charat mongkolsawat

From:	Nitiporn Saardmoung [nitiporn.ijg@j-geoinfo.net]
Sent:	Saturday, September 06, 2008 11:24 AM
To:	charat@kku.ac.th
Cc:	nitingis@gmail.com
Subject:	Submit detail manuscript for special issue on HealthGIS
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GEOINFORMATICS

iief
nar Tripathi
kt@ait.ac.th

P. O. Box: 44, Klong Luang, Pathumthani 12120, Thailand
Tel: +66-2-963-9148, Fax: +66-2-501-1677

September 06, 2008

To:
Dr. Charat Mongkolsawat
Geoinformatics Centre for Development of Northeast Thailand
Khon Kean University
khon Kean
Thailand

Sub: Submit detail manuscript for special issue on HealthGIS

Dear Author

We are really thankful to you for attending and contributing your research work in the 2nd Int. Conf. on HealthGIS 2008 in Bangkok during 14-16 January.
As proposed a special issue on selected papers is proposed to be published in the peer reviewed International Journal of Geoinformatics in December 2008.

I am very happy to inform you that your paper has been identified by the peer committee and the Guest Editors. There are 18 papers in shortlist from which only 12 will be published.

Kindly submit your extended manuscript as per the attached guidelines to nitingis@gmail.com before October 15.

Thanks and looking forward your reply.

Nitin Tripathi

Dr. Nitin K. Tripathi
Editor-in-Chief, International Journal of Geoinformatics
Director, UNIGIS@AIT Centre (Online Masters and Diploma Program in GIS)
Associate Professor, Remote Sensing and GIS,
School of Engineering and Technology,
Asian Institute of Technology,
P. O. Box: 4, Klong Luang, Pathumthani-12120, Thailand
Phone: +66-2-524 6392, Fax: +66-2-524 5597, +66-2-501 1677
E-mail: nitinkt@ait.ac.th, nitingis@gmail.com

GIS Modeling for Avian Influenza Risk Areas

Charat Mongkolsawat Thapanee Kamchai

Geoinformatics Center for the Development of Northeast Thailand
123 Khon Kaen University,
Muang, Khon Kaen
+66 4334-8268

charat@kku.ac.th thapanee_k@kku.ac.th

ABSTRACT

As the first outbreak of highly pathogenic avian influenza (HPAI) in Thailand in 2004, the zoning of HPAI disease is needed for effective prevention and control and also to reduce the socio-economic impact of the outbreak. The purpose of this study is therefore to establish a model for predicting the avian flu risk areas using the integrated themes concerned. The risk areas can be used for a surveillance of avian flu outbreaks and eradication. The methodology included an analysis of affected theme layers, the overlay processing and the assessment. The theme layers are distance from the former outbreak communities (C), density of poultry population (D), distance from the poultry farms (F), land use type (L) and distance from the market or the slaughterhouse or the cockpit (P). Khon Kaen province was selected as the study area which covers an area of about 10,886 sq.km and is located in the Northeastern part of Thailand. Each of the above theme layers mentioned with its associated attribute data were digitally performed in GIS database to eventually create five thematic layers. Simultaneous overlay operation on these layers with the defined model (Risk Area = CDFLP) produces a resultant polygonal layer, each of which is a mapping unit with the risk area class. The process involved the formulation and testing the model followed by the iteration of the model to the geo-referenced information. We used this model with 5 factors ratings and selected the best choice of the model. These are classified into 4 classes of high, moderate, low and very low risk areas. The study indicates that the high, moderate, low and very low risk areas cover an area of about 1.60, 26.31, 71.88 and 0.21 % of the entire province area respectively. The reliability of the result was also tested to validate the defined model. The established information has been stored in GIS and can be rapidly used for future analysis.

Keywords

Avian Influenza, Modeling, Risk areas, GIS.

1. INTRODUCTION

Bird flu or Avian influenza is an infection caused by virus called “Orthomyxoviridae”. The highly pathogenic avian influenza (HPAI) is a form that causes severe symptom and spreads rapidly through flocks of poultry. Influenza virus type A is responsible for causing bird flu which was first found in Italy in 1878. The subtype H5N1 virus of type A is the main cause of the bird flu. The transmission route of bird flu can be spread out from one to another and from country to country. In 2004 the Thai national reference laboratory confirmed the presence of H5N1 virus in layer chicken farm in Suphanburi province (Tiensin et al., 2005). The transmission route by which the virus took place could not be identified.

On January-February 2004, the first H5N1 surfaced in Khon Kaen province, corresponding the cool season. On July 2004, the recurrence of H5N1 was confirmed in Khon Kaen. The first outbreak in Khon Kaen led to destruction of about 848,294 chickens (Department of Livestock Development [DLD], 2004). The outbreak of bird flu has profound effect on socio-economic at local, regional and the whole country as well. The outbreak has diminished the poultry trade, poultry product consumption, poultry raising, demand and supply of feeding ingredients. The outbreak effects extended widely over the vast areas of communities. As a result, the spread of epidemic and its impacts covered extensively for numerous provinces, geographic information on the infection of bird flu was then realized in Thailand during the outbreak period. The information stored in the form of spreadsheet requires effort to visualize geographic distribution as related to severity of the epidemic and environmental factors involved. The conversion of those information into GIS database was then performed. The information obtained could be digitally analyzed to study the area at risk. In Thailand, three different zones are defined: the infected farm, a restricted area from 0-5 km., a surveillance zone from 5-10 km. and movement control 10-50 km. The study conducted by Gilbert et al., 2006 provided information about the spatial distribution of HPAI outbreak in relation to numerous variables. The results demonstrate a strong association between H5N1 virus in Thailand and abundance of free-grazing ducks and to a lesser extent, native chickens, cocks, wetland and humans. Wetland used for double-crop rice production where free-grazing duck feed year round in rice paddies, appear to be a critical factor in HPAI persistence and spread. Ehlers M. et al., 2003 reported the application of VetGis to perform analysis numerous indices for effective management of avian influenza in Italy. In order to define control, buffer zone or surveillance areas, risk assessment studies are necessary to curb the spread of the disease. GIS capability in integrating various spatial risk parameters could be a valuable tool to carry out risk assessment and assist defining sound control strategies (FAO, 2004a)

A surveillance and eradication of avian flu require extent of areas at risk. This study was then conducted with objective of establishing a model for predicting the avian flu risk areas with respect to an integration of spatial risk variables.

2. DESCRIPTION OF THE STUDY AREA

The study area, Khon Kaen province (Fig 1.) is located in the central portion of Northeast Thailand and covers an area of about

10,886 sq.km with elevation difference between 900 m. and 100 m. mean sea level. It is characterized by gently undulating topography with small hills. The area is drained eastwards by Phong and Chi rivers to Mun river and ultimately to the Mekong river. Ubon Ratana Dam with storage capacity of 2,264 million m^3 is main water resource supply for agriculture and domestic uses. Total population of Khon Kaen province is about 1.77 million persons in 2004, 75% of which is engaged in rain fed agriculture and livestock feeding. The average temperature of Khon Kaen is approximately 27°C with 33 °C mean max. and 22.5 °C mean min. The duration of cool season covers the period October-February, followed by dry season February-May. The rainfall pattern starts on May and ends on October with mean annual rainfall of 1,200 mm. The land use in Khon Kaen is dominated by paddy rice, field crops, forest and others which accounted for 42.26%, 30.69%, 11.14% and 15.91% respectively.

Figure 1. Study area.

3. METHODOLOGY

3.1 Variable Analysis

This study uses a synergistic approach, combining the outbreak data of Khon Kaen province during the year 2004, the previous study made by a number of agencies and spatial analysis of the outbreak variables. The actual data for outbreaks of bird flu have been taken from DLD. On January-February 2004 and July-December 2004 the H5N1 virus spread in Khon Kaen province covering mainly the eastern portion of the province. The data collected by DLD included the locations and their associated attributes of the outbreaks, number of poultry farms, poultry markets, slaughterhouses and cockpits. (Table 1.)

Table 1. Data types collected by Department of Livestock Development in Khon Kaen Province

Data type	Number	Some Related Information
Poultry farm	267	Total number = 941,117 chickens
Slaughterhouse	58	Rate of chicken killed = 10,584 per day
Cockpit	45	Operating once a week
Market	42	Live chicken and products
The 1st outbreak (Jan-Feb 2004)	18 (location)	Total destruction 848,294 chickens
The 2ed outbreak (July-Dec 2004)	7 (location)	Total destruction 2,183 chickens

The data types for poultry farm, slaughterhouse, cockpit and market were recorded in the Ms Excel format containing the owner name and address, poultry type, number of poultry and coordinates of farm location. The outbreak location included the records of address, date, poultry type and number of destruction.

In the process of the analysis we also considered the transmission route carried by migratory birds. They require certain habitat during the short period in Khon Kaen. The food and covers suitable for the migratory birds in the area are considered as an important variable which enhances the risk area. The food and covers can be inferred from the pattern of land cover which can be carried out using satellite data.

Spatial analysis was then performed to visualize and to define the abundance of the infected chickens as related to the spatial risk variables. As a result we are able to define relative risk area for each spatial variable.

3.2 Model for Bird Flu Risk Area

A model for bird flu infection was based on an integration of spatial risk variables concerned. To determine the risk area for bird flu infection in Khon Kaen province it can be formulated by coupling a GIS to additional model relating the variables. Susceptible poultry becomes infected when they come in contact with the contaminated surfaces within a certain distance of the outbreak. In Thailand DLD defined a protection zone having radius of 5 km., a surveillance zone having 10 km. and a movement control having 50 km. (FAO, 2004b)

The risk factor of a potential infection source for a herd of interest decreases with decreasing animal density (Ehlers et al., 2003). The outbreaks in January were concentrated in the central, the southern part of the Northern and Eastern regions of Thailand which are wetlands, water reservoirs and dense poultry areas (Tiensin et al., 2005).The areas at risk of infection include those of shorter distance to poultry farm, to wetlands and to rice paddies. The consistent dissemination of infection was confined to backyard chicken and ducks raising on the wetland. In addition the vicinity to commercial poultry productions is high risk of HPAI infection. The commercial poultry productions encompass market, slaughterhouse and cockpit which facilitate the virus transmission.

As a results, the spatial risk variables included the distance to the outbreak location, poultry density, distance to poultry farm, land cover and distance to commercial poultry production. (Centre for disease control and prevention [CDC], (2004), FAO (2004b), FAO (2005), FAO (2004c) and CDC (2005))

3.3 The Organization and GIS Database Establishment

The development of spatial database of geo-referenced data and its associated attributes for the study area was established. The spatial database consisted of the five thematic layers: the outbreak region, poultry density, poultry farm, land cover and area of commercial poultry production. Each of layer encompasses diagnostic factor and associated attributes on which factor rating of risk is assigned. (Table 2.). The factor rating assigned was based on the outbreak area in relation to the variables at risk. The individual layer was assigned the factor rating as 1.0 (S1), 0.6 (S2), 0.4 (S3) and 0.2 (N) for high, moderate, low and very low respectively.

Table 2. Thematic layers and factor ratings

Layer or variable	Diagnostic factor	Unit	Factor rating (Risk)				References
			S1 (1.0)	S2 (0.6)	S3 (0.4)	N (0.2)	
The 1st outbreak region	Distance to the 1st outbreak (C)	km.	0-5	5-10	10-50	>50	DLD (2004a), CDC (2004), FAO (2004b)
Poultry density	Poultry density (D)	number/ km²	>15,000	10,000-15,000	5,000-10,000	<5,000	FAO (2004b), FAO (2005), Ehlers et al (2003)
Poultry farm	Distance to the poultry farm (F)	km.	0-5	5-10	10-50	>50	FAO (2004d)
Land cover	Land cover type (L)	-	W	X	Y	Z	FAO (2004c), FIC (2005), Tiensin et al (2005)
Distance to commercial poultry production	Distance to market, to slaughterhouse, to cockpit (P)	km.	0-5	5-10	10-50	>50	FAO (2004c) FAO (2004c) CDC (2005)

Remark: W = Wetland, rice paddies, swamp and communities
X = Evergreen forest and field crop
Y = Plantation and range land
Z = Others

The outbreak region was generated using the location data collected by DLD with the GIS capability, the buffer zone of 0-5, 5-10, 10-50 and >50 km. was produced and encoded in the GIS database. The poultry density was digitally performed on the basis of chicken number within a given area with the Kernel Density function available from ArcView 3.2a.

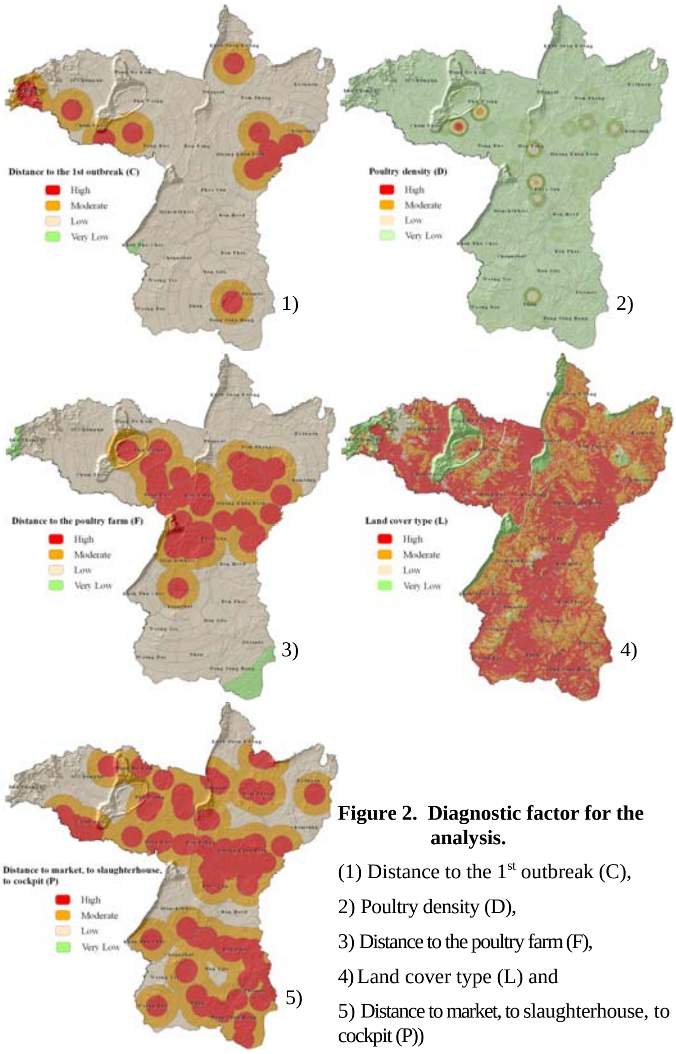

Figure 2. Diagnostic factor for the analysis.

(1) Distance to the 1st outbreak (C),

2) Poultry density (D),

3) Distance to the poultry farm (F),

4) Land cover type (L) and

5) Distance to market, to slaughterhouse, to cockpit (P))

The poultry farm locations available provided information to digitally perform the buffer zone of 0-5, 5-10, 10-50 and >50 km. Landsat TM data on December 2002 was processed to generate land cover layer which provided information about the susceptible area for the bird flu infection. The zones of commercial poultry production of 0-5, 5-10, 10-50 and >50 km. were produced based on the information collected.

The five thematic layers were digitally encoded in the GIS database and were used for further analysis.

Fig 2. represents the spatial risk variables generated using GIS database established.

3.4 The Development and Iteration of the Model

This phase involved the formulation and testing the model followed by the integration of the model to the geo-referenced area information to create the map output.

As a result of testing the combination of variables for class of the risk area was given using the value of the factor ratings as follows:

Risk area = C x D x F x L x P

These layers were integrated by spatially overlaying each with the risk model of the defined five layers which yielded 4 classes according to the results shown in Table 3.

Table 3. Class of risk and overall factor rating

Class of risk	Overall factor rating (C x D x F x L x P)
High (S1)	1.0000 - 0.0779
Moderate (S2)	0.0778 - 0.0103
Low (S3)	0.0102 - 0.0003
Very low (N)	< 0.0003

The overall factor rating was based on the multiplication (C x D x F x L x P) on which each layer was assigned a value ranging from 1 for S1 to 0.2 for N. These values were then multiplied and used for identifying the risk area. The upper limits of values for S1, S2, S3 and N were $(1)^5$, $(0.6)^5$, $(0.4)^5$ and $(0.2)^5$ respectively (Table 4.).

The validation of the model for the area at risk was assessed, based on the areas of bird flu infection by which the information was collected by DLD during the outbreak period. Adjustment of the limit and range of values could be iterated until the reliable result was obtained.

4. RESULTS AND DISCUSSIONS

4.1 Spatial Distribution and Acreage of Risk Area

The risk area for bird flu infection resulting the spatial overlay of the variables is shown in Fig 3. The acreage of the risk for the bird flu in Khon Kaen province in addition to spatial distribution is shown in Table 4. The study provides the overall insight into each variable for bird flu infection and the area at risk resulting from the integrations of the variables spatially and quantitatively. It is evident from the study that the risk area for bird flu infection covers 1.60% and 26.31% for highly and moderately risked areas respectively. It is evident that the risk area resulting from this study is the region with vicinity to the outbreak area, dense poultry population, close to the farm, surrounding area of commercial poultry production with wetland and rice paddies land types.

Table 4. The risk area for bird flu infection in Khon Kaen province

Class	Area	
	Sq/km	%
High risk (S1)	174.44	1.60
Moderate risk (S2)	2,864.32	26.31
Low risk (S3)	7,824.42	71.88
Very Low risk (N)	22.78	0.21
Total	10,886.00	100.00

4.2 Validation of the Model

The validation of the model was carried out by comparison of the map production and the area of the infection with referenced to the same location with the Extension Hawth's tools available in the ArcGIS. The selection of 25 locations of the virus infection was randomly checked and compared of the 25 locations we used 8 locations, mismatch of 2 locations or about 25%. However it would suggest caution in the application of this model. Numerous factors likely contribute to the apparent inaccuracies of the output prediction. The validation method was less than perfect because the infection of bird flu in some areas unlikely fitted to the condition defined. Rationales behind this are the human factors involving the raising of chicken, the movement of poultry, the migration of birds and etc.

In conclusion this study implements integrated approach, combining static variables. Difficulties in using dynamic variables for the analysis process may cause inaccuracies of the result. The effective control measures made by veterinary authorities, sanitary raising of chicken and climatic variation may cause the contrary result of this study. The geo-informatics technologies offer the tool to visualize the spread of epidemic to establish information database in relation to location and to effectively model the variables.

In addition, the computer-based GIS provides information rapidly available for up-dated model in case of further knowledge enhanced.

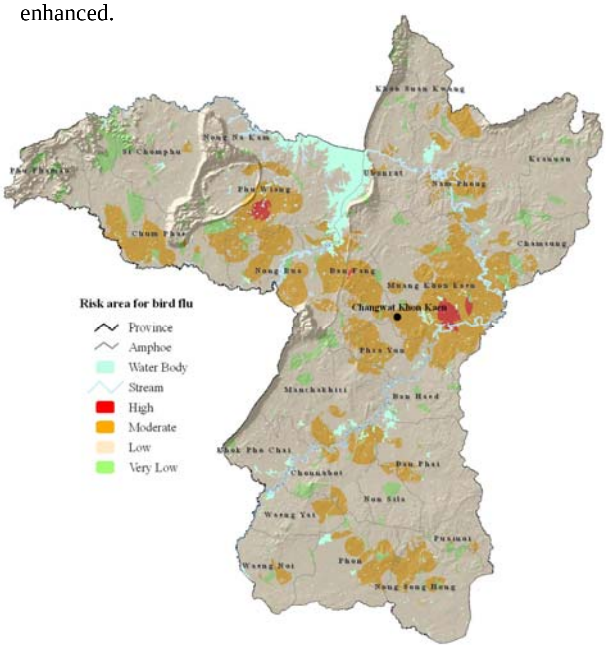

Figure 3. Risk area for bird flu infection.

5. REFERENCES

[1] CDC. 2004. Highly Pathogenic Avian Influenza H5N1. Bangkok, Th,. DOI= http://www.cdc.gov/ncidod/EID/vol11no11/05-0608.htm+OIE+stamping+out+5+km Thailand+&hl=th

[2] DLD. 2004a. Avian Influenza Control and Eradication Measure. Bangkok, Th,. DOI=http://www.dld.go.th/home/bird_flu/chick3.html

[3] Ehlers, M., Moller, M., Marangon, S., and Ferre, N. "The use of Geographic Information System (GIS) in the frame of the contingency plan implemented during the 1999–2001 Avian Influenza (AI) epidemic in Italy", Avian Disease, 2003, 47, 1010-1014.

[4] FAO. 2004a. Control strategies currently in implementation. DOI=http://www.fao.org/ag/againfo/subjects/en/health/diseases-cards/Table1_08.html

[5] FAO. 2004b. FAO Recommendations on the Prevention, Control and Eradication of Highly Pathogenic Avian Influenza (HPAI) in Asia. DOI=http://www.fao.org/ag/againfo/subjects/en/health/diseases-cards/27septrecomm.pdf

[6] FAO. 2004c. FAO Expert Meeting on Surveillance and Diagnosis of Avian Influenza "Guiding Principles for Highly Pathogenic Avian Influenza Surveillance and Diagnostic Networks in Asia". Bangkok, Th,. DOI=http://www.fao.org/docs/eims/upload//210749/Gui_principlesHPAI_july04_en.pdf

[7] FAO. 2004d. Control measures undertaken in Asia during the crisis. DOI=http://www.fao.org/docrep/007/y5537e/y5537e07.htm

[8] FAO. 2005. Avian Influenza: Background. DOI=http://www.fao.org/ag/againfo/subjects/en/health/diseases-cards/map2.html

[9] FIC. 2005. China: Concrete measures to tackle avian influenza. Zhejiang, Cn,. DOI=http://www.flu.org.cn/en/news-7524.html

[10] Gilbert, M., Chaitaweesub, P., Parakamawongsa, T., Premashthira, S., Tiensin, T., Kalpravidh, W., Wagner, H., and Slingenbergh, J., "Free–grazing Ducks and Highly Pathogenic Avian Influenza, Thailand", Emerging Infectious Diseases, 2006, 12, 227-234.

[11] Tiensin, T., Chaitaweesub, P., Songserm, T., Chaisingh, A., Hoonsuwan, W., Buranathai, C., Parakamawongsa, T., Premashthira, S., Amonsin, A., Gilbert, M., Nielen, M., and Stegeman, A., "Highly Pathogenic Avian Influenza H5N1, Thailand, 2004", Emerging Infectious Diseases, 2005, 11, 1664-1672.