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RISK ASSESSMENT of RAINSTORM DISASTER in GUANGXI BASED on MULTI-SOURCE DATA

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Abstract: In order to cope with the frequent rainstorm disaster and its increasingly adverse effects on Guangxi Zhuang Autonomous Region，Principal Components Analysis (PCA) and Analytic Hierarchy Process (AHP) methods are used on the bases of GIS with multi-source data involving meteorology, historical disaster events, social economy and geography of Guangxi, to develop a data sequence processing and quantitative technology. By which, a rainstorm disaster risk evaluation model has been developed, including four kinds of factors: the dangerousness of real time rainstorm, the sensibility of hazard-formative environment, the vulnerability of receptors and the regional capacity of disaster resistance. Then, the spatial distribution map of rainstorm risk level evaluation in Guangxi has been developed by using the model, and the verification results in this paper show that the risk evaluation results consistent with actually happened disaster condition well.[1]

Key Words: rainstorm; risk evaluation; GIS; Guangxi

INTRODUCTIOIN

Under the background of global warming, weather disasters are endless around the world (Shi P J et al, 2006; Sheng Wenping et al, 2007; Li Shujun et al, 2012) besides, with the development of global economy, the loss caused by the meteorological disasters is increasing dramatically. Guangxi is located in the low-latitude regions, verge the sea in the southern, connect the Yunnan-Guizhou Plateau in the west, and has complex topography, the joint action of this particular geographical environment and atmospheric circulation results in frequent rainstorms in Guangxi every year, which seriously affects life of people and their property.

Not only was the loss, which caused by rainstorm disasters, affected by the strength of the storm itself, but also affected by the status of local land cover status, socio-economic development, and other factors, which causes that the corresponding evaluation Index system of hazard also presents multivariate and multilevel nature, and yet its preciseness cannot be evaluated by a truly universal assessment model of rainstorm hazard. Some scholars had research on establishment of rainstorm hazard assessments model and division of disaster level (Mo Jianfei et al, 2012; Mo Jianfei et al, 2010; Shi Peijun et al,1992; Jiang Aijun et al,2000) and also had achieved some research results. Zhang Jing had adopted GIS technology, Natural Disaster Risk Index Method, and assessment model of flood risk, to solve Flood Disaster Risk Index of county in Hebei, and map out the risk zoning map (Zhang Jing et al, 2009). Xie Yiyang, Han Suqin, et al (2004), had utilized water logging disaster simulation model to numerical simulate different types of rainfall process, and quantitative evaluated water logging disaster risk caused by rainstorm in Tianjin. Zhou Chenghu et al (2000), had proposed flood disaster risk zoning indicator model based on geographic information system, and achieved the flood disaster integrated zoning of Liaohe river basin. As Guangxi is affected by the combined effect of complex topography and climate, hazard-formative indexes and disaster-bearing body vulnerability of rainstorm disaster are different. Therefore, it is necessary to carry out research on quantitative rainstorm disaster risk level evaluation technology, which regards different hazard-bearing body (agriculture), to improve relevance, accuracy, and timeliness of rainstorm disaster assessment. Through studying and solving the identification technology and sequence construction methods of rainstorm hazard -formative factors in Guangxi, which based on hazard-bearing body , the hazard -formative environment, hazard -formative factors ,and anti-disaster capability, this research applied real-time rainfall data of automatic station in Guangxi, historical disaster data, socio-economic data of Guangxi, and basic geographic information data, to construct rainstorm disaster risk assessment model for agriculture in Guangxi that based on rainstorm-induced factors risk level, disaster-informative environment vulnerability, disaster-bearing vulnerability, and anti-disaster ability, determine classification indexes of rainstorm risk assessment level, and finally map out the spatial distribution of rainstorm disaster risk for agriculture in Guangxi and verify its results.

1 MATERIAL and METHODS

1.1 Material

Hourly rainfall data of 1187 automatic stations in Guangxi was selected as meteorological data, storm and flood disaster census data (from the civil affairs department and the agricultural sector) at county or district unit in Guangxi Zhuang Autonomous Region from 1984 to 2010 was selected as disaster data, socio-economic data was extracted from "Guangxi Statistical Yearbook" from 1984 to 2010 and " the economy in Guangxi region in reform and opening up 17 years", population density, GDP, water logging prevention area, etc, of administrative zone at county or district unit were also selected, basic geographic information data, including DEM in Guangxi 1:250,000 map data and river data, was selected, finally.

1.2 The Main Research Method

1.2.1The quantitative extraction method of data sequence

Due to large discrepancy and different in unit of measure of indicator data used in this paper, in order to increase the comparability among these data, it was necessary to non-dimensionalize and standardize the related data, therefore the quantitative extraction method as formula(1) was employed to extract all the factors.

$$X_i' = X_i / X_{\max} \qquad [1]$$

Where means actual value of the data sequence, $X_{\max}$ is corresponding maximum of this data sequence, X_i' is normalized value of this data sequence.

1.2.2 Weighted comprehensive evaluation method

The weighted comprehensive evaluation method (Gong Qinghua et al, 2009), which comprehensively takes impacted degree of comprehensive evaluation factor affected by all indexes into consideration ,and integrates effect of all special indexes with a quantitative index concentrated, was repeatedly used in this paper. Weighted comprehensive evaluation method as follows,

$$\mathcal{F} = \sum_{i=0}^{m} \mathcal{W}_i \times \mathcal{D}_i \qquad [2]$$

Where $\mathcal{F}$ stands for evaluated factor value, D_i stands for normalized value of index i , W_i stands for weigh of index i , and m stands for the number of evaluated indexes.

2 THE DETERMINATION of WEIGHT of RAINSTORM DISASTER RISK ASSESSMENT INDEXES

Real-time rainfall data of different time scale, population density, GDP, direct economic losses, distance to sea, terrain factor, water factor, water logging prevention area, per capita GDP were taken as risk assessment indexes, and counted weight of that(shown in tab1) by employing analytic hierarchy process(Liu Qiong et al, 2009) to construct hierarchy after quantitative extracted of that in this article.

3 RAINSTROM DISASTER RISK ASSESSMENT MODEL

3.1 Rainstorm Disaster-informative Factors Risk Level Assessment Model

Rainstorm days that daily rainfall over 50mm, rainfall that daily rainfall over 50mm during rainstorm process, and maximum of daily rainfall were extracted as assessment factors of rainstorm-induced factors risk level, and then normalized these selected factors. Furthermore, the sequence of rainstorm days that daily rainfall over 50mm, rainfall that daily rainfall over 50mm during rainstorm process, and maximum of daily rainfall in every counties of Guangxi over the years were established, finally, rainstorm-induced factors risk level model (shown in formula (3)) was constructed by employing analytic hierarchy process results.

$$Rainstormrisklevel(\mathrm{D}) = 0.2611 \times a_1 + 0.6250 \times a_2 + 0.1466 \times a_3 \qquad [3]$$

Where a_1 is normalized value of rainstorm days that daily rainfall over 50mm, a_2 is normalized value of rainfall, which daily rainfall over 50mm, during rainstorm process, a_3 is normalized value of maximum of daily rainfall.

Tab 1: The Assessment Index Weight of The Rainstorm Risk in Guangxi

Target layer	Weight	Guidelines layer	Weighs	Evaluation layer	Weight
Rainstorm disaster real-time risk level in Guangxi	1	Disaster-informative factors risk level model	0.4796	Days of rainstorm	0.2611
				Rainfall	0.6250
				Daily maximum rainfall	0.1466
		Hazard-bearing body vulnerability	0.1899	Terrain factor	0.4286
				Water factor	0.4616
				Distance to sea	0.1526
		Rainstorm disaster vulnerability	0.2717	Population Density	0.1760
				GDP	0.3177
				Economic losses in agriculture	0.5744
		Anti-disaster ability	0.1050	Per capita GDP	0.3580
				Water logging prevention area	0.7133

3.2 Disaster-informative Environment Vulnerability Assessment Model

As the southwest of Guangxi along the coast, which has greater chance of rainstorm affected by typhoon, so taken comprehensive influence, affecting by distance to sea, terrain, water etc, on rainstorm disaster formation into consideration while evaluated disaster-informative environment vulnerability. Generally speaking, the farther away from the sea, the smaller affected by the typhoon, rainstorm disaster risk degree is also smaller, so reciprocal of distance to sea was taken as one of the disaster-informative environment vulnerability factors.

Terrain changes mainly include the changes of elevation and terrain. The lower at elevation, the smaller at elevation standard deviation and the greater at vulnerability, the more conducive at the formation of flood disaster. Elevation data was extracted from 30 * 30 m digital elevation model of Guangxi, and terrain effected distribute indexes of rainstorm disaster in Guangxi was generated by using expert scoring to value different combination of terrain elevation and elevation standard deviation (shown in tab2).

Tab 2: The Compound Assignment of The Digital Elevation and The Standard Deviation of Digital Elevation

Terrain elevation（Meter）	Terrain standard deviation（Meter）		
	Level one（≤1）	Level two（1-10）	Level three（≥10）
Level one（≤100）	0.9	0.8	0.7
Level two（100-300）	0.8	0.7	0.6
Level three（300-700）	0.7	0.6	0.5
Level four（≥700）	0.6	0.5	0.4

Water environment vulnerability evaluation mainly includes two evaluation indexes (river density and distance to water). The denser at river network and the closer at distance to river, lake and so on, the greater at risk degree suffered from flood disaster. River density is river total length in a watershed area unit; the river density was normalized by counting 1:250000 river data of Guangxi in this article, with default value of radius used. Buffer analysis function of GIS was adopted to divide the effect of distance to water into two buffer zones, and value the two buffer zones with appropriate value from zero to one. Weight of each zone influenced by river density and buffer was 0.5, finally, index of effected by water was counted by using weighted comprehensive evaluation method.

Disaster-informative environment vulnerability model (shown in formula (4)) was established by employing weighted comprehensive evaluation method with the aforementioned factors (distance to sea, terrain, water).

$$\text{Disaster} - \text{informative environment vulnerability(F)} = 0.1526 * b_1 + 0.4286 * b_2 + 0.4616 * b_3 \quad [4]$$

Where b1 is reciprocal of normalized value of distance to sea, b2 is value affected by terrain factors, and b3 means value affected by water factors.

3.3 Hazard-bearing Body Vulnerability Assessment Model

Losses caused by rainstorm depend on the economic and the population density in happening place. Social statistics data (regional average population density, regional average GDP, and regional average economic loss of agriculture) was taken as factor of the hazard-bearing body vulnerability. Since this study focused on agriculture, regional average population density, regional average GDP, and regional average economic loss of agriculture were also taken as factors of the hazard-bearing body vulnerability. After normalizing aforementioned each factors, rainstorm disaster vulnerability of hazard-bearing body model for agriculture (shown in formula (5)) was generated by utilizing the analytic hierarchy process.

$$\text{Rainstorm disaster vulnerability (L)} = 0.1760 * c_1 + 0.3177 * c_2 + 0.5744 * c_3 \quad [5]$$

Where c1 stands for normalized value of population density, c2 stands for normalized value of GDP, c3 stands for economic loss of agriculture.

3.4 Anti-disaster Ability Assessment Model

Disaster prevention and mitigation capability indicates the degree of the affected areas recover from meteorological disasters in a long-term and a short-term, and are engineering and non-engineering measures used in response to the damage caused by rainstorm disaster. Taking into account the construction of these measures and projects must have the economic support of the local government; per capita GDP and ratio of water logging prevention area were taken as the evaluation factor of anti-disaster level. The smaller in per capita GDP value and water logging area value, the worse in the anti-disaster force. Anti-disaster ability model generated is shown in formula (6).

$$\text{Anti} - \text{disaster ability (R)} = 0.7133 * d_1 + 0.3326 * d_2 \qquad [6]$$

Where d1 means the normalized value of waterlogging prevention area, d2 stands for normalized value of per capita GDP.

3.5 Assessment Model and Level Classification Indexes of Rainstorm Disaster Risk in Guangxi

Rainstorm disaster risk assessment model (shown in formula 7) was generated by comprehensive integrating rainstorm hazard -formative factors risk level model, hazard -formative environment vulnerability level model, hazard-bearing body vulnerability model, and anti-disaster model.

$$\text{Rainstorm real} - \text{time risk level (agriculture)}\ \ RI = 0.4796 * D + 0.1899 * F + 0.2717 * L + 0.1050 * R \qquad [7]$$

Where RI means rainstorm disaster risk assessment index in Guangxi, D means rainstorm hazard -formative factors risk level, F means hazard -formative environment vulnerability level, L means rainstorm disaster vulnerability level, R means anti-disaster ability.

The classification indexes of rainstorm risk assessment in Guangxi were determined by historical and actual disaster data.

Tab 3: The Classification Index of Rainstorm Risk Assessment in Guangxi（Agriculture）

	Risk level				
Rainstorm risk of agriculture	Low-risk areas	Second low-risk areas	Medium risk areas	Second high-risk areas	High-risk areas
Degree index RI	0.14≤ < RI＜0.27	0.27≤ < RI＜0.33	0.33≤ < RI＜0.40	0.40≤ < RI＜0.52	RI≥0.52

4 SPATIAL DISTRIBUTION and CERTIFICATION of RAINSTORM DISASTER RISK in GUANGXI

Spatial distribution of rainstorm disaster risk in Guangxi, from which we can see that rain disaster agriculture high risk level zones in Guangxi consistent with annual rainstorm agriculture hardest hit in Guangxi, for agriculture was drawn by using employing rainstorm disaster risk assessment model in Guangxi (shown in fig 7).

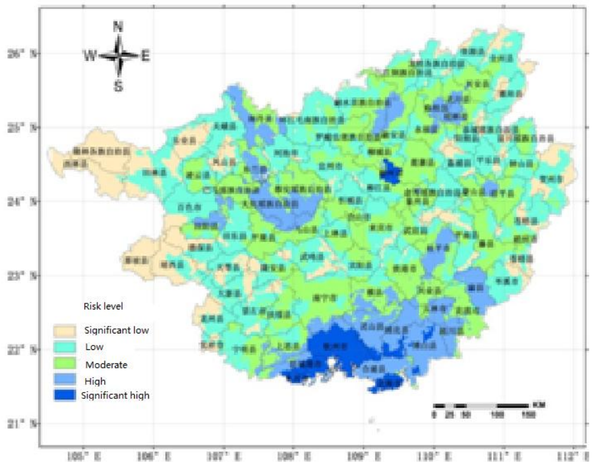

Fig 1: The Spatial Distribution of Rainstorm Disaster Risk in Guangxi (agriculture)

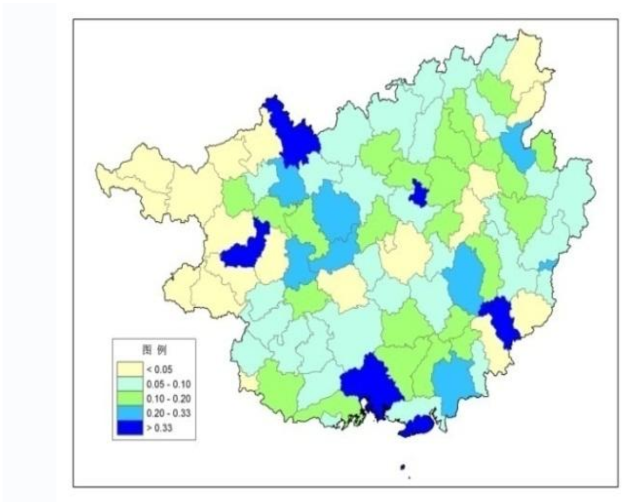

Fig 2: The spatial distribution of rainstorm flood area in Guangxi (agriculture)

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