle.Visibility) = "hidden"
End If
' Remove the overview toggle if 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 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://"))
    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
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
    End If
End Else

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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 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
        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

    Toc1Refresh()

    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")
        End If
    End If
End Sub
Else
    Functions.FillCombo(ddIlceler, "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)
    End If
End If

mainTitle = ddlIller.SelectedItem.Text.ToUpper().Replace("İ", "I").Replace("Ö", "O").Replace("Ü", "U") + " by DISTRICTS"
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
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)))
  End If
End If
End If
Else
End If
Else
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
        Else
        End If
    Else
    End If
Else
End If
Else
End If
Else
    params.Add(New Data.SqlClient.SqlParameter("@LEVEL", groupByLevel))
End If
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

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 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
    icolorStart.RGB = colorStart.ToArgb()

    Dim icolorEnd As ESRI.ArcGIS.Display.IColor = New ESRI.ArcGIS.Display.RgbColor
    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 iTmp As ESRI.ArcGIS.Display.IRgbColor = New ESRI.ArcGIS.Display.RgbColor
            iTmp.UseWindowsDithering = True
            iTmp = cols.Next
            iTmp.UseWindowsDithering = True
        Next
    Else
        Dim color1 As System.Drawing.Color = System.Drawing.Color.FromArgb(0, 250, 209, 85)
        colors.Add(colorStart)
        colors.Add(color1)
        colors.Add(color2)
        colors.Add(color3)
    End If
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 
CType(Map1.GetFunctionality(grResourceIndex), 
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("")
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)
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(UnionEnv))
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 gfunc As IGISFunctionality
    For Each gfunc In gfc
        If gfunc.Resource.Name = "Buffer" Then
            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("TaskResults") Then
            MapResourceManager1.ResourceItems.RemoveAt(i)
            Exit For
        End If
    Next
    Map1.Refresh()
    Toc1.Refresh()
End Sub

    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
        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
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 gfunc As IGISFunctionality
For Each gfunc In gfc
    If gfunc.Resource.Name = "Buffer" Then
    End If
Next gfunc

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


Dim dt As System.Data.DataTable
For Each dt In gResource.Graphics.Tables
    If dt.TableName = "Rings" + bufring.Radius.ToString() Then
        glayerRings = CType(dt,
    End If
Next dt
If glayerRings Is Nothing Then
    glayerRings.TableName = "Rings" + bufring.Radius.ToString()
    gResource.Graphics.Tables.Add(glayerRings)
End If

    ge.Symbol.Transparency = bufring.RingTransparency
    glayerRings.Add(ge)


' 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.DataSources.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


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 '****/


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
     'GetFunctionality(resource).Resource
    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