Remote Sensing Monitoring and Loss Estimated System of Flood Disaster based on GIS

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Abstract

Remote Sensing Monitoring and Loss Estimated System of Flood Disaster based on GIS is an integrated system comprised flood disaster information receiving and collection, flood disaster simulation, and flood disaster estimation. When the system receives and collects remote sensing monitoring and conventional investigation information, the distributional features of flood disaster on space and time is obtained by means of image processing and information fusion. The economic loss of flood disaster can be classified into two parts: direct economic loss and indirect economic loss. The estimation of direct economic loss applies macroscopic economic analysis methods, i.e. applying Product (Industry and Agriculture Gross Product or Gross Domestic Product — GDP) or Unit Synthetic Economic Loss Index, direct economic loss can be estimated. Estimating indirect economic loss applies reduction coefficient methods with direct economic loss. The system can real—timely ascertains flood disaster and estimates flood Loss, so that the science basis for decision-making of flood control and relieving disaster may be provided.

Keywords: Remote sensing monitoring , Flood disaster , Flood loss estimation

1 Introduction

Flood disaster and loss estimation is a basis for decision-making of flood control and relieving disaster, so that this work has become one of the most attention problems to people. A lot of achievements of scientific research in this respect are applied in decision-making of flood control and relieving disaster. Now, there are three problems: First, the data of remote sensing monitoring in submerged area and the data from each department at the same time in the same area are very different; Second, the statistics of the situation of a disaster and loss mostly depend on the data of traditional on-the-spot sampling investigation, so that the veracity is liable to be interfered by the artificial factors, and the efficiency is difficult to meet the requirements of flood control and relieving disaster; Third, the estimation of flood loss is short of macroscopic data. This article proposes remote sensing monitoring and loss-estimated system of flood disaster based on Geographic Information System (GIS). The system is a special GIS, and takes flood disaster as an analysis object. When acquiring flood

disaster information, the system can rapidly and real-timely ascertain submerged area, and macroscopically estimate economic loss of flood disaster, so that scientific basis for decision-making of flood control and relieving disaster may be provided.

2 The composition of remote sensing monitoring and loss estimated system of flood disaster

Remote sensing monitoring and loss estimated system of flood disaster integrates database with model base in support of GIS. When real-timely acquiring remote sensing or non-remote sensing information of flood disaster, the system can rapidly and real-tamely provide flooding area and estimate economic loss. Figure 1 is a flow chart of remote sensing monitoring and loss estimated system of flood disaster.

2.1 Information receiving and collection

The analysis of flood disaster requires a lot of information. In the information, some information is provided from user, some information is provided from various public service departments, some information is the data of on-the-spot investigation and general survey provided from scientific research institution and production departments. The information can be expressed as follows in data: ①Graph data — the data mainly are special map, fundamental map and topographic map of various scale. Now these maps still are principal data source of GIS. With development of general data base, many basic map are provided to user in digital form; ②Observation data of ground gauge network –the data mainly are a long-period observation data of hydrologic network; ③Statistical data - the data mainly are conventional statistical data in respect of natural resources and social economy; ④Remote sensing data - the data mainly are various specific and comprehensive information. Remote sensing technique is a tool to rapidly provide ground truth data.

2.2 Data base

Data base is a basis of flood loss estimated, it consists of the following: ①Natural geographical information (including digital topographic data, administrative divisions, land use and so on); ②Socio-economic information (including population, crops yield, investment, gross product etc.);③Remote sensing information; ④Water resources project information;⑤ Historic flood disaster information;⑥ Hydrologic and meteorological information.

2.3 Model base

Model base provides the methods to rapidly estimate flood disaster and flood loss by using data in database. These methods consist of the following: ① Remote sensing image recognition model. The model can accomplish digital process of remote sensing image, extraction of flood border, estimation of submerged area, recognition of land use type and so on in support of remote sensing image processing software ERDAS. ②Simulation model of flood

disaster. Applying spatial analysis technique, this model can accomplish dynamic simulation of flood disaster in support of GIS software ARC/INFO, so that it may reproduce the course of development of flood disaster and count up submerged area, water depth and stricken villages, population, farmland, the line of communication and so on. ③Model of flood loss estimated. The model can estimate loss (including direct economic loss and indirect economic loss) of flood disaster in submerged area.④ Model of flood loss evaluated. The model can respectively evaluate normal year flood loss and some typical year flood loss (example, year of disastrous floods and year of some design floods).

3 The technological process of remote sensing monitoring and loss estimated system

(1) Real-time monitoring of flood disaster — Information receiving and collection

Monitoring of flood disaster includes precipitation, evaporation, water stage, velocity of flow etc. observed by hydrological network, and also includes the information of flood and rainfall collected by using remote sensing technique and radar. We must pay attention to combine convention method with the most advanced technique and to combine microcosmic measurement with macroscopic observation, so that flood disaster situation real-timely overall may be grasped.

(2) Information processing of flood disaster

Applying remote sensing image before disaster occurrence and investigated various data of ground truth, various classification background map may be described, for example population distribution map, villages distributed map and so on; Applying remote sensing image during flood occurrence and after flood occurrence, submerged area map of distinct stages may be described in the course of flood disaster occurrence, and flood disaster map may be described after flood disaster occurrence. Applying digital elevation model (DEM), digital elevation map may be described. After fulfilling above various classification map-making, required situation of flood disaster can be obtained by means of image-integrated technique. For example, integrating submerged area map with land use classification map and digital elevation map, submerged zone of various land use classification may be obtained, submerged area and corresponding water depth of various classification land use also may be obtained. Again for example, mosaicking submerged area map of distinct stages in the course of flood disaster occurrence in order of time, development process of flood disaster may be obtained.

The article also has designed flood routing (hydraulics) model in the simulation of flood disaster. The model can rapidly compute submerged area of flood, submerged water depth, velocity of flow, submerged period of time, also can reproduce situation of flood disaster. In addition, the model can have ability to forecast flood disaster.

(3) The estimation of flood economic loss

Combining disaster data obtained by means of information processing of flood disaster with socio-economic data, the flood loss in a certain administrative division, a certain basin or a certain flood control zone in accordance with various trade may be respectively estimated.

4 Estimation method of flood economic loss

Flood economic loss can divide into direct loss and indirect loss. Flood loss, especially flood indirect loss is short of definite meaning and adequate data, and unified statistical method, so that flood loss has great non-determinacy. According to present research level for the estimation of flood loss, we must give consideration to indirect loss and non-economic loss, also must persist in principle to combine the estimation of direct loss with the estimation of indirect loss.

4.1 estimation method of flood direct economic loss

According to provided data condition, we can estimate flood direct economic loss in Gross Product (GP) or unit-synthetic loss index.

(1) The method of estimating flood direct economic loss in GP

The flood direct economic loss in GP may be estimated by using Gross Domestic Product (GDP) or GP of industry and agriculture. Above data are obtained in statistical yearbook published socio-economic situation in flood disaster zone. Estimation formula is as follows;

$$S_D = \alpha_G S_G (1 + f_G)^T \qquad (1)$$

Where SD — Flood direct economic loss of unit area (Mu) in flood disaster zone, in Yuan/Mu;

S_G — GP of unit area (Mu) in flood disaster zone ,in Yuan/Mu, it is equal to GDP or GP of industry and agriculture divided by area of flood disaster zone;

α_G — flood loss rate (%),it is property loss degree in a flood, and depends upon flood frequency and the material of social economy and natural geography in submerged zone. α_G Listed in table 1 can provide a choice for flood loss rate.

f_G — growth rate of flood disaster zone (%),it is loss rate increased with an increase of economy in same area suffered same floods, and can been chosen according to relevant information. We suggest f_G value to 0.1% ~ 3.0% according to present economic development situation in our country

T — years from statistical year to computing year of flood loss.

For example, T=0 is in this year of statistical year;

T=1 is the last one year of statistical year;

T=2 is the last two year of statistical year;

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(2)The method of unit-synthetic loss index

Unit-synthetic loss index include two synthetic loss index: average synthetic loss index in population and average synthetic loss index in a unit area

(Mu).Average synthetic loss index in Mu is average direct economic loss of unit submerged area in flood disaster zone, in Yuan/Mu. Average synthetic loss index in population is average direct economic loss of every population in flood disaster zone, in Yuan/Population. Unit-synthetic loss index have large difference due to difference of economic development level in every region.

Unit-synthetic loss index can been estimated by using statistical yearbook published socio-economic situation in flood disaster zone.

4.2 Estimated method of flood economic indirect loss

Flood indirect economic loss deal with many field, its range has not clear limit, so that overall accurate quantitative calculation is very difficult. Now, estimated method of flood indirect economic loss mainly adopted reduction coefficient method. Estimation formula is as follows ;

$$S_{ID} = \sum_{i=1}^{n} S_{ID,i} = \sum_{i=1}^{n} \lambda_i S_{D,i} \qquad (2)$$

Where S_{ID} — flood indirect economic loss;

$S_{ID,i}$ — flood indirect economic loss of ith trade or department caused by flood disaster;

$S_{D,i}$ — flood direct economic loss of ith trade or department caused by flood disaster;

λ_i— reduction coefficient of ith trade or department. chosen range of λis 20% ～ 30% according to concerned statistical data at home and abroad.

4.3 Estimated method of flood total loss

Flood total loss (S) is equal to flood direct loss (S_D)plus flood indirect loss (S_{ID}),i.e.

$$S = S_D + S_{ID} \qquad (3)$$

5 The system applied example

This article takes a flood disaster of a flood diversion zone in Jingjiang, Hubei province in Aug. 1998 as example, so that explain how the system application. Area of the zone is 921.34 km^2.There are 8 towns,2 villages, 195 ruralities,120 thousand families,500 thousand population. Gross Product of industry and agriculture count roughly 15 hundred million Yuan(Chinese money) in this zone.

(1)The submerged area mapping

The determination of submerged area is a contrast process before and after flood occurrence. Mapping submerged area mainly includes following three step: ①the determination of water boundary before flood occurrence; ②the determination of water boundary after flood occurrence; ③integrating above two water area map, so that the submerged area in this flood is obtained.

Applying Landsat TM image on Sept.25,1996,we can describe water area map before this flood occurrence; Applying ERS-2 SAR image on Aug.7,1998,we can describe water area map during this flood occurrence. Integrating above two map, the submerged area map can be described, see Figure 2.

(2)Describing DEM and calculation of submerged water depth

Applying topographic map on the scale of 1:10000, DEM can be described ,and integrated with submerged area map, so that the distribution area map of submerged water depth can be obtained. In addition, we also can carry out flood routing at DEM, the distribution map of submerged water depth and the submerged area map can be obtained.

(3)Making land use classification

Applying Landsat TM image on Sept.25,1996,land use classification map is made, see figure 3.The map integrated with submerged area map, submerged area of various land use classification may be obtained.

(4)Image integrated and statistical analysis of flood disaster

Land use classification map respectively integrated with the submerged area map, so that the distribution map of submerged water depth, submerged area and water depth can be obtained, see (2),(3) column in table 2.

(5)Estimation of flood loss

According to above submerged area and water depth of various land use classification, flood direct economic loss can be respectively estimated in a certain flood loss rateα_G .See (4),(5),(6) column in table 2.

Flood indirect economic loss is calculated in reduction coefficient $\lambda=20\%$ multiplied by flood direct loss, i.e.

$S_{ID}=\lambda S_D=20\%\times223.51\times10^6=44.7\times10^6$ (Yuan)

Total flood loss is equal to flood direct loss plus flood indirect loss, i.e.

$S = S_D + S_{ID} = 223.51\times10^6 + 44.7\times10^6 = 268.2\times10^6$ (Yuan)

6 Conclusions

Remote sensing monitoring and loss estimated system of flood disaster combines data base of flood disaster with model base of special technique in support of GIS. The system can accomplish the simulation of flood disaster, and reproduce situation of flood disaster on the basis of remote sensing monitoring.

According to macroscopic economic index of GDP and GP or unit-synthetic economic loss index (example, average synthetic economic loss in Mu, average synthetic economic loss in population),this article proposes estimated method of flood economic loss by means of macroscopic economic analysis method, so that flood direct and indirect economic loss is estimated . In addition, the system also can accomplish evaluation of flood loss ,including evaluation of normal year flood loss, some typical year flood loss and forecasting evaluation. Those evaluations are accomplished on the basis of flood loss estimation.

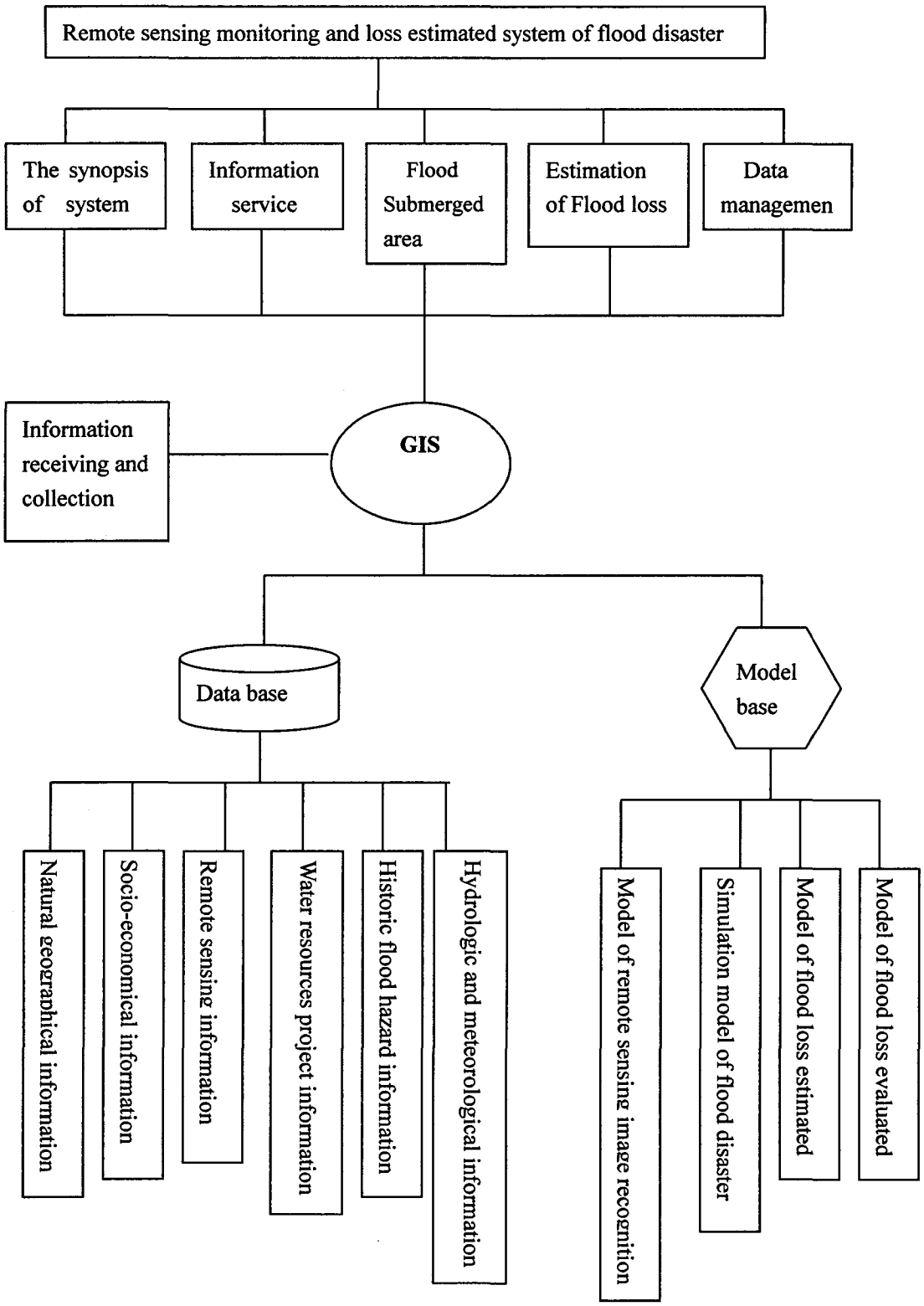

Figure 1. Flow chart of remote sensing monitoring loss estimated System of flood disaster

Table 1 Choice range of flood loss rate α_G

Flood frequency P (%)	75	50	20	10	5	3.33	2	1	0.5
Flood loss rate α_G (%)	0.008 ~ 0.012	0.128 ~ 0.192	1.824 ~ 2.736	3.728 ~ 5.592	5.696 ~ 8.544	8.264 ~ 12.396	10.36 ~ 15.54	12.72 ~ 19.08	20.24 ~ 30.36

Table 2 Estimated table of flood direct economic loss

Statistical Project / classification	Submerged Area (km^2)	Average Water Depth (m)	Unit area Index (Yuan/Mu)	Flood Loss Rate (%)	Flood direct Economic loss (10^6 Yuan)
(1)	(2)	(3)	(4)	(5)	(6)
Dry farm	8.36	0.32	900	80	9.03
Paddy field	24.68	0.46	1200	80	35.54
fishery	1.24	0.86	4000	75	5.58
Rural residential area	7.58	0.43	/	/	38.66
The area of cities and towns	6.71	0.57	/	/	134.2
Other	0.51	0.30	/	/	0.5
Total	49.08	/	/	/	223.51

Figure 2 Submerged area map in a flood diversion area of Jingjiang, hubei province（ 1998 · 8 · 7 ）

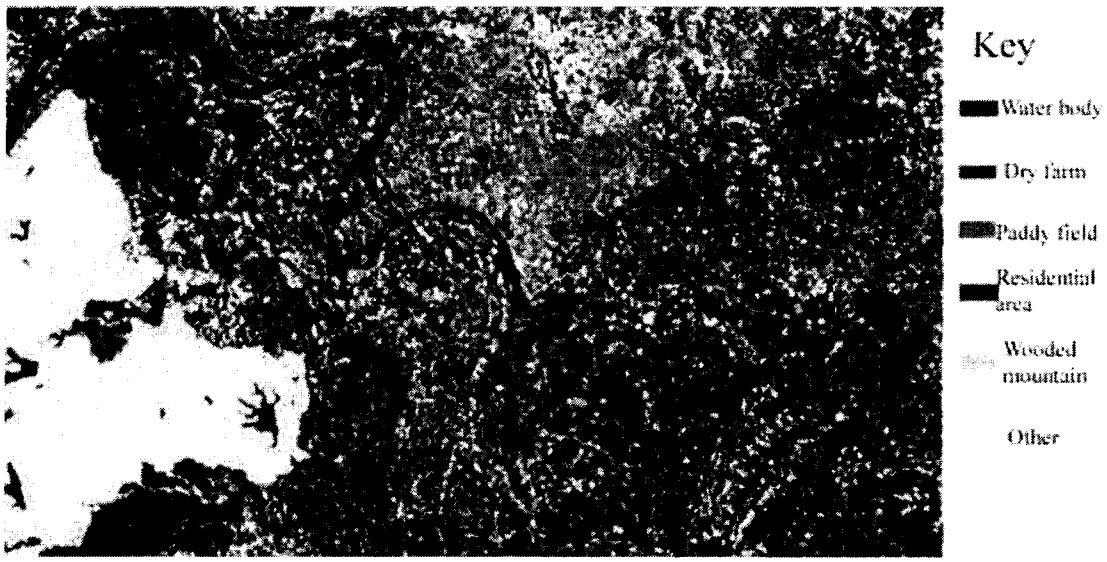

Figure 3 A land use classification map in the Jingzjiang area,Hubei province（ 1996 · 9 · 25 ）