

## THE ROLE OF GEOGRAPHIC INFORMATION SYSTEM (GIS) IN THE CONTROL AND PREVENTION OF ANIMAL DISEASES

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**Summary:** *A Geographical Information System (GIS) is a computer system that displays stored digital data on a map representing the Earth's surface.*

*The application of GIS to the veterinary field has been developed over the last decade. Specialised software is becoming more affordable and user friendly.*

*GIS can be applied to different veterinary activities. It can help to understand and explain the dynamics and spreading pattern of a disease and increase the speed of response in the case of a disease emergency. Additional input, such as the Normalised Difference Vegetation Index (NDVI), satellite images and information on the distribution of vectors, can correlate the disease trends and be used as an early warning tool or a tool to predict the evolution of the hypothetical introduction of a particular disease.*

*The use of GIS tools in the routine activities of the majority of countries of the Middle East Region is not optimal. While there is a general understanding of the advantages of using GIS in the control and prevention of animal diseases, only a few countries really apply this tool on a regular basis. This is mainly due to a lack of training for personnel and the difficulty of accessing good quality data, including digital data.*

**Key words:** Middle East – Geographical Information System (GIS) – epidemiology – Normalised Difference Vegetation Index (NDVI)

### Introduction

A Geographical Information System (GIS) is a computer system for processing, storing, checking, integrating, manipulating, analysing and displaying data related to positions on the surface of the earth. It is then presented cartographically, graphically or as a report.

GIS users add to the specialised software, procedures, operating staff and also the spatial data that feed the system.

Most of the information about our world contains a location reference that places this information at some point on the earth. Without this location reference, there is no geographical information.

To locate geographical information on a map, you use either maps that use a coordinate system to allow locations to be read, or you use shapes (polygons) of the geographic information, where shapes of the features and themes are drawn onto the map. Applications of GIS could reveal links between different sources of information, when it is presented on a map and can find out relationships between features that are not readily apparent in spreadsheets or statistical packages. It creates often new information from existing data, resources very useful for decision making (Veterinary Services), which can lead to better management of disease control programmes and emergency situations.

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**How does a GIS work?**

GIS is usually a computer-based system and it relies on the development of dynamically-linked databases having common geographical components.

Maps can be represented as several different layers where each layer holds data about a particular kind of feature (characteristic, variable). Each characteristic is linked to a position on the graphical image on a map and a record in an attribute table.

The strength of a GIS is related to its ability to relate different information into a spatial context and to reach a conclusion about this spatial relationship that cannot be seen if the information is looked at independently. Therefore it is used to determine where or what an individual feature is and to help in finding patterns by looking at the distribution of overlapped features on the map instead of just a set of individual features not linked together.

**Applications of GIS**

GIS can relate otherwise disparate information, on the basis of common geography, revealing hidden patterns, relationships, and trends that are not readily apparent in spreadsheets or statistical packages, often creating new information from existing data resources. This information is very important as a management tool and produces valuable information needed for better decision making.

GIS applications are very wide and are used in all human activities. It is used for marketing studies, telecommunications, location of restaurants, museums and hospitals; in tracking trucks traffic; in establishing maps of animal population density by species or maps of vegetation coverage change; in locating forests, rivers, mountains; in determining soil compositions, etc.

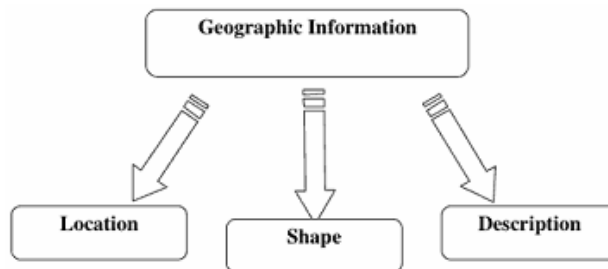
**How can a GIS use the information in a map?**

Information relating to what is where, and sometimes when, on the earth, represents simple information that can be located.

The most known source of geographic information is maps, in which information about the world around us is plotted within a structured framework (a coordinate system) that allows us to find its location.

Maps use a coordinate system and shapes (polygons) to allow locations to be read (see Figure 1).

*Figure 1: Geographical information*



If the data to be used are not already in digital form, i.e. in a format that the computer can recognise, various techniques can capture the information.

Maps can be digitised by hand-tracing with a computer mouse on the screen or on a digitising tablet to collect the coordinates of features.

There are also raster data which consist of a matrix of pixels organised into a grid. Each grid contains information on location co-ordinates and an attribute value. Areas containing the same attribute value are recognised as such. However, raster structures cannot identify the boundaries of such areas as polygons. Satellite images (see Figure 4) and aerial photographs are some examples of raster data.

Geo-coordinates from Global Positioning System (GPS) receivers can be uploaded into a GIS. The GPS uses the Global Navigation Satellite System (GNSS) that utilises a constellation of at least 24 medium earth orbit satellites that transmit precise microwave signals. The latter enables the GPS receiver to determine its location, speed/direction and time.

The Europeans have launched in 2005 the Galileo space programme. This new system is expected to be operational by 2008 and completed by 2010.

### Application of GIS in the livestock sector

The application of the GIS in the veterinary field has developed over the last decade. Specialised software has become more affordable and more user-friendly, in addition to the development of open source tools for mapping.

GIS is an excellent tool for spatial data presentation, inclusion of additional layers (e.g. environmental factors) for better analysis. It is an excellent tool for decision making not yet implemented or used by many Veterinary Services around the world.

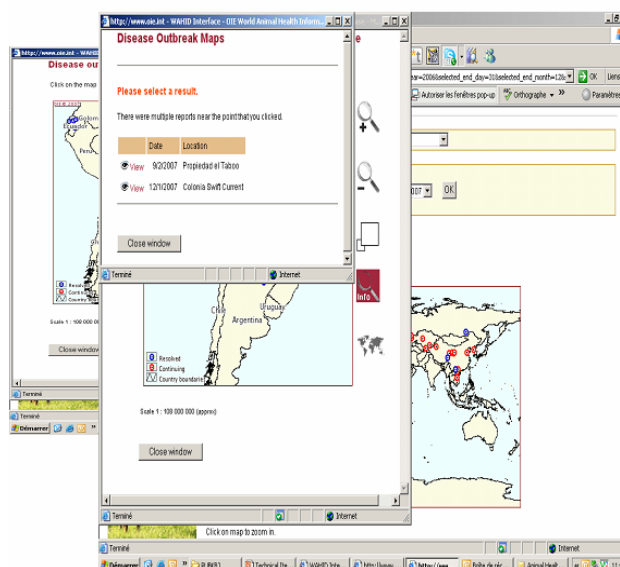
It is not the scope of this paper to describe all the possibilities of applications of GIS in the livestock sector. However, a few examples are given below.

GIS helps in understanding and explaining disease dynamics and spreading patterns. It helps increasing the speed of response in case of an emergency linked with the introduction of a disease. Overlapping maps of location of outbreaks, with the map of location of farms, abattoirs or roads, for example, can help better drawing the perimeter of security, surveillance zones as well as available facilities to implement the decided control measures. The addition of other factors, such as the Normalised Difference Vegetation Index (NDVI), satellite images and vectors distribution in case of vector-borne diseases, can correlate disease trends and be used as an early warning tool, for example, or for the prediction of the evolution of a newly introduced disease.

- **Links between disease occurrence and related explanatory data**

A simple example is to locate the outbreaks on a map and get details on locations, affected animals, etc.

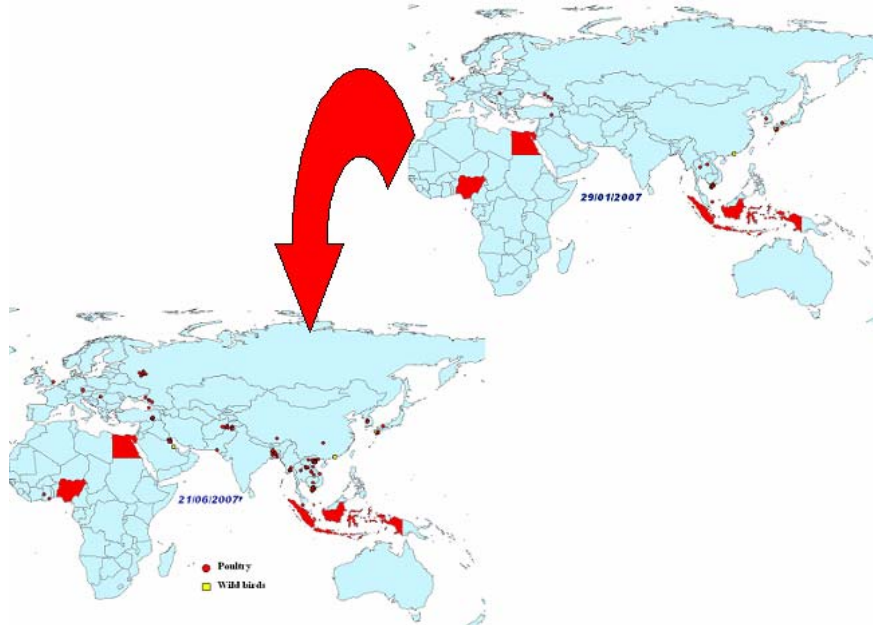
Figure 2: Geographical location of outbreaks of a disease



- **Evolution of disease outbreaks (dynamic maps)**

When many features are drawn up on the same map it is possible to describe and explain disease dynamics and spreading patterns (see Figure 3).

*Figure 3: Worldwide evolution of highly pathogenic avian influenza outbreaks between January and June 2007*



- **Response to a disease emergency situation**

GIS can assist in increasing the speed of response in case of an emergency linked with the introduction of a disease. The availability of up-to-date data on the location of farms, poultry premises, roads, etc., prior to an emergency can help in implementing disease control measures, surveillance activities including control of the movements of vehicles, etc.

The existence of digital data locating abattoirs, mines, incinerators, etc., can ease destruction of susceptible animals, if stamping out or modified stamping out is to be implemented to combat the introduction of a disease.

- **Correlation of disease trends with climatic and other information that could be used for predictions**

GIS can correlate disease trends with, for example, climatic variation and other information such as entomological data that could be used for predictions.

A good example is the prediction of Rift Valley fever (RVF) in the Horn of Africa using satellite images.

RVF has been recognised in African countries, with an underlying association with high rainfall and dense populations of vector mosquitoes. In 2000, it was introduced in Yemen and the south of Saudi Arabia.

Forecasting can predict climatic conditions that are frequently associated with an increased risk of outbreaks, and may improve vector-borne disease control. In Africa, Saudi Arabia and Yemen, RVF outbreaks are closely associated with periods of above-average rainfall. The response of vegetation to increased levels of rainfall can be easily measured and monitored by Remote Sensing Satellite Imagery. In addition, RVF outbreaks in East Africa are closely associated with the heavy rainfall that occurs during the warm phase of El Niño. El Niño refers to the large-scale ocean-atmosphere climate phenomenon linked to a periodic warming in sea-surface temperatures across the central and east-central equatorial Pacific (between approximately the date line and 120°W). El Niño represents the warm phase of the El Niño/Southern Oscillation (ENSO) cycle, and is sometimes referred to as a Pacific warm episode. El Niño originally referred to an annual warming of sea-surface temperatures along the west coast of tropical South America.

Scientists have discovered that the combination of warmer than normal equatorial Pacific Ocean associated with El Niño and rising sea-surface temperature in the western equatorial Indian Ocean increases the quantities of rains that become higher than normal. This increases the number of mosquitoes and their distribution and can trigger outbreaks of RVF in Eastern Africa. Quantities of rains reflect on the vegetation coverage which become higher than normal and can be monitored by satellite images (see Figure 4). This monitoring of the situation can help in designing risk maps of possible occurrence of outbreaks of RVF.

These findings have enabled the development of forecasting models and early warning systems for RVF using satellite images and weather/climate forecasting data. Early warning systems, such as these, could be used to detect animal cases at an early stage of an outbreak, enabling authorities to implement measures to avert impending epidemics.

Figure 4: Normalised Difference Vegetation Index Anomaly map

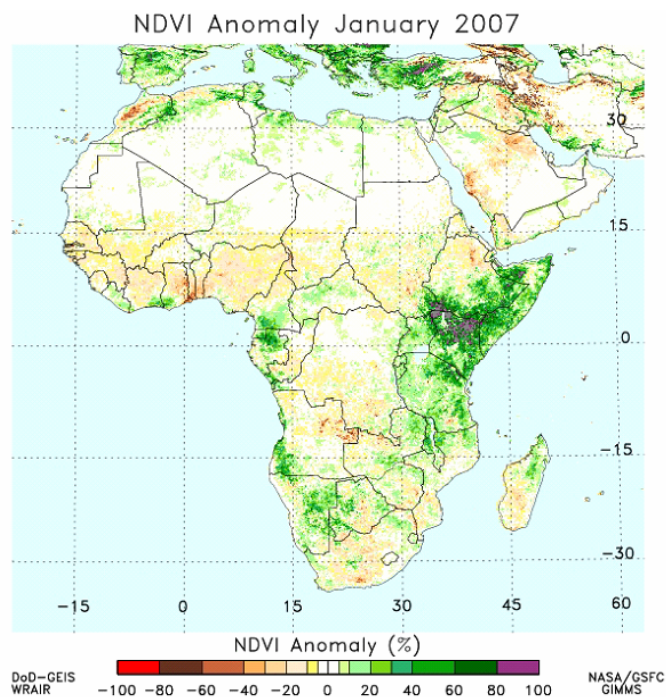
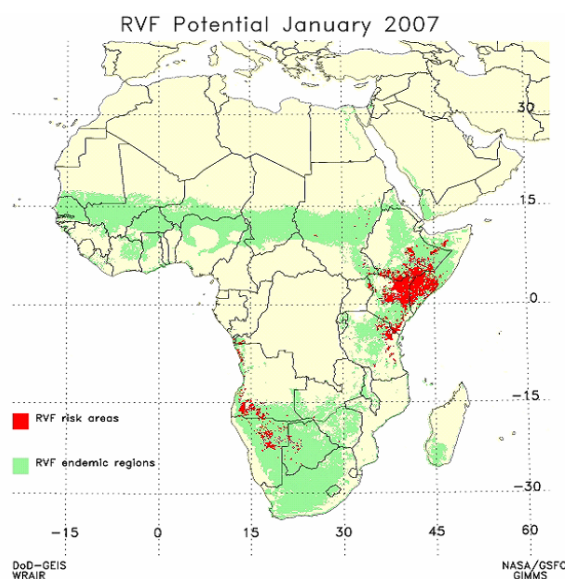


Figure 5: Risk map for Rift Valley fever for the month of January 2007



The above maps show clearly that Eastern Africa was at risk to RVF in January 2007. The dark zones represent regions that have more than normal vegetation coverage during the same period and are zones at risk for vectors proliferation and for the occurrence of RVF outbreaks in animals and in humans.

## Analysis of responses to the questionnaire sent to OIE Member Countries of the Middle East Region

Out of 20 countries member of the OIE Regional Commission for the Middle East<sup>1</sup>, 11 responded to the questionnaire, giving a response rate of 55% (see [Appendix I](#)).

- **Available technologies**

Responding countries use a computer or other form of digital information in their tasks. Microsoft Office is by far the most common software used, but Microsoft Access, ArcView and ArcGIS are also used.

All countries have access to internet: 8 have direct connection and 3 use a modem.

The digital information concerns mostly baseline data on Veterinary Services (VS), such as disease outbreaks, vaccination, livestock census, etc. The information is used in disease surveillance, analysis of disease outbreaks including geographical distribution, and the evaluation of disease control programmes.

Only 5 countries use maps or blueprints on a regular basis. The maps are generally country maps indicating borders, districts, rivers, mountains, and in one case, political boundaries as well. Only one country states that the maps indicate the distribution of Veterinary Services including mobile units. One country states that it uses satellite images.

Of the 5 countries using maps, 4 observe that the maps are accurate for their needs; the remaining country states that the map is too old as it does not reflect the exact number of districts in the country. However, most of the countries feel that a better map would help them do their job better. Such a map would need to include water resources, soil layers and composition of soil, rainfalls and plant coverage areas.

- **Applications of GIS in the countries of the Middle East**

Six countries are currently using computer-based mapping technologies in respect of animal health activities. The countries that do not use such technologies rely on maps received from mapping agencies, their association with other partners or on an internet mapping service.

The main barrier from acquiring computer-based mapping technology seems to be the lack of trained staff. Costs are indicated as the main barrier in three countries. Countries using mapping technology seem to prefer ArcGIS packages followed by ArcView.

Of the 6 countries using a GIS, 3 claim to be using it daily and 3 use them on a monthly basis; 4 countries share digital information with other agencies, departments, or international organisations; 1 country shares the geo-coordinates with the OIE World Animal Health Information System (WAHIS) system.

Countries using a GIS are unanimous in stating that it provides a way to view/analyse important issues for livestock and a means to identify areas of potential disease risk for early warning purposes. Some other countries state that GIS is useful for mapping, recording and tracking livestock population. Only 2 countries feel that GIS is important for public outreach or for educational activities.

Of the 6 countries using a GIS, 5 integrate GIS maps and data in their baseline data documentation.

Most countries feel that GIS could be helpful for their VS, particularly the components dealing with data input and the output products.

The VS of all 6 countries using GIS use the global positioning system (GPS) to collect data for GIS documentation activities and track their projects in a database or spreadsheet. However, only 1 country feels that its VS are maximising the benefits accruing from GIS. The main reasons for not maximising its use are lack of awareness of the potential uses of GIS and scarcity of trained staff.

The majority of countries would like to build in house GIS capacity to view data and print basic maps and to develop data layers and produce and analyse detailed large-scale maps. A few countries would

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<sup>1</sup> The OIE Regional Commission for the Middle East comprises 20 members, as follows: Afghanistan, Bahrain, Cyprus, Djibouti, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Oman, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Turkey, United Arab Emirates, Yemen

like to establish a GIS resource centre to provide mapping services to other livestock activities in their countries on an on-call basis.

Only 2 countries use satellite imagery in identifying animal health problems, tracking animal movement or monitoring disease and resources. Of the countries that do not use it, 2 indicate that their VS do have the capacity to archive data. They state that software such as Oracle 10G, ArcGIS and quantitative data such as those relating to disease incidence, geographical distribution of diseases, bovine passports, etc., are available.

- **International obligations**

In countries using mapping technology, that responsibility has been entrusted to the animal health departments particularly the epidemiological units. These units are also generally the OIE focal points for WAHIS.

Four countries faced exceptional disease events in 2006 which have been reported to the OIE along with the geo-coordinates of the location of the outbreaks. The geo-coordinates have been obtained by using GPS or from the WAHIS map.

Regarding the six-monthly notifications to the OIE, 4 countries have an updated map for at least the first administrative division; 3 countries keep their maps in shape files or other formats. The projections used to produce these maps are all known.

Seven countries informed that they have checked their digital maps that are built in WAHIS. Two countries have already sent their maps that have been updated into WAHIS. Four countries state that their maps are not updated. In one case the first administrative level is not differentiated for the new separated provinces. In another case, changes at administrative levels are on-going. One country feels that updating is not necessary.

## Conclusions

Only few countries in the region regularly use GIS in their routine activities. While there is a general understanding of the facilities offered by the application of GIS in the control and prevention of animal diseases, only few countries really applying this tool regularly. The lack of training of the personnel and the difficulty to access good quality data, including digital data, are the main handicaps in the use of GIS by the majority of the countries of the region.

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.../Appendix



Appendix I

**Members of the OIE Regional Commission for the Middle East having responded to the questionnaire on “The role of Geographic Information System (GIS) in the control and prevention of animal disease”**

1. Bahrain
  2. Cyprus
  3. Egypt
  4. Iran
  5. Jordan
  6. Kuwait
  7. Sudan
  8. Syria
  9. Turkey
  10. United Arab Emirates
  11. Yemen
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