Veterinary geographic information systems applications in Nigeria: limitations, challenges and needs

Olutayo O. Babalobi

Summary

In developed countries, the application of geographic information systems (GIS) and other geo-information technologies in facilitating epizootiological studies of animal disease outbreaks, disease reporting, monitoring, surveillance, prediction and intervention (prevention, treatment and control) programmes, has been in vogue for decades. Although not yet in the curricula of any of Nigeria's five veterinary schools, Veterinary geo-information technologies have been promoted and applied at the Faculty of Veterinary Medicine, University of Ibadan, Nigeria, since 2001. Limitations encountered in the course of its application include poor, rudimentary and inconsistent disease reporting procedures, non-computerised (manual) disease recording techniques, raw unanalysed data, poor information networking and poor awareness of the role of geo-informatics in veterinary medicine. The major challenge is the development of sufficient and relevant veterinary databases. Major needs include the training and retraining of personnel involved in the use of GIS for veterinary medicine, the acquisition of relevant hardware and software and the funding of a Nigerian unit/centre devoted to GIS application to veterinary medicine. While Nigeria necessarily develops a national (veterinary) spatial data infrastructure, multilateral training and funding assistance is needed for a developing country like Nigeria to use developed country geo-information technologies to reduce the impact of animal diseases on animal and human populations.

L'applicazione dei sistemi informativi geografici veterinari in Nigeria: limiti, cambiamenti e necessità

Riassunto

Nei paesi sviluppati l'applicazione dei sistemi informativi geografici (GIS) e di altre tecnologie di geo-informazione volte a facilitare gli studi epizoologici dei focolai delle malattie, la notifica delle malattie, il monitoraggio, la sorveglianza, i programmi di previsione e di intervento (previsione, trattamento e controllo) è in voga da decenni. Sebbene non ancora presenti nei curricula di studi in nessuna delle cinque scuole veterinarie della Nigeria, le tecnologie geo-informatiche veterinarie sono state promosse e applicate nella Facoltà di medicina veterinaria, Università di Ibadan, Nigeria dal 2001. I principali limiti riscontrati nell'applicazione sono stati i seguenti: scarse, rudimentali e inconsistenti procedure di notifica delle malattie, procedure di notifica non computerizzate (manuali), dati grezzi non

Department of Veterinary Public Health and Preventive Medicine, Faculty of Veterinary Medicine, University of Ibadan, University Post Office Box 4150, Ibadan, Nigeria
oo.babalobi@mail.ui.edu.nig, tayobabalobi@yahoo.com

analizzati, collegamenti tra gli elementi dei network scarsamente informativi e scarsa consapevolezza del ruolo dei servizi di geo-informatica in medicina veterinaria. La principale sfida consiste nello sviluppo di sufficienti e rilevanti banche dati veterinarie. Le necessità principali sono la formazione e l'aggiornamento del personale coinvolto nell'utilizzo dei GIS nell'ambito della medicina veterinaria, l'acquisto di rilevanti software e hardware nonchè la creazione di una unità o centro dedicato all'applicazione dei GIS nell'ambito della medicina veterinaria. Nonostante la Nigeria sia stata in grado di sviluppare autonomamente una infrastruttura di dati spaziali (di carattere veterinario) a livello nazionale, nei paesi in via di sviluppo come la Nigeria al fine utilizzare tecnologie geo-informatiche per ridurre l'impatto delle malattie animali sulla popolazione animale, è forte l'esigenza di un' assistenza sia dal punto di vista formativo che economico-finananziario.

Parole chiave

Applicazioni, Cambiamenti, Limitazioni, Necessità, Nigeria, Servizi veterinari, Sistema informativo geografico.

Introduction

Over the last fifty years, up to 75% of emerging disease outbreaks in humans (such as the avian flu, Ebola virus infection, rabies, West Nile virus infection, salmonellosis, Lyme disease and severe acute respiratory syndrome or SARS) are zoonotic diseases of animal origin (26). These diseases are transboundary, respecting no territorial or geographic borders, stealthily spreading worldwide. 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.

Geo-information (information tied to a particular location such as flora and fauna, people and animal populations or topography and vegetation specific to a particular area), provides for effective monitoring, prevention,

control and management of such diseases (14, 15). Usually presented in map form to facilitate understanding, geo-information facilitates understanding, promotes creative problem solving and sound decision-making with lasting positive impacts on people's lives (15).

Geographic information systems (GIS), remote sensing (RS) and global positioning systems (GPS) are the three commonly used 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 (9, 10, 14, 15). These technologies create opportunities and challenges for achieving wider and more effective use of geo-information in decision-making for sustainable development (15). In addition, the Internet has brought new dimensions to information and knowledge management. Among its dramatic benefits, it allows selected data and information to be shared among users within countries and between continents around the world. The Internet has extended its reach and applications to spatial information services (15).

In the developed countries, geo-information and Internet technology have been found invaluable for users to identify and locate geographic data at widely dispersed sites and for producers to disseminate their services and data and to assess user's needs (11). Widely used in the developed countries like the United States, United Kingdom and European countries (10), at present geo-spatial data and information in Africa are under used (11) due to the low adaptability/affordability of the information and communication technologies (ICT) culture and a low level of awareness of these electronic ICT facilities in African countries (3, 5).

Geographic information systems applications and challenges in Africa

In Africa, GIS have been employed in livestock research since 1987 at the International Livestock Research Institute (ILRI) in Nairobi

to develop information and decision support systems to help improve the ability to understand and anticipate animal health problems faced by African farmers (24). Since 1990, GIS/RS/GPS have found various applications in veterinary medicine in studies of such diseases as trypanosomosis and theleriosis in Africa (16). Collaborative efforts across national boundaries are also on the increase; the Regional Tsetse and Trypanosomosis Control Programme, for instance, involved agencies from Zimbabwe, Zambia, Mozambique and Malawi (15).

There are a number of factors that undermine the ability of a country or a group of countries to use spatial information effectively in the planning process (11). These factors include:
- lack of awareness by decision-makers
- low stock of base data
- uncertain data discovery, access and exchange mechanisms
- lack of interoperability among datasets
- insufficient human and technical resources.

Five factors, collectively known as spatial data infrastructure (SDI), which determines a country's ability to use geo-information effectively, have been identified (15). These are:
- existence of core data sets
- the accessibility of documentation about existing geo-information
- the adherence of geo-information to accepted standards
- policies and practices promoting the exchange and reuse of geo-information
- sufficient human and technical resources to collect, manipulate and distribute geo-information.

The concept of SDIs with emphasis on co-ordination and partnerships to deliver spatial data and information products to decision-makers in an easy-to-use forms, are increasingly recognised as an indispensable part of the national infrastructure of countries that need to be established and maintained (as are other elements of the infrastructure, such as energy supply, transport and communication facilities). They are a robust response to the challenges that governments and societies confront in the use of spatial data and its

transformation into information and knowledge that are needed for decision-making. Also referred to as 'national geographic information infrastructure' (8), SDI encompasses the policies, technologies and institutional arrangements involved in delivering spatially related information from many different sources to the widest possible group of potential users. They enable unconstrained and transparent access to geo-information by all members of society (8, 15).

In Africa, the establishments of national SDIs have been pioneered by a number of organisations and groups, encompassing United Nations (UN) organisations, professional associations and the private sector, notably Environmental Information Systems-Africa (EIS-Africa), Global Spatial Data Infrastructure Association (GSDI), African Association of Remote Sensing of the Environment (AARSE), International Federation of Surveyors (FIG: *Fédération Internationale des Géomètres*), International Cartographic Association (ICA), International Institute for Aerospace Survey and Earth Sciences (ITC), Environmental Systems Research Institute (ESRI), United Nations Environmental Program (UNEP) and Economic Commission for Africa (ECA). A number of awareness raising and capacity building seminars and workshops have been organised regionally and nationally in the last three years to help understand what these infrastructures are, how are they build, how they work and why they are important. Preparations of many others are underway (15).

Geographic information systems applications and promotion of veterinary medicine in Nigeria

In Nigeria, the Federal Government established in May 1999, the National Space Research and Development Agency (NASRDA) responsible for the consolidation of all space science and technology-related activities in order to make greater impact on development efforts in Nigeria. NASRDA is

incidentally part of the Federal Ministry of Science and Technology, which has a veterinarian as Minister. On 27 September 2003, the Agency launched NigeriaSat-1, a low earth orbit micro-satellite it designed and built. In June 2004, NASRDA, in collaboration with Remote Sensing and Geoinformation Society of Nigeria (RESGAN) and the Geoinformation Society of Nigeria (GEOSON), organised a national satellite imagery validation workshop titled 'Remote sensing (NigeriaSat1) and GIS: a solution to sustainable national development challenges'. The workshop was also intended to provide more awareness for satellite data utilisation in Nigeria. Some of the papers presented at the workshop are documented in a special edition of *NASRDA News* (18).

NASRDA's scant recognition of veterinary application/relevance was reflected in a letter referenced NASRDA 13/11 and dated 31 January 2005 (which requested a date for a presentation on space technology as a veritable research tool for sustainable socio-economic development in Nigeria), to the Vice-Chancellor of the University of Ibadan, for the attention of a number of listed academic departments/faculties (excluding veterinary medicine). It took another letter to NASRDA from the author for the agency to formally appreciate the relevance of space technology to veterinary medicine applications in Nigeria (O.O. Babalobi, personal communication).

As noted in an Food and Agricultural Organization (FAO) document on the Emergency Prevention System (13), computer supported quantitative epidemiology including risk analysis, disease modelling, GIS-based disease mapping, decision support systems and disease forecasting emergency system are areas that are deficient in most national veterinary planning. GIS application in Nigeria is a recent phenomenon that is slowly catching on. Although the theme of the 2001 Congress of the Nigerian Veterinary Medical Association was 'Advances in information technology: impact on the veterinary profession', apart from a keynote paper, only one other paper, dealt with the application of geo-informatics to veterinary medicine (20).

At the national level, a GIS-based National Animal Disease Information System (NADIS) is being developed as part of the Nigerian component of the Pan African Programme for the Control of Epizootics (PACE) sponsored by the European Union (EU) (17). It will include an epidemio-surveillance network and the assessment of the status of the five major transboundary animal diseases – rinderpest, contagious bovine pleuropneumonia, Newcastle disease, African swine fever and foot and mouth disease. In 2001, five veterinarians were sponsored to attend an intensive four-week training on the use of GIS/RS in epidemiology at the Regional Centre for Training in Aerospace Survey, Ile-Ife, Nigeria as part of the capacity building aspect of the Nigeria component of PACE. A French technical assistant was in charge of the GIS programme of PACE. RS/GIS is not yet in the curricula of any of Nigeria's five veterinary schools, neither is there as yet any unit/centre devoted to the application of RS/GIS to veterinary medicine in Nigeria. However, the curricula of the veterinary schools in Nigeria are being reviewed to incorporate GIS (17).

Since 2001, veterinary geo-informatics technologies have been promoted and applied at the Faculty of Veterinary Medicine of the University of Ibadan. Contributing to the adoption and use of veterinary geo-informatics technology by staff of the Faculty of Veterinary Medicine at the University of Ibadan was a publication in the Faculty's international journal, which reviewed the application of GIS to veterinary medicine (6). Three recently concluded PhD theses by staff of the Faculty/Department of Veterinary Public Health and Preventive Medicine employed GPS/RS/GIS to study the ecological effects of lead nitrates on African *Clarias gariepinus* (catfish) (2), the ecology of *Lymnaea natalensis*/fascioliasis in cattle (1) and the last outbreak of African swine fever in south-west Nigeria (22). At the Department of Veterinary Public Health and Preventive Medicine at University of Ibadan, students at undergraduate and postgraduate levels have applied GIS to the study of the landscape epizootiology of trypanosomosis (19) and a

recent outbreak of African swine fever (21). These were conducted in collaboration with GIS personnel in the University's Department of Geography and the private sector.

A recent postgraduate project study (23) applied GIS and GPS to establish a geographic baseline database of some abattoirs in Ibadan, Nigeria, one of Africa's largest cities (12), as a basis for running an effective veterinary information system for epizootiological disease surveillance, monitoring and control of abattoir-related diseases, such as fascioliasis, a disease of significant economic and public health importance. Such baseline data could form the basis for the running of an effective veterinary information system for disease diagnosis, monitoring and surveillance.

This paper highlights the general limitations, challenges and needs encountered in the application of GIS to veterinary medicine in Nigeria (Fig. 1).

Geographic information systems applications in Nigeria; limitations, challenges and needs

Limitations

Specific limitations to the promotion of the effective use of geo-informatics for disease surveillance, monitoring and control in Nigeria (typical of other developing African countries), include the following:
- poor, rudimentary and inconsistent disease reporting procedures (based mainly on administrative boundaries rather than geo-referenced points)
- non-computerised (manual) disease recording techniques
- raw, unanalysed data
- poor information networking between personnel involved in disease reporting
- poor awareness of the role of geo-informatics in veterinary medicine
- non-training of veterinary administrators in modern information systems development
- inability to afford the purchase of relevant software and hardware and the resultant

absence of appropriate hardware and software
- low quantities of livestock-based data
- non-development of sufficient and relevant databases.

Figure 1
Nigeria

Efforts been made to overcome these limitations include the following:
- promotion of awareness of the indispensable role of veterinary geo-informatics in modern emerging zoonotic disease prevention and control (by papers presented at local veterinary conferences and publications in local and international journals) (4, 5, 6, 7, 20)
- application of veterinary geo-informatics in supervised projects of undergraduate and postgraduate students (1, 2, 19, 21, 22, 23)
- review of the veterinary curriculum to incorporate veterinary geo-informatics at undergraduate and postgraduate levels (17)
- development of the GIS-based NADIS as part of the Nigerian component of the EU-sponsored PACE (17)
- occasional training workshop such as the intensive 2001 four-week training on the use of GIS/RS in Epidemiology in Ile-Ife, as part of the capacity building aspect of the Nigeria component of PACE.

Challenges

Challenges encountered in the course of data collection are often the result of poor disease

reporting systems, non-computerised recording techniques, lack of information management, poor information networking, low quantities of livestock-based data, and the non-development of a sufficient and relevant livestock database. These data-related issues are the major challenges to the effective and efficient application of GIS to veterinary medicine in Nigeria.

It is common ground nowadays that 'data are the fuel of GIS' (8). In other words, any GIS project can meet its objectives only if the appropriate data is available. The initial acquisition of the necessary geographic data commonly accounts for about 80% of the total cost of an average GIS project (8). Maintenance of the data (updating) will later add to the cost. If the necessary data is not available at all (or at least is not available in any useful form (scale, accuracy, etc.), the success of the GIS project will be endangered. GIS (and other geo-informatics) provide a powerful means of managing data related to a disease outbreak, especially in designing surveillance strategies and monitoring spatio-temporal trends as cases are reported (14). In recent times, Nigeria has suffered devastating losses from outbreaks, such as African swine fever (21, 22, 25). To effectively curtail future outbreaks, it is vital that Nigeria meets the major challenge of having a national veterinary SDI which will provide some essential information generated by veterinary geo-informatics on administrative boundaries, roads, terrain, watersheds and vegetation, livestock and poultry movements, as well as establish partnerships with other data providers to obtain appropriate population and environmental information to help prevent disease spread.

Needs

However, there are some major needs that have to be met in order to augment the application of GIS and other veterinary geo-information technologies in Nigeria. These are as follows:

▪ the need for training and retraining of personnel involved in the use of GIS/GPS for veterinary medicine, especially in the areas of veterinary data generation and in particular disease recording, reporting, collation and analysis

▪ funding for the acquisition of relevant geo-informatics software and hardware

▪ funding and equipping of a national centre for veterinary epizootiology and geo-informatics.

Although the EU-sponsored PACE programme of which GIS is a component is a modest start, much more multilateral assistance is required to actualise this desirable and necessary application of GIS, GPS and RS to epizootiology and veterinary medicine in Nigeria. The recent FAO 'Training of trainers' workshop on transboundary animal disease information systems (TAD-info software), organised by the Nigeria National Special Programme for Food Security (NSPFS) in Abuja Nigeria from 11 to 16 September 2006 is a welcomed additional step in the right direction.

Conclusions

The application of veterinary geo-informatics has become the most effective approach to the control of animal diseases which do not respect spatial or temporal boundaries. Diseases like rinderpest, contagious bovine pleuropneumonia, Newcastle disease, African swine fever and foot and mouth disease, as well as the new and emerging transboundary zoonotic diseases of public health importance such as the bird flu and SARS, are already prevalent and are of significant socio-economic and public health relevance in Nigeria. Application of GIS and GPS geo-informatics also enhances the spatial auditing of abattoirs, the first point of concentration of animals and of great epizootiological and public health importance for detection, surveillance, monitoring and control of animal and human diseases, such as brucellosis, helminthiasis, anthrax and tuberculosis (14).

While the application of GIS and GPS are been promoted and adopted in Nigeria, for a wider spatial national, international and global coverage, there is a need to include the applications of remote sensing mapping and information gathering to animal disease

surveillance and control in Nigeria. In view of the need for effective monitoring, prevention and control of such rampaging outbreaks, ultimately there will be need for international veterinary organisations, such as the Paris-based World Organisation for Animal Health (OIE: Office International des Épizooties), to seriously consider the funding and equipping of a regional centre for veterinary epizootiology and geo-informatics in West Africa at the Faculty of Veterinary Medicine of the University of Ibadan which has recently been designated by the College of Veterinary Surgeons of Nigeria as a centre of excellence for postgraduate training in animal disease management.

Realising the need to reduce the impact of animal diseases on the agriculture of developing countries, the Federation of American Scientists' Animal Health/Emerging Animal Diseases (AHEAD) project has proposed a major programme in sub-Saharan Africa, called International Lookout for Infectious Animal Disease (ILIAD) which involves the use of developed country technologies. At the core of ILIAD is the need for a permanent and sustainable regional programme of *in situ* surveillance designed to detect, monitor, treat, prevent and control infectious diseases with the goals of increasing livestock production in remote farming communities, protecting the health of wild species, building indigenous physical and professional resources and introducing communications and epidemiology inform-ation technologies (25).

As earlier espoused in a related publication (7) 'there thus must be deliberate commitment by multilateral agencies to assist in the promotion of the application and use of veterinary geo-informatics, especially to epizootiology in a developing country like Nigeria, if we must have a reliable and fast worldwide disease surveillance, monitoring, control, policy planning veterinary decision support system and information system, as advocated by the EMPRES and highlighted in the EMPRES concept paper on the Global Early Warning System (GEWS) for livestock priority transboundary diseases' (13). Ultimately, developed country technologies have to be used to reduce the impact of animal diseases on livestock, poultry and wildlife in a developing country like Nigeria (25).

Nonetheless, until the major challenge of the development of an adequate and relevant livestock/veterinary GIS database in Nigeria has been accomplished, the use of GIS in veterinary medicine in Nigeria will remain a dream. The way to meet this challenge is the creation of a Nigerian national SDI as earlier espoused (8, 15). Multilateral assistance in the funding and training of Nigerians for the creation of a Nigerian national (veterinary) SDI, using developed country geo-information technology, is an imperative requirement if the impact of animal diseases on developing countries is to be reduced. This is a priority area in the development of the international veterinary use of GIS, which is associated with the theme of the 2006 First OIE International Conference on the use of GIS in veterinary activities.

References

1. Adedokun A.A. 2005. Application of geographical information system to the ecology of *Lymnaea natalensis* and the development of a computer simulation model for fascioliasis in cattle. PhD thesis, Department of Veterinary Microbiology and Parasitology, Faculty of Veterinary Medicine, University of Ibadan, Ibadan, 285 pp.

2. Adeyemo O.A. 2005. Bioconcentration and toxicological effects of lead nitrates on African *Clarias gariepinus* (catfish). PhD thesis, Department of Veterinary Public Health and Preventive Medicine, Faculty of Veterinary Medicine, University of Ibadan, Ibadan, 305 pp.

3. Alden C. 2004. For most Africans, Internet access is little more than a pipe dream. Annenberg School for Communication. *Online Journalism Review* (www.ojr.org/ojr/workplace/1079109268.php accessed on 18 July 2007).

4. Babalobi O.O. 2003. Towards an increasing awareness and use of remote sensing and geographical information systems in veterinary medicine in Nigeria. *In* Proc. International Geoscience and Remote Sensing Symposium 2003 (IGARSS '03), 21-25 July, Toulouse. IEEE International, **4**, 2962-2963 (ieeexplore.ieee.org/Xplore/login.jsp?url=/iel5/9010/28604/01294646. pdf?arnumber=1294646 accessed on 18 July 2007).

5. Babalobi O.O. 2007. Towards the development and use of Internet Web and information communication technologies for veterinary medicine education in Nigeria. *In* Proc. 5th International Conference of animal health information specialists (5ICAHIS), 4-7 July 2005, University of Pretoria, Onderstepoort (in press).

6. Babalobi O.O., Fabiyi O. & Oguamanam L. 2002. The application of geographical information systems to veterinary medicine: an overview. *Trop Vet*, **20** (2) 117-125.

7. Babalobi O.O., Onyeka L. & Ogundipe G.A.T. 2005. Towards an increasing awareness and use of veterinary geo-information technologies in Nigeria: a review. *Vom J Vet Sci*, **1** (2), 45-51.

8. Bitter P. & Jayatilaka S. 1996. Towards a geographic information infrastructure for Sri Lanka. *In* Proc. Asian Association on Remote Sensing 1996 (ACRS 1996), Section 11: GIS (www.aars-acrs.org/acrs/proceeding/ACRS1996/Papers/GIS96-3.htm accessed on 18 July 2007).

9. Clarke K.C., McLafferty S.L. & Tempalski B.J. 1996. On epidemiology and geographic information systems: a review and discussion of future directions. *Emerg Infect Dis*, **2** (2), 85-92.

10. Durr P. (ed.) 2004. GIS and spatial analysis in veterinary science. CABI Publishing, Wallingford, 314 pp.

11. Economic Commission for Africa (ECA) 2004. SDI Africa: an implementation guide-preamble (geoinfo.uneca.org/sdiafrica/default1.htm accessed on 18 July 2007).

12. Filani M.O. (1994). Ibadan Region. R. Charles Publication in conjunction with Connel Publications, Ibadan, 271 pp.

13. Food and Agriculture Organization (FAO) 2001. EMPRES concept paper on the Global Early Warning System (GEWS) for livestock priority transboundary diseases, Appendix 9. FAO, Rome, FAO Animal Production and Health Paper No. 133 (www.fao.org/docrep/004/w3737e/w3737e13.htm accessed on 18 July 2007).

14. Freier J.E. 2000. Mapping outbreaks using GIS. *Emerg Infect Dis (Perspectives)*. **12** (3), 10-12.

15. Gavin E. 2002. Geo-information supports decision-making in Africa. An EIS-AFRICA Position Paper. EIS-AFRICA, Pretoria, 12 pp (geoinfo.uneca.org/sdiafrica/Chap_HTML/..%5CReference%5CRef0%5CSDI%20Declaration%20for%20WSSD_en.pdf accessed on 18 July 2007).

16. Lessard P., L'Eplattenier R., Norval R.A.I., Kundert K., Dolan T.T., Croze H., Walker J.B., Irvin A.D. & Perry B.D. 1990. Geographical information systems for studying the epidemiology of cattle diseases caused by *Theileria parva*. *Vet Rec*, **126**, 225-262.

17. National Animal Disease Information and Surveillance (NADIS INFO) 2002. Nigeria, National Animal Disease Information and Surveillance. *NADIS*, **2**, July, 8 pp.

18. National Space Research and Development Agency (NASRDA) 2004. Nigeria. *NASRDA News*, **1** (3), Special Edition.

19. Oguamanam L. 2001. Application of geographical information systems to landscape epizootiology: a case study. Final year project: PhD thesis, Department of Veterinary Public Health and Preventive Medicine, University of Ibadan, Ibadan, 83 pp.

20. Oguamanam L., Babalobi O.O. & Fabiyi O. 2001. Application of geographical information systems to assess the risk of trypanosomosis in Apete, Ibadan. *In* Proc. 38th National Congress of the Nigerian Veterinary Medical Association (NVMA), November, Topo, Badagry, Lagos Nigeria. Nigeria Veterinary Medical Association, Lagos, 211-217.

21. Ogunwale C. 2002. Preparation of digital map on African swine fever 2001-2002 outbreak in Ibadan North Local Government Area of Oyo state, Nigeria. A case study. Final year project: PhD thesis, Department of Veterinary Public Health and Preventive Medicine, University of Ibadan, Ibadan, 60 pp.

22. Olugasa B.O. 2005. Epizootiology of African swine fever outbreak in south-west Nigeria, 1998-2005. PhD thesis, Department of Veterinary Public Health and Preventive Medicine, University of Ibadan, Ibadan, 203 pp.

23. Onyeka L. 2004. Development of a geographic systems database for veterinary disease surveillance, monitoring and control. Master of Preventive Veterinary Medicine (MPVM), Department of Veterinary Public Health and Preventive Medicine, University of Ibadan, Ibadan, 86 pp.

24. Perry B.D., Kruska R.L. & Reid R.S. 1995. GIS at the International Livestock Research Institute (ILRI). ILRI, Nairobi.

25. Preslar D.B. 1999. Lessening the impact of animal disease on developing country agriculture: a proposed program using developed country technologies. Novello Press, London, Sustainable Agriculture Solutions – Action Report 1999 (www.fas.org/ahead/ukart2.htm accessed on 18 July 2007).

26. Saperstein G. 2006. Veterinarians play a vital role in maintaining public health *Worcester Telegram Gaz*, 17 March (enews.tufts.edu/stories/031706VeterinariansPlayVitalRole.htm accessed on 18 July 2007).