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Review on the Application of Geographical Information Systems (GIS) in Veterinary Medicine

Review Article

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Abstract

Geographical Information System (GIS) is a computer system that displays stored digital data developed over the last decade. GIS is a platform consisting of hardware, software, data and people and encompasses a fundamental and universally applicable set of value-added tools for input, transforming, data management and storage, analyzing, and output information that are geographically referenced. 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. In an outbreak of a disease it could make the management of the situation easier, and it could also provide a tool to evaluate different strategies to prevent the spread of infectious diseases. The following areas in which GIS and special GIS-functions could be incorporated are presented: surveillance and monitoring of animal diseases, recording and reporting information, epidemic emergency, modeling disease spread, and planning control strategies. The technology has many features which make it ideal for use in animal disease control, including the ability to store information relating to demographic and causal factors and disease incidence on a geographical background, and a variety of spatial analysis functions.

Keywords: Geographical Information Systems; Remote Sensing; Satellite Imagery; Disease Surveillance; Veterinary Medicine.

Introduction

The association of geographical information has defined GIS in terms of computerized data base management systems for capturing, storing, checking, integrating, manipulating, analyzing and displaying data which are spatially referenced to the Earth with a primary function to integrate data from a variety of sources [1].

One of the most widely used definitions of GIS is "a powerful set of tools for collecting, retrieving at will, transforming, and displaying spatial data from the real world". Overall, a GIS is a platform consisting of hardware, software, data and people and encompasses a fundamental and universally applicable set of value-added tools for capturing, transforming, managing, analyzing, and presenting information that are geographically referenced [8].

Geographic information systems used as a tool for any discipline which handles data that can be connected with geographical locations, such as countries, regions, communities, or coordinates. The systems are developed rapidly during the past decade there is a number of different software which is more user-friendly than in the past. The need for using this system also in the field of veterinary medicine has been emerging during the last decade [22]. Including information on specific locations (spatial data), maps (geographic coverage), and attributes (descriptive data of the area) in the form of a relational database associated with the mapped features [30].

Establishing GIS which can involve many challenges relative to data collection, analytical methods, and response. Analytical challenges include dealing with unknown time, place, and size of an outbreak, trying to adjust for natural spatial and temporal variations, and the lack of suitable population-at-risk data. While detection of disease clustering in time or space may be accomplished by mapping or plotting cases as a time series, it may be difficult to detect and visualize the interaction between time

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and space. The use of geographic information systems (GISs) and spatial statistical analyses is needed to fully explore time-space clustering of disease and mortality events precisely [61].

One of the main strengths of a GIS is its ability to integrate different types of spatial data. For example, a GIS can be used to map available epidemiological information and relate it to factors known to influence the distribution of infectious diseases, such as climate and other environmental factors. The ability to acquire relevant climatic information, particularly in the tropics, where there is an inadequate infrastructure for the collection of meteorological data, has been enhanced by remote sensing (RS) techniques that can provide proxy environmental information derived from satellite sensors [24]. Geographic information system (GIS) is a new cutting edge technology that is being used as a biological risk visualization, management and tracking tool in veterinary epidemiology [15].

Presently these systems widely used by professionals in research, government and industry, in dealing with spatially related data [29]. With the use and analysis of data obtained by contemporary technology based on GIS and GPS (Global Positioning System), it is possible to get relevant data on the location and size of mosquito larval sites, estimate the density of insect populations, decide on insecticidal product to be used, and employ optimal techniques to create a rational, environmentally friendly strategy to control nuisance mosquitoes and vector-borne diseases [64].

Therefore the objectives of this review paper are:

- To review GIS with support general disease surveillance, reporting, control and eradication.
- To describe suitable site selection of abattoir using Geographical Information systems.

Basics On Geographic Information Systems (GIS)

Main Use of GIS

GIS is an automated system for the input, storage, analysis and output of spatial information. These data combined with population data and previous disease records for prediction of diseases [11].

Data input: Data input refers to the process of identifying and gathering the data required for specific application, thus involving acquisition, reformatting, geo-referencing, compiling, and documenting the data. The data input component converts data from their existing form into one that can be used by the GIS. The data to be used in a GIS may be available in different formats including paper maps, tables of attributes, electronic files of maps and associated attribute data, aerial photos, satellite images and other sources in digital format. One important virtue of a GIS is its efficient capability of integrating different data in different format acquired from a wide range of data sources into compatible format [35, 60].

Data management and storage: Data management include linking, integrating and editing many kinds of data that are located on the Earth's surface, such as health, social, environment data. GIS facilitate the integration of quantitative determination and control data with data obtained from maps, satellite images, and aerial photos. Frequently, socioeconomic data and qualitative information on health facilities have a spatial basis, and can also be integrated. GIS allows analysis of data generated by Global Positioning Systems (GPS). Combined with data from surveillance and management activities, GIS and GPS provide a powerful tool for the analysis and display of areas of high disease prevalence and the monitoring of ongoing control efforts. The coupling of GIS and GPS enhances the quality of spatial and non-spatial data for analysis and decision making by providing an integrated approach to disease control and surveillance at the local, regional, and national level. Spatial and ecologic data are combined with epidemiologic data to enable analysis variables that play important roles in disease transmission. This integration of data is essential for health policy planning, decision making, and ongoing surveillance efforts [7].

Data manipulation and spatial analysis: When dealing with problems of space, the step beyond simple cartography and mapping is spatial analysis, which in geographic research is the tool used to compare the spatial distribution of a set of features to a hypothetically-based random spatial distribution [40]. These spatial distributions, or patterns, are of interest to many areas of geographic research because they can help identify and quantify patterns of features in space so that the underlying cause of the distribution can be determined [18]. The process of identifying unique spatial distributions, or statistical pattern recognition, can range from simply "eye-balling" features on a map to complex computer-based spatial algorithms that can detect very minute differences on a surface [40].

Visualization: Can be used in novel ways to explore the results of traditional statistical analysis. Displaying the locations of outlier and influential values on maps and showing variation in values over space can add a great deal to epidemiologic research. Although such tools are being developed and explored, they would benefit greatly from a closer and more seamless link between statistical packages and GIS [4].

Neighborhood Operations: Evaluate the characteristics of an area surrounding a specified location. Operations included in this category incorporate search, Line-in-Polygon and Point-in-Polygon, Thiessen Polygons, interpolation and contour generation. They determine whether points/lines are inside or outside a polygon boundary. The attributes of these points/lines identified as being within the polygon can then be processed for analysis by display on a map, computing statistics of attribute values, listing attribute values in tabular form, and so on. Point/line-in-polygon operations are typically performed by topological overlay procedures [35].

Buffer analysis: GIS can create buffer zones around selected features. The user can indicate the size of the buffer and then join together this information with disease incidence data to establish how many cases fall within the buffer. Buffer or proximity analysis can be used to map the impact zones of vector breeding sites, where control activity needs to be strengthened. The buffer analysis capabilities of GIS are used for computing the health events located within a specified radius of each grid intersection [7]. Buffering is a GIS tool that creates a circle of specified radius for point data such as a well, or parallel lines of specified distance from linear data such as a river or a road [46].

Overlaying: Involves superimposing thematic plane of GIS features containing geographically and logically related data two or more map layers to produce a new map layer. Map overlay operations allow us to compute new values for locations based on multiple attributes or data layers and to identify and display locations that meet specific. This allows the analyst to compute new values for locations based on multiple features or data layers. GIS can overlay diverse layer of information [7].

Data out put: The data output component of GIS provides a way to see the data or information in the form of maps, tables, diagrams, and so on. The results may be output in hard-copy, soft-copy, or electronic format. Maps and tables are commonly output permanently in hard copy format. The hardcopy output takes longer to produce and requires more expensive equipment. However, it is permanent and easily transported and displayed. A large map can be shown at whatever level of detail is required by making the physical size of the output larger. Outputs in electronic formats, on the other hand, consist of computer-compatible files. They are used to transfer data to another computer system either for additional analysis or to produce a hardcopy output at a remote location [2, 35].

Sources of Data for GIS

Satellite imagery: Satellite imagery, are an increasingly important component in understanding and monitoring the Earth. There are a wide variety of satellites now flying; the United States alone had more than 80 civil Earth observation instruments operating. [44].

About 26% of users indicated that the only satellite imagery they used in the year prior to the survey came from Landsat sensors. The remaining 74% of Landsat users indicated they used a mix of satellite imagery, with the majority on average coming from Landsat, followed by MODIS (Moderate Resolution Imaging Spectroradiometer), ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer), SPOT (Satellite Pour l'Observation de la Terre), and Quickbird. Landsat imagery provides unique spatial information for use by many people both within and outside of the United States. However, the population of these users is unknown, so determining exactly who these users are, how they use the imagery, and the value and benefits derived from the imagery is a challenge. There have been a few surveys and studies that have addressed this issue. As part of a larger study including multiple surveys and case studies [39].

Geographical data: The database management component provides the environment within which the GIS functions and the means by which the data is controlled. Any information that is coded by location such as country, province, district or latitude/longitude coordinates, can be stored and manipulated in the GIS. The advantage of using a GIS rather than traditional database management systems (DBMS) is that the data can be viewed, queried and summarized visually through the graphical environment. Moreover, because the data has topology (this means that each feature "knows" its geographical position relative to other features), a variety of spatial processing functions which are not possible on a standard DBMS can be employed to process the information [53].

Previous institutional experiment with remotes sensing: The potential value of remotely sensed data in decision making is worth an investment of resources. Substantial efforts have been made for more than 15 years to provide the technology transfer and infrastructure for utilizing satellite imagery in many African nations. Within a few months of the launching of LANDSAT 1 (=ERTS I), USAID, through the U.S. Geological Survey's Office of International Geology, began sponsoring training in Africa as well as other regions throughout the globe. By the late 1970s, the first Regional Remote Sensing Center was created in Nairobi, Kenya. The purpose of the center, and its associated activities, was to train local and regional scientists and engineers so that they could process, interpret and apply satellite data to specific problems. The strategy was to combine locally trained individuals, the proper facilities, and some economically and politically attractive projects in the expectation that the host governments would adopt the new technology. The strategy was successful in some cases but not in most [41].

Remote sensing of the Earth traditionally has used reflected energy in the visible and infrared and emitted energy in the thermal infrared and microwave regions to gather radiation that can be analyzed numerically or used to generate images whose variations represent different intensities of photons associated with a range of wavelengths that are received at the sensor. This gathering of a (continuous or discontinuous) range(s) of wavelengths is the essence of what is usually termed multispectral remote sensing [55]. The coverage and resolution of biophysical data derived from remote sensing (RS) satellite data substantially increase our potential to assess the effects of climate change on ecosystems on a regional and global scale. Missing variables, low resolution, inadequate duration, temporal and spatial gaps, and declining coverage in remote sensing data are pervasive [4, 36].

The Remote Sensing is also an important data resource for presentation of vegetation, landcover and land use as well as the categorization of the habitats and population density of insect vectors, parasite and reservoir hosts [6] and [63].

The accuracy of RS methods for providing estimates of temperature was investigated in Africa by comparing estimates of land surface temperature with meteorological ground measurements [23]. A significant correlation between land surface temperature and ground observations was found, with root mean square errors of around two degree celsius. Current trends show that systems based on spatial data analysis and the use of remote sensing is now applied to a wide variety of diseases and geographical areas. This is particularly the case with the use of meteorological satellite data to predict spatial distribution patterns of parasites, vectors, intermediary hosts and hosts, not only in the tropics but also at subtropical and temperate latitudes [21].

Application of GIS Technologies In Veterinary Medicine

GIS for Epidemiological Investigation of Complex Diseases Problems

Geo-spatial tools were used for collection of data, and outbreak mappings were recorded [15]. The GIS was used in the geo-spatial analysis and for monitoring the spread of FMD outbreaks, herd proximity and outbreak locations and topography, distribution of disease serotypes and closeness to features that can spin off the virus within the study area [34]. Recent outbreaks of disease in humans and animals have motivated public health agencies and researchers to develop early disease outbreak detection systems utilizing non diagnostic information [28, 45].

Advantages of the space-time permutation scan statistic method are that it re-quires only case data, is easy to use, makes minimal assumptions about the geographic location, time, or size of the outbreak or stranding event, while automatically adjusting for any natural purely spatial and purely temporal variation, and it allows adjustment for space by time interaction [31].

Land scape related with epidemiology: The landscape of a place is characterized by a mosaic of habitats within the ecosystem. The elements and patterns associated with the biotic, abiotic, and cultural processes within a Landscape are used to identify the factors that influence disease transmission over time and space [38]. The important environmental factors are determined from the examination of the biome and natural nidus of a region where disease activity exists. Identified by its distinct plants, animals, insects, and microbes, a biome is a broad biotic region that is highly predictable based on climate, altitude, and latitude. The natural nidus is the habitat composed of the vectors, hosts, and reservoirs involved in a continuous cycle of transmission that sustain a pathogen within an ecosystem [47].

Relating the disease cycle to the underlying physical environment: Veterinary epidemiology being a holistic approach aimed at coordinating the use of different scientific disciplines and techniques during an investigation of disease and their causation, impaired productivity or welfare of animal population [50]. In this context, the spatial as well as the temporal dimension of disease occurrence is important to measure. GIS technology show the power and potential of spatial analysis capabilities for addressing important health issues at the international, national, and local levels. The application of GIS in Veterinary epidemiology is twofold: used in a research oriented environment to understand a disease (risk factor determination, spatial disease modeling and distribution and prevalence studies) and as a powerful tool in controlling the disease i.e. emergency response, disease detection, operational optimization of the response etc. Among the exploratory methods for epidemiology and public health facilitated by GIS project, some important tasks are to visualize the space-time clusters or hotspot of disease of interest, determining the zones of relative risk around clusters, describing the outbreak (what, when, who and where), analyzing the outbreak (why and how), identify areas in need of resources which can ultimately contribute in planning, controlling and implementing preventive measures of disease concerned. GIS has the ability to combine geo-referenced data generated by global positioning systems (GPS) with ecological data and data from surveillance and management activities for identification and mapping of environmental factors associated with low or high disease prevalence which make it particularly useful for disease surveillance and monitoring of ongoing control efforts [33].

Ecological analysis also describes the relations existing between the geographic distribution of diseases and environmental risk factors and their analysis by means of statistical procedures [39]. A wide number of papers have been published on the analysis of the relationship between disease indicators (e.g. positivity, incidence and prevalence) and the explanatory environmental and climatic variables [25]. In order to make ecological analysis, the following fundamental steps can be utilized: GIS construction for the study area utilizing data layers on environmental and climatic features; geo-referencing the geographic units of interest, creation of buffer zones of a given diameter centered on these geo-referenced points; extrapolation of values for each environmental feature within each buffer zone; databases with environmental and parasitological data; statistical analyses (univariate, multivariate etc.) and individualize of environmental risk factors and/or development of forecast models [12, 51].

GIS for Early warning systems

The availability of climatic, geological and phytographic digital data and the accessibility of GIS software also have permitted the implementation of several epidemiological studies in relation to ecological factors and disease prediction, as well as have been providing evidences that its use is indispensable before the elaboration of control plans [5, 35]. Early Warning is the provision of timely and effective response through the recognized institutions that allows individuals exposed to hazards to take actions, to avoid or reduce risk and prepare for an effective response [20]. Early Warning and Response (EWS) are based on the concept of dealing with a disease epidemic in its early stages. From a public health perspective, early warning of outbreaks with a known zoonotic potential of disease will enable control measures that can reduce human morbidity and Mortality rates. The main uses of early warning system include education as an aid to understanding the crucial elements involved in early detection and response to environmental threats [16].

Disease surveillance: A sentinel network is an interactive disease surveillance system that involves the collection of health data on a routine basis, usually, by health care professionals over a wide (usually at country level) area [9]. In most industrialized nations, notification of many infectious diseases is a statutory requirement. Rapid collection of data and assessment of regional and national statistics leads to early detection of changes in the incidence of infections [26, 32]. The database also provides information for the planning and implementation of intervention [10]. The growth of such sentinel systems, from independent national networks to coordinate international information systems, has, generated a demand for health information systems capable of forecasting disease [17].

The present understanding that a facility-based sentinel surveillance system can play an important role disease in providing information for monitoring communicable diseases, guiding further investigation, evaluating control measures and predicting epidemics [49].

Monitoring of Epidemics diseases: In recent years, several vector-borne, parasitic or vector-borne diseases have emerged or re-emerged in different part of the world, with major public health, socio-economic and political consequences. Emergence of these diseases linked to climatic change, human induced landscape changes and human activities that have affected disease ecology. National approaches are used to explore vector and host distribution and identify areas where substantial changes in vector and vector-borne disease distributions have occurred. Introduction the pathogens into new areas may be the consequence of the land cover/land use. There has also been increased the opportunity the vectors to spread their historical distribution areas, via passive transportation (for West Nile virus-WNV the principal hosts are wild and resident birds [57].

Model of forecasting disease: Disease forecasting involves modeling, which may be based either on statistical relationships established between past case numbers and environmental predictors 'statistical approach' or an attempt to capture the biology of the transmission processes 'biological approach' [42]. Briefly, the statistical approach requires samples from as wide a range of environmental conditions as possible predictions arising from this approach assume that the relationships already established between case numbers and environmental variables will persist into the future [19].

Disease mapping: One of the most useful functions of GIS in epidemiology continues to be its utility in basic mapping. Usually, when data are collected either routinely or through purposely-designed surveys, they are presented in tabular forms, which can be exploited for analytical usage. However, the reading and interpretation of such data is often a laborious and time-consuming task and does not permit easy decision-making [48].

GIS for Recording and Reporting disease information

Geographical Information System can be used to produce maps of disease incidence, prevalence, mortality and morbidity on farm, region, or national levels. The information is more easily understood when visualized on a map. Because information on diseases often tends to be aggregated (from information on each individual herd to municipality or county level) the information loses some of its value. If the information is mapped at the farm level, only small parts of a region can be visualized at the same time. Another way to describe the incidences of diseases in a defined area can be to create density maps by using the density function. The density function creates a grid with a defined cell size and gives each cell in the area a density value of the infected farms. To adjust for the underlying population, a density map of the whole population at risk is created with the same cell size. The density maps are then divided to provide a map that shows the incidence of the particular disease in each area unit at the time unit chosen. This function can further provide maps which how the spread of the disease by displaying the maps as a movie. The GIS can also be incorporated in a real time outbreak notification, as done in an eradication program of the Aujeszky's disease in North Carolina [37].

GIS for planning disease 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 toper form overlay analysis to find high or low risk areas for diseases which depend on geographical features or conditions related to the geography Studies of trypanosomiasis [52].

Buffering and overlay are two of the most common operations in disease modeling. A buffer zone is an area that is within a given distance from a map feature. Points, lines, or polygons can be buffered. Buffers are used to identify areas surrounding geographic features. An overlay is the primary way to combine information from two separate themes. Overlays are most common for polygonal data, and perform a geometric intersection, which results in a new layer with the combined attributes of both initial layers. With vector borne disease areas closer to rivers/streams are seen to suffer most [54]. A buffer distance of 500m, 1000m, 1500m and 2000m was generated since the 2000m, is not sufficient because of current ecological differences as far as mosquito flight distance is concerned. The 2000m is the average flight distance of the mosquito [62].

GIS for Abattoir Site Suitability Analysis

GIS is a computer based system that offers a convenient & powerful platform for performing suitability evaluation. GIS techniques and procedures have an important role to play in analyzing decision problems. Indeed, GIS is often recognized as a decision support system involving the integration of spatially referenced data in problem solving environment. Site suitability assessment is inherently a multi-criteria problem that involves several competent factors appearing at the same time. GIS, through its spatial analysis tools that are particularly suited for an overlay analysis of various competent factors, ease the task of decision makers. On the other hand, GIS can facilitate the spatial analysis of the detected change through time by overlaying the spatial components of the same feature during two or more periods of time. Accordingly, many spatial decision problems give rise to the GIS based multi criteria decision analysis [23]. The impact that the abattoir poses may manifest in the form of liquid wastes (characterized by effluent salinity and bacterial contamination), airborne wastes (mainly disagreeable odours), large potential for the transmission of zoogenic diseases, noise, traffic congestion, attraction of animals (such as hyenas) and big birds, etc. Much of such environmental problems can greatly be reduced through appropriate siting of the abattoir [14].

Site selection: Identifying a new service location is one of the most basic functions of business development. Having the ability to quickly access the geodemographic dynamics of your existing markets in contrast to the likely demand for services at a new location requires a flexible, yet powerful analytical software tools. ArcView Business Analyst, ArcView GIS, Atlas GIS, and Business map project software all provide varying levels of capabilities for site selection [56]. A multi-criteria evaluation (MCE) method can serve to identify, classify, analyze and conveniently arrange the available information concerning choice-possibilities in urban land use planning. It is mainly involved with how to combine the information from several criteria to form a single index of evaluation. It is used to deal with difficulties that decision makers encounter in handling large amounts of complex information. Abattoir site location was determined within the study town through the integration of geographic information system (GIS), weighted linear combination (WLC) analysis, and remote sensing techniques. Several parameters were collected from various sources in vector and raster GIS formats, and then, used within the GIS-based WLC analysis to select suitable abattoir site [58].

A main concern of urban land use planning is the designation of suitable sites for the appropriate land uses. The selection of suitable site for abattoir must be based on a set of local criteria to ensure that the maximum cost-benefit ratio for a community is attained. The suitability of a site for an abattoir is influenced by the various characteristics of the site. However, each characteristic only reflects an aspect of the overall suitability for the specific land use. Furthermore, when a site is found suitable for an abattoir it does not automatically ensure a maximum benefit for the community to assign the site for such a use. Several land uses may compete for the same site. The necessary choices are the subject of the overall urban development planning or the master plan of an area [27].

Suitable distance from main roads, churches, schools and health services: The landfill site should not be placed too far away from existed road networks. Also, it can be reached by alternative roads under all weather conditions. Hence, a weighting of 6 is applied if > 1000 m away and 1 for < 250 m away [43]. As Aysheshim [3] recommended that if the abattoir is not separated from such churches with sufficient distance, one could imagine the severity of potential problems that can be created by big birds hovering around the abattoir. A minimum of 250 meters of distance is thus considered to separate the abattoir from residential and administrative areas, and commercial places. The abattoir should be located at least 300 meters from schools, health services, worship places, recreational places and bus terminals. In order to avoid possible contamination of the river/stream and to prevent the abattoir from being flooded, the site should not lie within 100 meters of rivers/streams.

Suitability of slope: Slope is associated with building cost. Building the abattoir is less expensive on low slopes. The slope is also closely related to surface drainage characteristics of the site. Desirable slope for abattoir site is suggested to be gently sloping area which ranges from two to ten percent. Slope values below two percent are not suitable from safe drainage point of view [59].

Overlaying suitable sites: Finally, all the parameters were weighted with their respective percent of influence and overlay to produce the suitability map. Also adopted criteria are applied to the spatial data using if or then queries, buffering capabilities within GIS, and map overlays and intersections to create a composite site suitability map [3].

Conclusion and Recommendations

GIS represent a new technology in veterinary epidemiology for the reporting of animal disease information and the study and modeling of specific disease problems. However, the technology is not a panacea in its own right and any adoption of such a system must be preceded by a careful evaluation of information needs. A fully featured GIS software package, the necessary hardware and the digital maps needed to run a complete system can be relatively expensive, when all that may be required is a standard database management system and an additional graphical package that can display coloured maps with a certain amount of text or numeric information appended. This would not provide any sophisticated spatial analysis functions, but may suffice as a reporting system. As needs grow and resources become available, an investment in a more complete system could be made. There are three situations in veterinary science where it is suggested that GIS will play an increasingly important role in the future: the need to solve epidemiologically complex disease problems, the need rapidly to monitor highly contagious diseases that might cross international boundaries, and the need to deal with politically sensitive diseases for which prompt and accurate reporting is essential.

Based on the above conclusion and points, the following recommendations are forwarded:

- The concerned body of government should develop and support GIS application in veterinary science to prevent and reduces the spread of disease and its economic impacts.
- The veterinary clinician and workers should aware how to use GIS in the office and field.
- It is highly recommended to use GIS tools and its application to produce maps to abattoir site selection around urban of Ethiopia.
- There should be a further study using GIS technologies for a change detection to explore the effect of Land cover on the disease.

References

[1]. Bailey TC (1994) A review of statistical spatial analysis in GIS. Spatial Analysis and GIS. Taylor & Francis, London. 13-45.

[2]. Aronoff S (1989) Geographic Information Systems: A Management Perspective. Ottawa WDL Publication, Canada.

[3]. Aysheshim MW (2002) Application of GIS for urban planning in Ethiopia with particular reference to abattoir site suitability analysis for Kulitotown: an exploration.

[4]. Clark JS, SR Carpenter, M Barber, S Collins, A Dobson, et al., (2001) Ecological forecasts: an emerging imperative. Science 293(5530): 657-660.

[5]. Bavia ME, Carneiro DDMT, Costa Gurgel H, Madureira Filho C, Rodrigues Barbosa Beck LR, et al., (2005) Remote Sensing and Geographic Information Systems and risk of American Visceral Leishmaniasis in Bahia, Brazil. Parassitologia. 47(1): 165-168.

[6]. Beck L.R, Lobitz B.M, Wood B.L (2000) Remote sensing and human health: new sensors and opportunities. Emerging Infectious Diseases. 6: 217-226.

[7]. Bhatt bindu M, Joshi janak P (2012) GIS in epidemiology: applications and services. National Journal of Community Medicine. 3(2): 261.

[8]. Burrough PA (1986) Principles of Geographical Information Systems for Land Resources Assessment. Clarendon, Oxford. 3(1): 108.

[9]. CDC (Centers for Disease Control and Prevention) (2010) Early Warning Disease Surveillance after a Flood Emergency- Morbidity and Mortality Weekly Report. 61(49): 1002-1007.

[10]. Childs JE, Gordon ER (2009) Surveillance and Control of zoonotic agents Prior to Disease detection in Humans. Mt Sinai J Med. 76(5): 421-428.

[11]. Connor SJ, Thomson MC, Flasse SP, Williams JB (1995) The use of low-cost remote sensing and GIS for identifying and monitoring the environmental factors associated with vector borne disease transmission. GIS for Health and the Environment. 75-87.

[12]. Cringoli G, Rinaldi L, Veneziano V, Musella V (2005) Disease mapping and risk assessment in veterinary parasitology: some case studies. Parassitologia. 47(1): 9-25.

[13]. Dhama K, Verma AK, Rajagunalan S, Kumar A, Tiwari R, et al., (2013) A Perspective on Applications of Geographical Information System: an advanced tracking tool for disease Survelliance and Monitoring in veterinary epidemiology.

[14]. Environmental Protection Authority (EPA) (2002) Abattoirs.

[15]. Esuruoso GO, Ijagbone IF, Olugasa BO (2005) Introductory Epizootiology. (2nd Edn), Vet Academic Resources Foundation (VARF), Ibadan, Nigeria; 196-198.

[16]. Farnswortha ML, Westb CH, Fitchett S, Newmanb SH, Rocqueb S, et al., (2010) Comparing national and global data collection systems for reporting, outbreaks of H5N1 HPAI. Prev Vet Med. 95(3-4): 175–185.

[17]. Flahault A, Dias-Ferrao V, Chaberty P, Esteves K, Valleron AJ, et al., (1998) Flunet as a tool for global monitoring of influenza on the web. JAM A. 280(15): 1330–1332.

[18]. Fotheringham AS, Brunsdon C, Charlton M (2002) Geographically Weighted Regression: the Analysis of Spatially Varying Relationships. John Wiley

and Sons. 284.
[19]. Frisen M (1992) Evaluation of methods for statistical surveillance. Stat Med. 11(11): 1489-1502.
[20]. Grasso V, Singh A (2011) Early Warning Systems: State-of-Art Analysis and Future Directions. Draft report United Nations Environment Programme (UNEP). 1-10.
[21]. Green RM, Hay SI (2002) The potential of Pathfinder AVHRR data for providing surrogate climatic variables across Africa and Europe for epidemiological applications. Remote Sens Environ. 79(2-3): 166-75.
[22]. Hay SI (2000) An overview of remote sensing and geodesy for epidemiology and public health applications. Ad Parasitol. 47: 1-35.
[23]. Hay SI, Lennon JJ (1999) Deriving meteorological variables across Africa for the study and control of vector-borne diseases: a comparison of remote sensing and spatial interpolation of climate. Trop Med International Health. 4(1): 58-71.
[24]. Hay SI (2000) Remote sensing and GIS in epidemiology. Academic Press, Oxford, United Kingdom, 2-27.
[25]. Herbreteau V, Salem G, Souris M, Hugot JP, Gonzalez JP (2005) Sizing up human health through remote sensing: usesand misuses. Parassitologia. 47(1): 63-79.
[26]. Heymann DL, Rodier GR (1998) Global surveillance of communicable diseases. Emerging Infectious Diseases. 4(3): 362–365.
[27]. Hofstee P (2000) Course on the design and Execution of Urban Projects for Arab States. Lecture Note: "Site Analysis and Site Selection", Aman, Jordan.
[28]. Kallen AP, Arcuri, JD Murray (1985) A simple model for the spatial spread and Control of rabies. J Theoretical Biology. 116(3): 377–93.
[29]. Kistemann T, Dangendorf F, Schweikart J (2002) New perspectives on the use of Geographical Information Systems (GIS) in environmental health sciences. Int J Hyg Environ Health. 205(3): 169-181.
[30]. Kitron U (1998) Landscape ecology and epidemiology of vector-borne diseases: tools for spatial analysis. J Med Entomol. 35(4): 435-445.
[31]. Kulldorff M, R Hefferman, J Hartman, R Assuncao, F Mostashari (2005) A space-time permutation scan statistic for disease outbreak detection. PLOS Med. 2(3): e59.
[32]. Lafferty KD (2009) The ecology of climate change and infectious diseases. Ecology. 90(4): 888-900.
[33]. Madelaine N (2001) Geographical Information System (GIS) as a Tool in Surveillance and Monitoring of Animal Diseases. Acta Vet Scand Suppl. 94: 79-85.
[34]. Maheshwaran R, Craglia M (2004) GIS in public Health Practice. (1stEdn), Boca Raton, Florida, CRC press LLC: New York. 69-89.
[35]. Margonari C, Freitas CR, Ribeiro RC, Moura ACM, Timbó M, et al., (2006) Epidemiology of visceral leishmaniasis through spatial analysis, in Belo Horizonte municipality, state of Minas Gerais, Brazil. Mem Inst Oswaldo Cruz. 101(1): 31-38.
[36]. Pettorelli N, JO Vik, A Mysterud, JM Gaillard, CJ Tucker, et al., (2005) Using the satellite-derived NDVI to assess ecological responses to environmental change. Trends Ecol Evol. 20(9): 503-510.
[37]. McGinn TJ, Cowen P, Wray DW (1997) Intergrating a geographic information system with animal health management. Proceedings of the 8th Internationalsymposium on veterinary epidemiology and economics, published in Epidemiologie et sant animale. 31-32: 12.C.36.
[38]. Meade MS, RJ Earickson (2000) Medical Geography. New York, The Guilford Press, England.
[39]. Miller HM, Sexton NR, Koontz Lynne, Loomis John, Koontz SR, et al., (2011) The users, uses, and value of Landsat and other moderate-resolution imagery in the United States—Executive report: U.S. Geological Survey . 2011–1031: 43.
[40]. Mitchell A (2005) The ESRI Guide to GIS Analysis. Volume 2: Spatial Measurements and Statistics. Report ESRI Press. 2011-1031: 43.
[41]. Morain SA (1991) Observations on transferring earth observing technology to the developing world. ACSM-ASPRS Tech Pav. 3: 282-293.
[42]. Myers MF, Rogers DJ, Cox J, Flahault A, Hay SI (2000) Forecasting Disease Risk for Increased Epidemic preparedness in public Health. Adv Parasitol. 47: 309–330.
[43]. Nas B, Cay T, Iscan F, Berktay A (2008) Selection of MSW Landfill Site for Konya, Turkey Using GIS and Multi-Criteria Evaluation. Environ Monit Assess. DOI: 10.1007/s10661-008-0713-8.
[44]. National Research Council (2012) Earth science and applications from space—A midterm assessment of NASA's implementation of the decadal survey: The National Academies Press: Washington, D.C. 124.
[45]. Norstrom M, Pfeiffer DU, Jarp J (2000) A space-time cluster investigation of an outbreak of acute respiratory disease in Norwegian cattle herds. Prev Vet Med. 47(1-2): 107–119.
[46]. Ormsby T, Napoleon E, Burke R, Groessl C, Feaster L (2004) Getting to know ArcGIS desktop. Basics of ArcView, ArcEditor and ArcInfo. ESRI Press.
[47]. Ostfeld RS, GE Glass, Keesing F (2005) Spatial epidemiology: an emerging (or re-emerging) discipline. Trends Ecol Evol. 20(6): 328-336.
[48]. Paolino L, Sebillo M, Cringoli G (2005) Geographical information systems and on-line GIS services for health data sharing and management. Parassitologia. 47(1): 171-175.
[49]. Paweska J, Blumberg L, Weyer J, Kemp A, Leman P, et al., (2008) Rift Valley fever outbreak in South Africa. NICD-NHLS Communicable Diseases Surveillance Bulletin,. 6(2): 1-2.
[50]. Pfeiffer DU (2002) Veterinary Epidemiology-An Introduction. (1st edn), Royal Veterinary College, United Kingdom. 62.
[51]. Rinaldi L, Fusco G, Musella V, Veneziano V, Guarino A, Taddei R, et al., (2005) Neospora caninumin pastured cattle: determination of climatic, environmental, farm management and individual animal risk factors using remote sensing and geographical information systems. Vet Parasitol. 128(3-4): 219-230.
[52]. Rogers DJ (1991) Satellite imagery tsetse and trypanosomiasis in Africa. Prev Vet Med. 11: 201- 220.
[53]. Sanson RL, Pfeiffer DU, Morris RS (1991) Geographic information systems: their application in animal disease control. Rev sci tech. 10(1): 179-195.
[54]. Shilpa H, Penny M, Errol V, Donald RR (2004) Spatial correlations of mapped malaria rates with environmental factors in Belize, Central America. Int J Health Geogr. 3: 6.
[55]. Short NM (2003) The remote sensing tutorial. National Aeronautics and Space Administration/Goddard Space Flight Center, Greenbelt.
[56]. Smith MJ, Goodchild MF, Longley PA (2007) Geospatial Analysis – The comprehensive guide to principles, techniques and software tools. 394.
[57]. Sutherst RW, Ingram JSI, Scherm H (1998) Global change and vector borne disease. Parasitol Today. 14(8): 297-299.
[58]. Teshome MS (2015) Application of GIS and Remote Sensing Using Multi-Criteria Decision Making Analysis for Abattoir Site Selection: the Case of Wolaita Soddo Town, Ethiopia.
[59]. Livestock Marketing Authority (LMA) (2000) Guideline on the Establishment of Export, Addis Ababa, Ethiopia.
[60]. United States Geological Survey (USGS) (2001) An overview of GIS Applications.
[61]. Ward MP, TE Carpenter (2000) Analysis of time-space clustering in veterinary epidemiology. Prev Vet Med. 43(4): 225–237.
[62]. Wim van der Hoek, Flemming K, Priyanie HA, Devika P, Piyaratne MK, et al., (2003) Towards a risk map of malaria for Sri Lanka: the importance of house location relative to vector breeding sites. Int J Epidemiology. 32(2): 280-285.
[63]. Zhou XN, Lv S, Yang GJ, Kristensen TK, Bergquist R, et al., (2009) Spatial epidemiology in zoonotic parasitic diseases: insights gainedat the 1st International Symposium on Geospatial Health in Lijiang, China. Parasites Vectors. 2: 10-26.
[64]. Zou L, Miller SN, Schmidtmann E (2006) Mosquito larval habitat mapping using remote sensing and GIS: implication of coal bed methane development and West Nile virus. J Med Entomol. 43(5): 1034-1041.