Study on the land desertification early-warning system of Xinjiang in China

Yan Zhang*

College of educational science, Xinjiang Normal University, Urumqi, Xinjiang, China, 830056

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Abstract

Land desertification is one of the greatest disasters in the world because of its wide-range influence, long duration, and enormous loss. The desertification early-warning system is very important to decrease the disaster occurrence and the reduction of disaster loss. The grid accumulation desertification early-warning model can provide this. Therefore, Land Desertification Early-warning System of Xinjiang (LDES_XJ) was built in Browser/Server (B/S) structure based on the grid accumulation land desertification early-warning model. The functions include the publishing of land desertification warning information sub-system, the desertification data management, the map browsing and query have been realized in the LDES_XJ. The system is a fundamental platform for the land desertification prevention and control as well as a convenient communication platform for the government, which makes it more convenient for relevant people to obtain the desertification early-warning information and also plays an important role in the desertification prevention and control in Xinjiang, China.

Keywords: desertification prevention, early-warning model, management information system, B/S structure

1 Introduction

Land desertification is one of the largest disasters in the world because of the influence of destruction and desertification prevention and control has become a hot issue and leading edge of the current scientific researches. The preventive measures should be taken to reduce the probability of the disaster and the damage from the disaster. In order to realize the early warning of land desertification, many scholars carried out numerous studies on land desertification warning model. Simple indicator threshold warning was first proposed. For example, Amrita G proposed an indicator of the land desertification warning for bare land [1]. Zhang put forward an indicator mechanism for the desertification disaster warning which has combined with the vegetation, soil, climate and social economy in Hunshadake basin. The comprehensive indicators of early warning were based on the indicator threshold warning with the combination of indicator weight [2]. For instance, Wang considered the indicators included vegetation, soil, and surface conditions, which determined the weight by Delphi Method [3]. Liu determined the indicator weight by AHP and constructed the land desertification early warning model of comprehensive indicators on the grid scale [4]. Chen set up a land desertification ANN early warning model by determining the indicator weight based on the cellular automation under GIS platform with the application [5]. The early warning model of mechanism was constructed considering the mechanism of desertification and features of change. For example, Wang constructed an early warning model of productivity considering the photosynthesis, temperature, water, soil, and human activities [6]. Li built up a wind-sand expansion warning model based on the gravity, the potential and the expansion model [7]. Li established the grid accumulation desertification early warning model considering the change (fluctuation) and the accumulation of desertification [8]. Along with deep studies, a great development has been made in the land desertification model.

With the development of the land desertification warning model and the computer technology and the geographic information technology (GIS), some progresses have also been made in the land desertification warning model. Wang proposed a framework of information system of the desertification monitoring and early warning; Considering the environment of desertification disaster [9], Ding established a comprehensive desertification environmental database with GIS technology [10]; Jiang and Yang set up a desertification information system based on the desertification census data [11,12]; Wu built up a desertification analysis module based on the land desertification information system [13]; Cai constructed a land desertification grid warning system based on the C/S structure, which combined the GIS technology with Liu's grid dimension comprehensive indicator land desertification warning model [14,15]. With the growing desertification disaster as well as the spread of information network, many people have a higher demand for the desertification disaster warning. It is so important for us to obtain the land desertification warning information as quickly as possible. However, the current

* ***Corresponding author*** e-mail: zyan1216@163.com

land desertification warning system is a C/S structure system. Few people can access the land desertification warning information. Therefore, it is urgent for us to establish a land desertification early-warning information system with B/S framework.

The land desertification early warning model of grid accumulation was selected as the base framework which adopted Browser/Server (B/S) and the Microsoft IIS6.0 was used as WEB server. The SuperMap iServer Java 6R was chosen as a GIS platform. The VB language was used to code the land desertification warning model. The attribute relational database was constructed by Microsoft SQL Server 2008. It is expected that land desertification information can provide a suitable guidance for the desertification prevention and control and references for social and economic development in Xinjiang.

2 Grid accumulation land desertification early-warning model

The evolution process of land desertification is very slow. Huang studied the desertification evolution of the Maowusu desert and found that the region began to degenerate from the Mid-Tang Dynasty [16]. Dong studied the stratums in Tengger Desert, Taklimakan desert, and Hunshadake Desert, finding that the desertification had started before the quaternary period [17]. It can be known that the desertification takes a long time, usually dozens of years or much longer. Land desertification also has fluctuations during this long process. Wang pointed out that the desertification would fluctuate with the climate change in North China in recent 50 years and also had an accumulation under the fluctuations [18]. Namely, the desertification development is based on the last state. Aruhan studied the factors of the desertification in Duo-lun County and found the desertification had an accumulation phenomenon [19]. Li proposed a grid accumulation land desertification early-warning model [8]. This model has better spatial scales and temporal scales, which also presents the slowness, change (fluctuation), and accumulation of the land desertification. The model formula is as follows.

$$E_d{}^n = \frac{\sum_{i=1}^{n}(U_n - U_0)}{n}, \tag{1}$$

where $E_d{}^n$ is the desertification early-warning degree at the grid pixel in year n. U_n is the desertification degree at the grid pixel in year n. U_0 is the desertification degree at the grid pixel in the base year, n is year. The assignment of desertification degree between U_0 and U_n is that: non-desertification is 0, mild desertification is 1, moderate desertification is 2, severe desertification is 3, and extremely severe desertification is 4. The warning degree of $E_d{}^n$ is divided by warning grade, the standards are shown in Table 1.

TABLE 1 The criterion of the desertification early-warning degree

Warning level	Already reducing	Severe reducing	Moderate reducing	Mild reducing	Changeable area	Mild warning	Moderate warning	Severe warning	Extremely Severe warning
Range	[-4,-2)	[-2,-1)	[-1,-0.5)	[-0.5,-0)	0	(0,0.5]	(0.5,1]	(1,2]	(2,4]

While accessing to the information of the land desertification, people also expect to bring back the comprehensive loss from the land desertification. Thus, the loss from the desertification can be determined based on the grid accumulation land desertification warning model when considering the land use type and the land comprehensive ecological value.

$$L^n = (C_l \times E_d^n + M_d \times E_d^n + F_l \times E_d^n + C_s \times E_d^n + W_l \times E_d^n + B_l \times E_d^n)/4, \tag{2}$$

where L^n is the comprehensive economic loss of the grid pixel which caused by the land desertification in year n; C_l is the comprehensive ecological value of the construction land; W_l is the comprehensive ecological value of the wetland; B_l is the comprehensive ecological value of other lands. $E_d{}^n$ is the desertification warning degree of the grid pixel in year n. L^n can be positive or negative. Positive L^n is the economic loss from land desertification. Negative L^n is the economic benefit when the land desertification improves.

The calculation of comprehensive ecological value for tillage, grass land, forest land, construction land, wetland, and other lands was in reference to Xinjiang Statistical Yearbook and Chinese land ecological system unit area and ecological service value equivalent table summarized by Xie [20,21]. The results are shown in Table 2. Both economic value and ecological value of arable land, grass land, forest land, wetland, and other lands have been considered. However, only ecological value was considered for construction land.

TABLE 2 Total output value of each type land in Xinjiang

	Arable land	Grass land	Forest land	Construction land	Wetland	Other lands
Total value (Ten thousand Yuan/ha)	5.72	5.77	18.02	10.76	51.92	0.34

3 Data source

In order to meet the need of the LDES_XJ, the data include: Xinjiang's land desertification degree data (date from 2000 to 2012); Xinjiang's land using data of year 2000, 2004, and 2008; the annual agricultural output, the animal husbandry output, the forestry output, the secondary industry GDP, and the service industry GDP in Xinjiang Statistical Yearbook from 2000 to 2013. Data involving the land desertification causes include: the annual precipitation, the annual average temperature and humidity, the annual average wind speed, max and min temperature, the annual number of sand storm; the annual water volume data; the economic and the social statistics including population, livestock amount and GDP data from 1949 to the present. Data related to the prevention and control of desertification mainly comes from the papers.

4 Land desertification early-warning system structure

LDES_XJ must satisfy the querying of the land desertification early-warning information. Meanwhile, a platform for mutual communication is also needed. The functional modules include: the data management, desertification early warning model calculation, the desertification disaster loss calculation, the map browsing and query.

According to the functional analysis of the LDES_XJ, the B/S structure is used for the design of the system. This system is divided into four layers: the application service layer, the middle ware layer, the data layer and the infrastructure layer. The overall framework is shown in Figure 1.

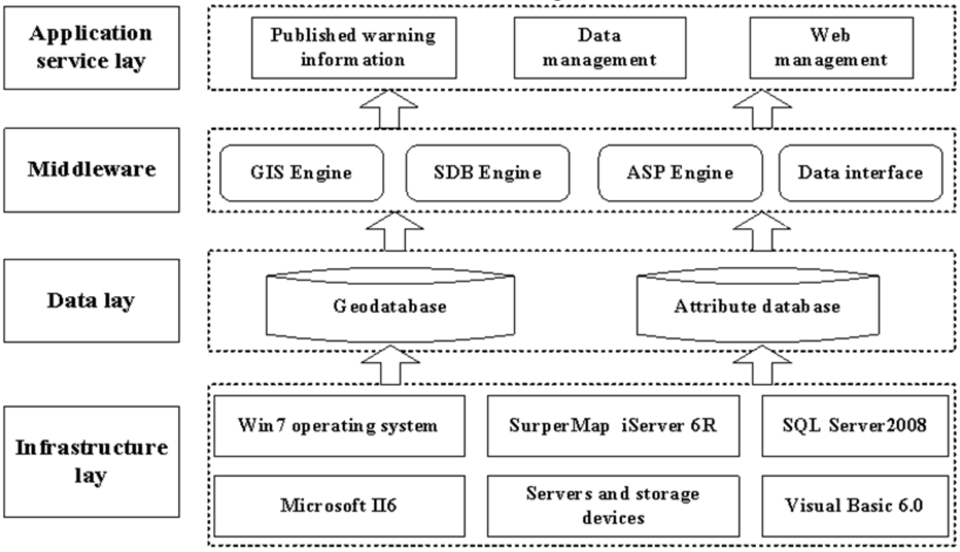

FIGURE 1 The function structure of desertification early-warning system

LDES_XJ involves in a lot of data. According to the attribute of data, the data can be divided into spatial and attribute relational. Spatial data includes vector data and grid data. Super Map Deskpro .NET 6R platform is used to build up the spatial database. While attribute relational data includes social and economic statistical data, weather station data, and hydrology station data for the cause of desertification. In addition, the data of desertification control measures and forum discussion data are also included. Attribute relational database is constructed by Microsoft SQL Server 2008. The spatial and the attribute relational database are connected with key fields [22], forming a large relational database for the LDES_XJ.

5 Application of the land desertification early-warning system of Xinjiang (LDES_XJ)

Microsoft IIS6.0 was used for Web server of the LDES_XJ and SuperMap iServer Java 6R for GIS server and the spatial database. VB language was used to code the land desertification early-warning model. Microsoft SQL Server 2008 was used to construct the attribute relational database. The interfaces of the LDES_XJ server entrance, data management and land desertification early-warning model of the LDES_XJ are displayed in Figures 2-4 (The system is designed in Chinese).

FIGURE 2 The interface of the LDES_XJ server entrance

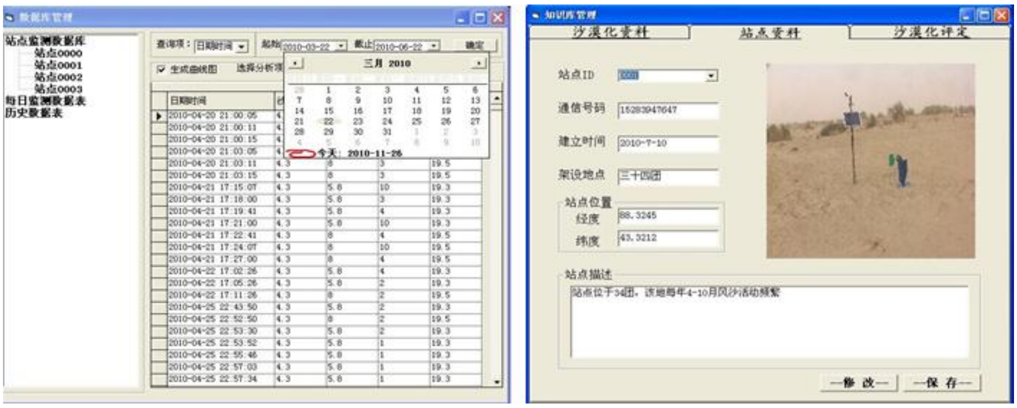

FIGURE 3 Interface of the desertification data management of the LDES_XJ (In Chinese)

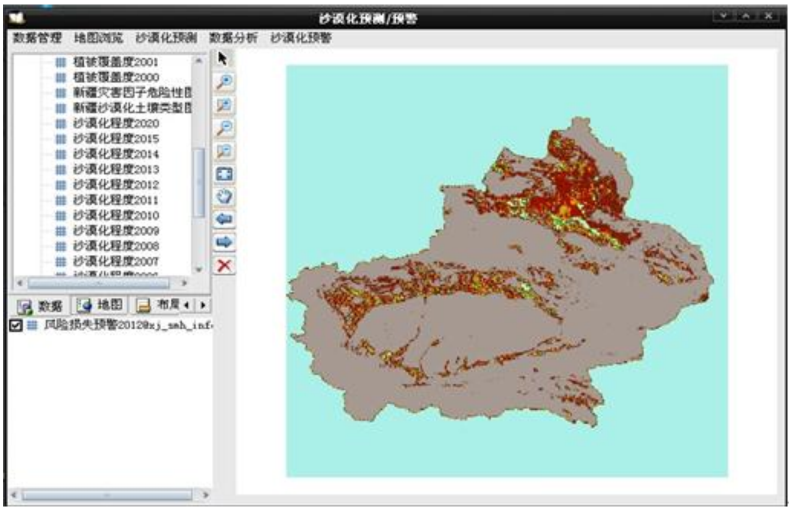

FIGURE 4 Interface of early-warning of the LDES_XJ (In Chinese)

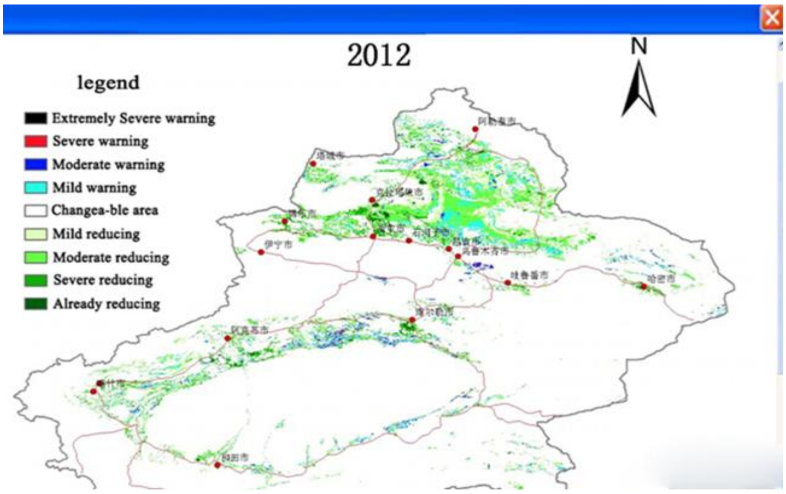

FIGURE 5 The publishing of LDES_XJ

Microsoft Active Server Page (ASP) is used for web publishing [23]. Main sections of the web include: desertification warning, desertification disaster evaluation, desertification cause query, desertification prevention and control, data remote management, desertification forum. The web publishing of the Xinjiang land desertification warning information is shown in Figure 5.

6 Conclusion

The LDES_XJ is very urgent for preventing the desertification in Xinjiang. This paper proposes a land desertification early-warning model of grid accumulation. Microsoft IIS6.0 was used as the WEB server and SuperMap iServer Java 6R as GIS server and the spatial database and VB language for the programming of land desertification warning model. Microsoft SQL Server 2008 was used to construct the attribute relational database and ASP for web publishing. The functions of the web publishing of desertification warning information, desertification data management, map browsing and query, desertification cause query, desertification control measures query, and online discussion can be realized in the LDES_XJ. It is a fundamental platform for desertification prevention and control in Xinjiang, which enables people to obtain the desertification early-warning information more conveniently. Nowadays, this system plays an important role in the desertification prevention and control in Xinjiang, China.

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Author

Yan Zhang, born in December, 1978, Urumqi, Xinjiang, China

Current position, grades: the lecturer of College of educational science, Xinjiang normal University, Xinjiang, China.
University studies: B.Sc. in compute technology from Yili normal University of Xinjiang in China. M.Sc. from Zhejiang normal University of Zhejiang in China. D.Sc. from Northeast normal university of Jilin in China.
Scientific interest: computer network construction and compute education.
Publications: 10 papers.
Experience: teaching experience of 2 years, 3 scientific research projects.