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Abstract. Animal husbandry has become one of the important pillars of agricultural economy. In the meantime, along with the rapid development of animal husbandry, all kinds of animal disease hazardous to health of livestock and poultry appear, such as High Pathogenic Avian Influenza (HPAI) and Foot and Mouth Disease (FMD). Therefore, establishment of animal epidemic prevention system is very necessary. Geographic Information System (GIS) has been widely used both in the field of disease control and prevention and livestock and poultry epidemic prevention for its strong ability of spatial analysis and visualization analysis. Despite all this, provincial livestock and poultry epidemic prevention system based on GIS is rare. To obtain animal epidemic information accurately and timely, and improve the mechanism of animal outbreaks, combing with the reality of Shandong province, an animal epidemic prevention and early warning forecast system is developed. The purpose of the system, the system structure, function module, and development platform are analyzed. Combined with GIS, handheld mobile GIS/GPS, and GPRS/CDMA, the system has proved its flexibility, stability, convenience, and easy extensibility, assuring effective implementation of animal epidemic monitoring.

Keywords: animal epidemic prevention, GIS, information system

1 Introduction

Animal by-products economic development is one of the important direction of our country's rural economic development. In recent years, animal husbandry in Shandong province keeps the sustainable and healthy development, for example, animal husbandry output value, the total output of meat, eggs and milk, livestock products export and other major economic indicators among the top. Animal husbandry has gradually transformed from subsistence to commercial, from traditional to modern, and has become the most dynamic and potential of the pillar industries of the rural economy, and is also an important way of farmers to get rich .
Meanwhile, animal disease has become an important factor which restricts animal husbandry economy rapid growth, prevents animal by-products to expand exports,

and threatens quality and safety of animal origin. Major animal disease prevention and control not only directly affects the animal husbandry development and farmers' income, but also relates to people's physical health, public health security and social stability. Therefore, to strengthen animal epidemic prevention system and animal disease traceability system construction, improve animal epidemic prevention, monitoring, quarantine supervision system, establish animal disease risk assessment and early warning forecast mechanism is of great significance, which is also the necessary premise of to achieve animal husbandry quality security, disease security and ecological security.

The application of information technology in livestock and poultry epidemic prevention, supervision and management has become the trend of the development of animal husbandry industry. By introducing professional data management module, establishing basic database, executing digital management, livestock and poultry epidemic prevention information platform is developed. GIS is an auxiliary space data information management system, combining unique visual effect, the map geographical analysis function, and database operations together [1]. It is an important means of realizing digital decision-making management, and provides strong theoretical support and technical support for epidemic prevention and control from the perspective of spatial evolution process analysis and forecast. GIS is mainly used in the field of animal epidemic prevention, which can be summarized as the following respects: (1) production of livestock epidemic spatial distribution thematic map, which means visually displaying epidemic analysis results in the form of space distribution thematic map and statistical charts, on the basis of GIS spatial analysis and visual display; (2) forecast of animal epidemic situation and development trend, which means using the multi-factor comprehensive analysis and statistical prediction model to predict and evaluate popular trend, space accumulation and dispersion model, and outbreak impact in a certain time; (3) control and planning of Animal epidemic prevention resources, which means optimizing the resources distribution of epidemic prevention with the help of GIS; (4) animal husbandry and outbreak early warning, forecast, and information publishing, which means the use of GIS for risk factors analysis and positioning, and early warning in related areas.

Domestic and international numerous agriculture departments have been using GIS for animal epidemic monitoring and early warning. The United States established the National Animal Health Report System (NAHRS) in 1996. Australia's National Animal Health Information System (NAHIS) is fully functional and works well. Since 1991, New Zealand began to build information system for emergency animal disease control Epiman-IMS [2-3]. In China, the national center for epidemiological studies was established and put into special funds to establish the national animal health information system in 2000, an integration of animal health information management and animal heath GIS. National SARS control and warning system was built in 2003, which supplied a modern means of prevention and control work. Chongqing city major animal epidemics GIS system was established in 2011. The application of GIS in the health filed at home and abroad has proved that animal husbandry GIS system is the inevitable trend for the scientific and automatic animal epidemic information management [4-6]. Although, there is a lack of domestic provincial animal husbandry outbreak early warning system based on GIS. The existing livestock and poultry epidemic monitoring mechanism in Shandong province is given priority to artificial investigation and reports submit, which is free from the technology of GIS, GPS, and big data, reducing the sensitivity, timeliness, and traceability of the epidemic monitoring.

2 System Framework

2.1 System Objectives

As the first step to develop the system, we identify the core requirements and objectives the system seeks to meet, which includes four aspects: (1) Integration of vector data, images, videos and statistical data, which is used to establish multi-source information database; (2) Development of livestock epidemic rapid acquisition subsystem based on portable mobile intelligent terminal (LERCS), which combines embedded GIS real-time positioning, wireless communication, video capture, barcode recognition technology together to achieve real-time collection, fast storage and instant report of epidemic information; (3) Development of provincial livestock epidemic monitoring and early-warning subsystem (LEMES), which demonstrates the popular trend and epidemic law, assess and predicts the harmfulness, and achieves rapid feedback and control in a timely manner of livestock epidemic; (4) Development of major livestock epidemic emergency decision support subsystem (LEEDSS), which supplies decision support for major animal epidemic response administration, and configures epidemic prevention resource optimally on the basis of LEMES.

2.2 GIS Platform and Development Mode

ArcEngine 9.3 second-development component, from ESRI' ArcGIS series products, is chosen as GIS development platform used on the Windows Server 2008 operation system. In consideration of multiple source data types, database is constructed on the basis of Oracle 9i. Visual C#.NET is selected as programming language.
There are three common development modes, which are Client/Server (C/S), Browse/Server (B/S), and Mobile client/Server (M/S). Here, we integrate C/S, B/S and M/S together, provide data sharing based on the unique data source, switch to appropriate mode when facing different users and application purposes, which guarantee the integrity and flexibility of the system.

2.3 Spatial Database and Non-Spatial Database

Livestock epidemic multi-source information database contains two major data types: (1) Spatial Database, which can be divided into basic geographic information and thematic geographic information about animal epidemic information, the former contains administrative boundary, roadway, and river system, while the latter contains the distribution of species group, livestock and poultry farms, disease communication media, and epidemic prevention resources.

(2) Non-Spatial Database, which covers a multitude of data types, for example, attribute data (the density of livestock and poultry, disease characteristics, traffic condition, environmental condition, et al.), image , and video.

2.4 System Architecture

As is shown in Fig.1, the overall structure of provincial animal epidemic prevention system includes four levels: The first level is the foundation layer, including a series of hardware and software, such as host device, operating system, database, Internet, Intranet, VPN; The second level is the data layer, containing spatial database and non-spatial database which are established in the form of vector data, image data, video data and statistical data; The third level is the support layer, which supplies developing environment, GIS platform, workflow engine, security opponents, short message service to construct livestock epidemic early warning mechanism; The fourth level is the business layer, respectively developed in the mode of C/S, B/S and M/S, and divided into three subsystems, LERCS, LEMES, and LEEDSS.

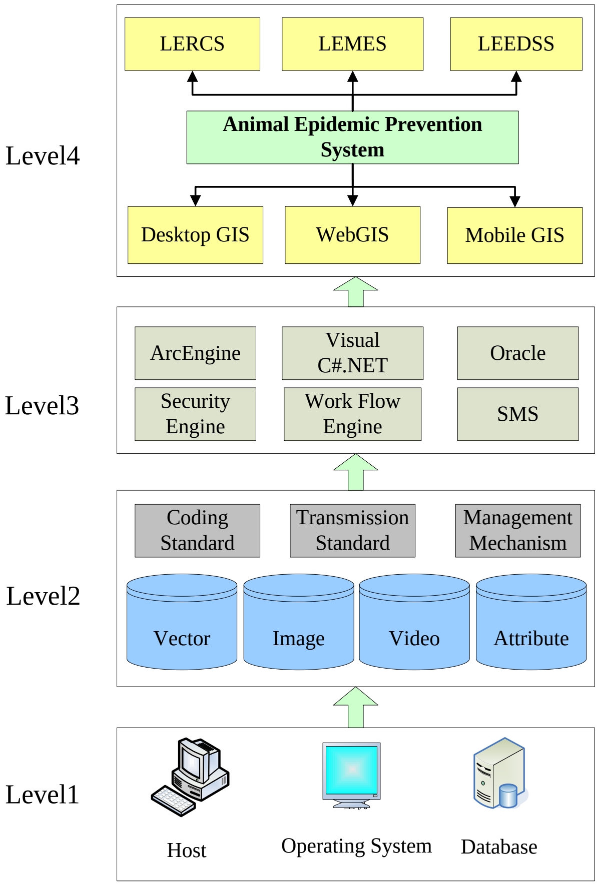

Fig. 1. The Architecture of Animal Epidemic Prevention System

3 System Function

3.1 LERCS

This subsystem is based on the embedded terminal device and can be used to acquire and transmit typical epidemical information. The standards of epidemic information collection are in accordance with the existing epidemic reporting requirement. Information acquired by LERCS refers to disease information, epidemic information, and animal die information in the form of image, video, QR code, and character. Meanwhile, information acquired can be transmitted in two means, one of which is by connecting the terminal device to data server with USB, the other is uploading to data server remotely by GPRS network [7]. Location mapping can precisely localize epidemic sampling points. LERCS function module is shown in Figure.2.

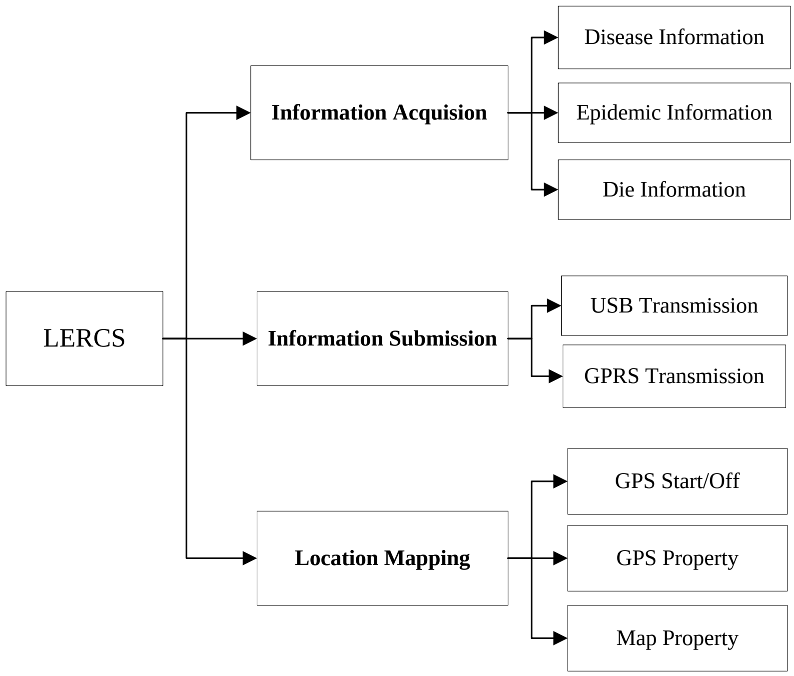

Fig. 2. Basic function module of LERCS

3.2 LEMES

Based on the basic geographic information, the spatial distribution of modern animal husbandry demonstration county, standardization of livestock and poultry breeding demonstration county, and no prescribed animal epidemics demonstration area in Shandong province, can be visually displayed on the map. By receiving animal epidemic information from LERCS, this subsystem takes full advantage of GIS spatial analysis, statistical analysis, and thematic map display to predict epidemic information and improve the capability of disease prevention and control. LEMES function module is shown in Figure.3.

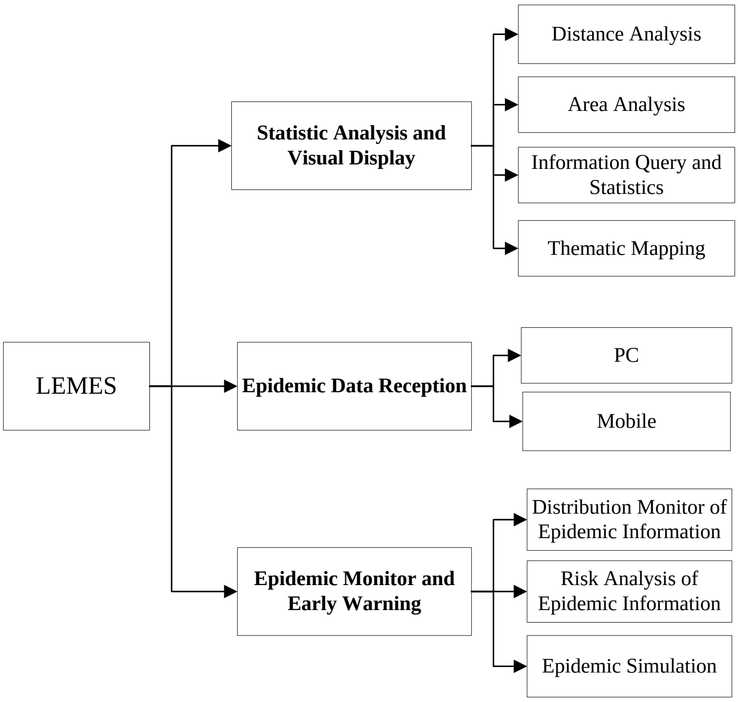

Fig. 3. Basic function module of LEMES

The most specific performance of statistic analysis and visual display is composed of distance analysis, area analysis, information query and statistics, and thematic mapping basically composite. Based on the above function, livestock and poultry relevant information can be queried, summarized, analyzed and fed back in the form of thematic map and statistical graph. After clear about data format, data type, data security safeguard, data transmission mechanism, epidemic information can be acquired accurately, timely, and diversely, which guarantees character, images, video and other related information about the outbreak field can be obtained by epidemic data reception function. Epidemic monitor and early warning function utilizes a series of GIS spatial analysis, such as density analysis, clustering analysis and dynamic analysis, to make an overall assessment of the distribution of epidemic prevention resources and breeding resources. Through the analysis and data-mining of real-time data and historical data, distribution, development and perniciousness of epidemic information can be monitored and predicted. At the same time, it is very feasible that by using the simulation method, changing the conditions of nature, geography, ecology, meteorology, transportation, virtually setting related factors such as population structure and breeding density, the key epidemic control and prevention area and the optimization control strategy can be determined [8].

3.3 LEEDSS

When there are major outbreaks, LEEDSS is able to acquire animal epidemical information accurately, timely and exhaustively, which enables a rapid definition of epidemical area of influence and grading of epidemic situation. After that, distance analysis can be utilized to summarize distribution of livestock and poultry farms and their attribute information in different level of distance range, dynamically display locations of disease management department, persons chiefly in charge and their contact information, and at last give an optimal path to the outbreak site. Meanwhile, base on mobile GIS and wireless transmission technology, outbreak sites can be located in the electric map. The scene of the real-time monitoring information will also be transmitted to emergency command staff. LEEDSS function module is shown in Fig.4.

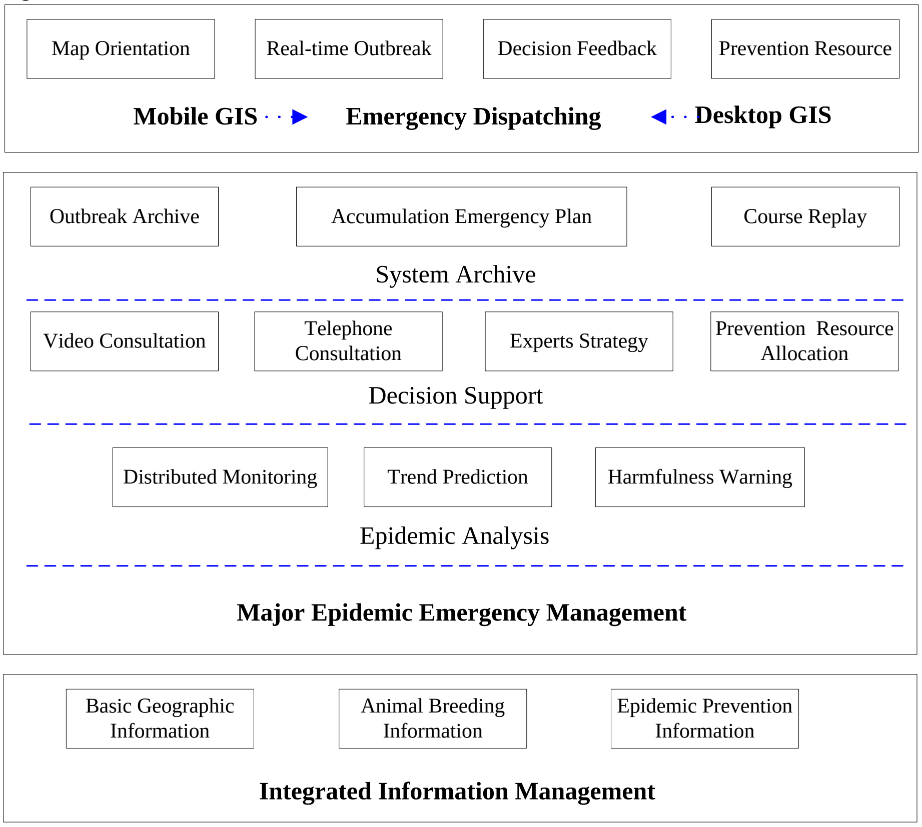

Fig. 4. Basic function module of LEEDSS

4 Conclusions

The characteristics of animal husbandry can be summarized as multi-subject, small scale modal, decentralized decision-making and scattered farmers. Due to subjective decision-making and traditional report filling method, in the actual epidemic prevention and control work, there will be a variety of problems, for example, relevant decisions is not conformed with actual fact, acquisition of epidemical information is not real-time. Thus, this paper builds up animal epidemic prevention system at the provincial level, respectively developing LERCS, LEMES, and LEEDSS in the three perspectives of epidemical information acquisition, epidemical early warning and monitoring, and epidemical prevention and control decision support. Relevant information about basic geographic information, animal breeding information, and epidemic prevention information is combined together to summarize animal husbandry and outbreak investigation and monitoring data of the whole province. This provides a scientific basis for government regulators, monitoring institutions at all levels, scientific research units, farmers about livestock and poultry epidemic prevention.

Provincial animal husbandry and outbreak early warning forecast system established in this study has presented limitations to some extent. In order to guarantee the accuracy of the early warning analysis, livestock epidemic prediction model needs to be further researched and improved with the combination of real-time and historical epidemical data, growth environment, breeding habits, and common epidemical disease for different kinds of livestock and poultry.

Acknowledgment

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