Nat Hazards (2015) 75:2167–2183
DOI 10.1007/s11069-014-1420-0

ORIGINAL PAPER

Small-scale natural disaster risk scenario analysis: a case study from the town of Shuitou, Pingyang County, Wenzhou, China

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Received: 30 March 2014 / Accepted: 4 September 2014 / Published online: 11 September 2014

Abstract An empirical-based natural disaster risk assessment was carried out in a sub-national region of China, using the town of Shuitou, Pingyang County, Wenzhou, as the small-scale study area. Risk factors identified associated with the Typhoon Morakot rainstorm–flood event included hazard, vulnerability, and disaster loss, with the corresponding indicators being submergence depth (m), loss rate (%), and flood loss values (Yuan). As a frequent rainstorm–flood area, the maximum flood depth in Shuitou is 3.57 m, and the average loss rates for housing property and business assets reach 20 and 30 %, respectively. The average maximum loss ranges around 40,000–100,000 Yuan. The comprehensive disaster risk level depends on the respective strengths of the principal component factors. Extremely high-submersion-risk and very high-submersion-risk areas in Shuitou are found in the northwest, specifically along the GongYuan and Yuanlin roads, covering an area of 0.33 km^2, about 17.65 % of study areas. This small-scale natural disaster risk assessment encapsulates the principle of "regional characteristics, case accumulation, long-term record." The evaluation results can be used as reference for regional temporary migration program design and implementation.

Keywords Risk scenarios · Typhoon rainstorm–flood hazard · Small scale · Shuitou town

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1 Introduction

Data covering the past half-century have increased levels of certainty regarding global warming (IPCC 1990, 1996, 2001, 2007, 2013; Frame and Stone 2013), with the rate of global mean sea-level rise also accelerating during the last two centuries (Warrick and Oerlemans 1990; Jevrejeva et al. 2008; Willis et al. 2010; Church and White 2011; IPCC 2013). Regional extreme disaster events have occurred as a seemingly endless stream (Allan and Komar 2006; Benestad and Haugen 2007; Grabemann and Weisse 2008; Alexander and Power 2009; IPCC 2012). For example, either the frequency or intensity of typhoons, rainstorms, and floods has exhibited an increasing trend in East Asian coastal areas (Zhai et al. 2005; Boo et al. 2006; Fujibe et al. 2006; Zou et al. 2006; Jiang et al. 2008; Krishnamurthy et al. 2009; Kenyon and Hegerl 2010; Donat et al. 2013); combined with the effects of human activities on the natural environment, the potential hazard risk in such areas is thus strongly increased (McGranahan et al. 2007; Zhang et al. 2007; Min et al. 2011). China's coastal cities (Tianjin, Shanghai, Guangzhou, etc.) are frequently subject to typhoon–rainstorm, inundation, and land subsidence hazards (Yin et al. 2011, 2013; Ying et al. 2011; Wang et al. 2012; Su et al. 2012; Hu et al. 2013;). Severe coastal hazards such as erosion and inundation are highly important in the context of disaster risk management (Seneviratne et al. 2012).

Governments, scientists, and the public have different perspectives on and responses to rainstorm–flood risk, and on different spatial and temporal scales (Christensen and Christensen 2003; Caesar et al. 2006; Meehl et al. 2007; Orlowsky and Seneviratne 2011). Whereas governmental policy-makers are largely concerned about the effectiveness of flood mitigation strategies, scientists investigate the reliability of hazard risk characterization, and the public's main concern is the guidance provided by a "Disaster Risk Index." Compared with analysis carried out on large and medium spatial scales, the accuracy of small-scale risk assessment may decrease, while application increases (Wang et al. 2013a). Flood risk assessment is a relatively mature concept; based on a set of scenarios, disaster losses and the probability of occurrence are frequently estimated in order to determine overall flood risk (Plate 2002; Kenyon 2007; Miceli et al. 2008; Xia et al. 2011; Camarasa-Belmonte and Soriano-García 2012; Diermanse and Geerse 2012; Ji et al. 2013). For small-scale areas (such as a community or neighborhood), household surveys focusing on the local history of typical flood events have gradually become an effective means of disaster risk analysis and assessment (Paul 1997; Shidawara 1999; Lanza 2003; Parker et al. 2007; Ibarra 2012).

The present study is one of series of natural disaster scenario risk assessments investigating China's coastal cities on multi-spatial scales (Liu et al. 2011a, 2012; Wang et al. 2013a). In order to analyze the spatial scale effects (down-scaling) of flood risk, this study takes the town of Shuitou, Pingyang County, Wenzhou city, as a small-scale empirical area. A typical typhoon (0908 Morakot) rainstorm–flood hazard risk analysis study using the post-flood household survey method was carried out.

This study focuses on flood risk characterization on a small-scale area, as well as the reliability and feasibility of risk indicators. Research ideas are for peer scholars' reference. The results of the study have important guiding significance for disaster prevention and migration in the town of Shuitou. In addition, the article discussed the flood risk classification criteria of frequent rainstorm–floods area. Temporary disaster immigrants can be developed in accordance with the results of the risk zoning. The research results can also be used as the case for the promotion and reference.

2 Materials and methods

2.1 Study area

Situated between 27°37′55″N and 27°39′10″N, and 120°17′35″E and 120°20′15″E, the town of Shuitou is located on the upper reaches of the Aojiang river near the southeast coast of Zhejiang Province (Fig. 1). Covering a total area of 1.87 km^2, the study area is bordered by the villages of Shanglin, Siqian, Shuifengwei, Zhonghou, Sanqiao, Wulongdai, Waidai, and Liujiaosikeng, with Shuitou's central square as the center point (Fig. 1).

Three main land-use types are present in the study area: housing, agriculture, and transport infrastructure (roads). Accounting for 1.12 km^2, or around 60.14 % of the total study area (Table 1), housing land (which includes residential housing and commercial shops) covers the largest area and is widely distributed across the central square, as well as the villages of Siqian, Liujiaosikeng, Wudai, Sanqiao, and Zhongwei (Fig. 1). Agricultural

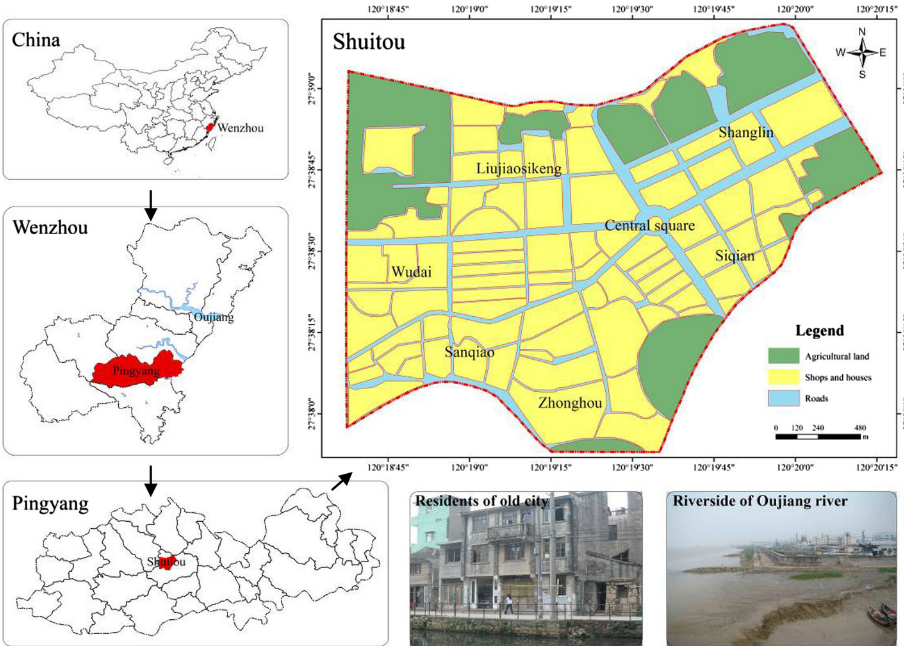


Fig. 1 Sketch map of the study area

Table 1 Spatial area statistics for the different land-use types in Shuitou

Land-use types	Area (km^2)	Area ratio (%)	Cumulative area ratio (%)
Roads	0.33	17.74	17.74
Agricultural land	0.41	22.12	39.86
Housing land	1.12	60.14	100.00
Total	1.87	100.00	–

land is mainly distributed in the northern area of Shanglin, the northwest of Liujiaosikeng, and the east of Zhonghou (Fig. 1), with a total area of 0.41 km^2, or around 22.21 % of the study region (Table 1). The area of land associated with the local road network is the smallest of the three, covering 0.33 km^2 or 17.74 % of the study region (Table 1).

According to field survey, the town of Shuitou is located on a windward slope downstream of the South Yan Mountains, oriented northeast–southwest. When Typhoon Morakot landed at the junction of Zhejiang and Fujian provinces, its airflow was uplifted because of the terrain slope, resulting in heavy rainfall. Such torrential rain is often directly responsible for many flood hazards. Indeed, the study area is flooded several times every year, with Shuitou itself also seriously affected during a number of historically strong typhoons. According to historical data, flooding occurs at a rate of around 1.25 events/year, with an average depth of between 0.5 and 1.2 m. This situation has continued for more than 10 years, and thus, the region can be defined as an area of "frequent rainstorm–floods"(Liu et al. 2011b; Wang et al. 2013b).

2.2 Definition of risk scenarios

A risk scenario is defined as an outcome that is determined by combining a set of conditions, such as time span, spatial scale, type of disaster, and man-made hazard factors, in order to assess the level of the risk involved (Liu et al. 2012; Wang et al. 2013a).

The specific disaster risk scenario employed for Typhoon Morakot rainstorm–flood hazards in Shuitou can thus be defined as follows: (1) small spatial scale (town), (2) unlimited time span, (3) exceeding 50-year hazards, and (4) three hazard or risk indexes (depth, loss rate, and loss value).

Based on a single typical return period, the present paper explores risk variation for the town of Shuitou in terms of three different indexes.

2.3 Data collection and processing

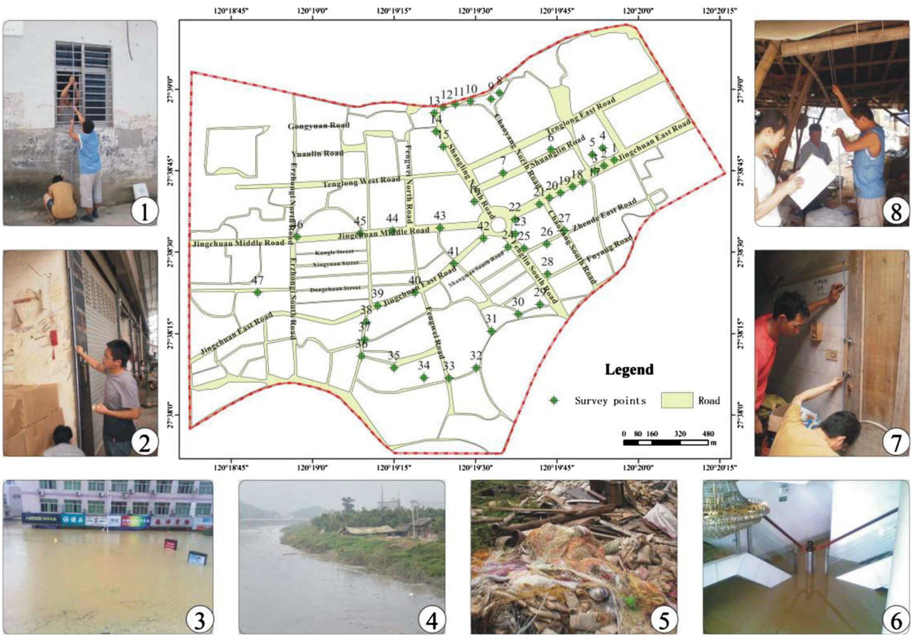
2.3.1 Flood depth measurements and field-based damage investigation

Flood damage field investigation is a direct and effective method with which to evaluate submergence depth and disaster losses (Paul 1997; Shidawara 1999; Lanza 2003; Parker et al. 2007; Ibarra 2012). In the present study, a survey was carried out investigating post-flood housing property and business asset losses in the town of Shuitou, Pingyang County (Fig. 2).[1] Specific methods included door-to-door visits, measurement of water depth, as well as the survey and recording of losses (Fig. 2). A total of 47 survey points were employed, encompassing buildings such as a hotel, shop, industrial company, houses, a Catholic church, a school, square, internet bar, pharmacy, factories, and others.[2]

Based on the property and loss value survey data (Appendix 2), disaster loss rates were calculated using the formula

[1] The results of the Typhoon Morakot rainstorm-flood loss survey questionnaire "The flood loss table of housing property and business assets" can be found in Appendix 1.

[2] Statistical data and basic information regarding the 47 survey points in Shuitou can be found in Appendix 2.



①Catholic church (Jiaoentang) at point 13 (flood depth: 3.2 m). ② Clothing and hardware stores (Shishishi Taisheng) at point 6 (flood depth: 2.4 m). ③ Shops along the street (Jingchuan Middle Road) at points 43, 44 and 45 (flood depth: >2.2 m). ④ Pig farms along the creek in south Shuitou. ⑤ Damaged leather raw materials submerged in water at a tannery at point 30. ⑥ Junction of the first and second floors of the Xingmao Hotel at point 1 (flood depth: 2.6 m). ⑦ Flooring processing room at point 40 (flood depth: 2.3 m). ⑧ Waste leather recycling station at point 33 (flood depth: 2.4 m).

Fig. 2 Spatial distribution of investigation points and flood hazard photographs in the studied Typhoon Morakot scenario

$$R_1 = \frac{L}{V} * 100\%$$

where R_1 (%) represents the flood loss rate, L (Yuan) the loss value, and V (Yuan) the property value.

2.3.2 ArcGIS interpolation analysis

The Interpolation toolset available in the ArcGIS software program is one of the most important tools in the spatial analyst's toolbox. Interpolation involves the prediction of values for cells in a raster from a limited number of sample data points and can be used to predict unknown values for any geographic point data, such as elevation, rainfall, chemical concentrations, and noise levels. The basis of interpolation can be described as spatial autocorrelation and Tobler's First Law of Geography.

The Geostatistical Analyst option in ArcGIS provides an extensive collection of interpolation methods, including global polynomial, local polynomial, inverse distance weighted, radial basis functions, diffusion kernel, kernel smoothing, ordinary kriging, simple kriging, universal kriging, indicator kriging, probability kriging, disjunctive kriging, Gaussian geostatistical simulation, areal interpolation, and empirical Bayesian kriging.

The Inverse Distance Weighted (IDW) method was employed in the present paper in order to predict the values of depth, losses, loss rate, and risk grades, and to create surfaces for the town of Shuitou (Figs. 3, 4, 5, 6). IDW interpolation explicitly implements the assumption that things that are close to one another are more alike than those that are farther apart. To predict a value for any unmeasured location, IDW uses the measured values surrounding the prediction location, with the measured values closest to the prediction location having a greater influence on the predicted value than those farther away. IDW thus assumes that each measured point has a local influence that diminishes with distance. Greater weights are therefore given to points closest to the prediction location, with weight values diminishing as a function of distance, hence the method's name.

2.3.3 Principal component factor index classification method

Principal component analysis (PCA) is a statistical procedure that uses orthogonal transformation to convert a set of observations regarding possibly correlated variables into a set of values regarding linearly uncorrelated variables, also known as principal components. Based on a review of the PCA research literature, here we propose three indicators which reflect the flood risk associated with the Typhoon Morakot rainstorm: submerged depth, disaster loss rate, and loss value, representing hazard, vulnerability, and disaster risk, respectively.

According to the Likert scale method (Likert 1932), flood risk can be divided into the following seven levels (Table 2): extremely low risk (blue), very low risk (green), low risk (dark green), intermediate risk (yellow), very high risk (orange), extremely high risk (red), and no risk (white).

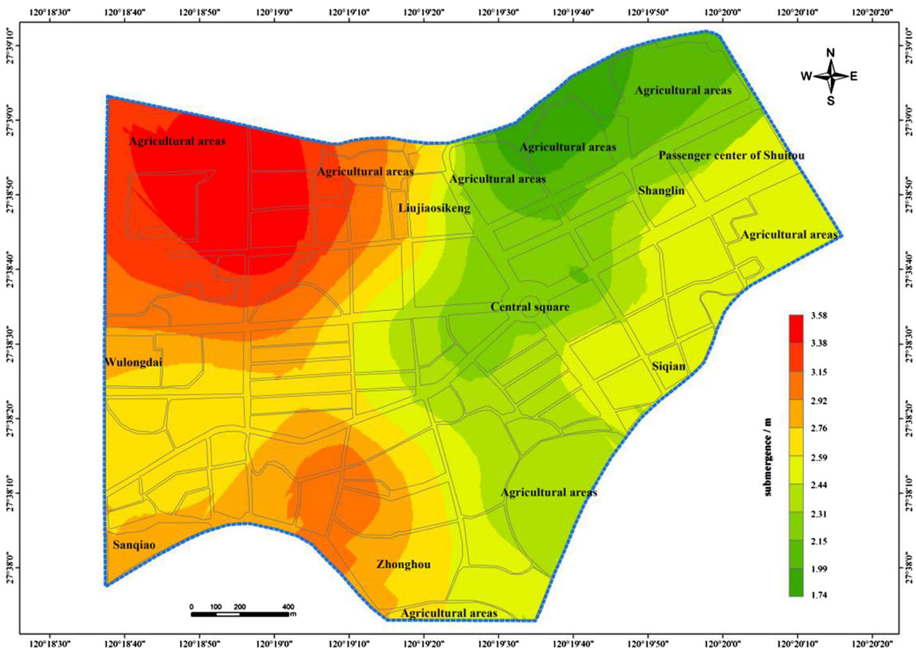


Fig. 3 Spatial distribution of flood submergence in the Typhoon Morakot scenario

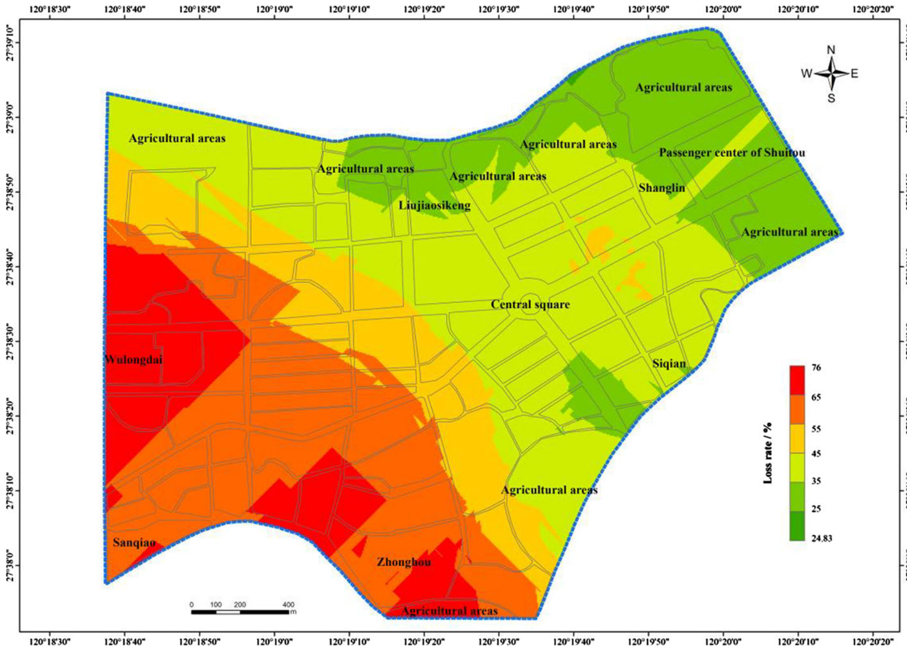


Fig. 4 Spatial distribution of flood hazard loss rate values in the Typhoon Morakot scenario

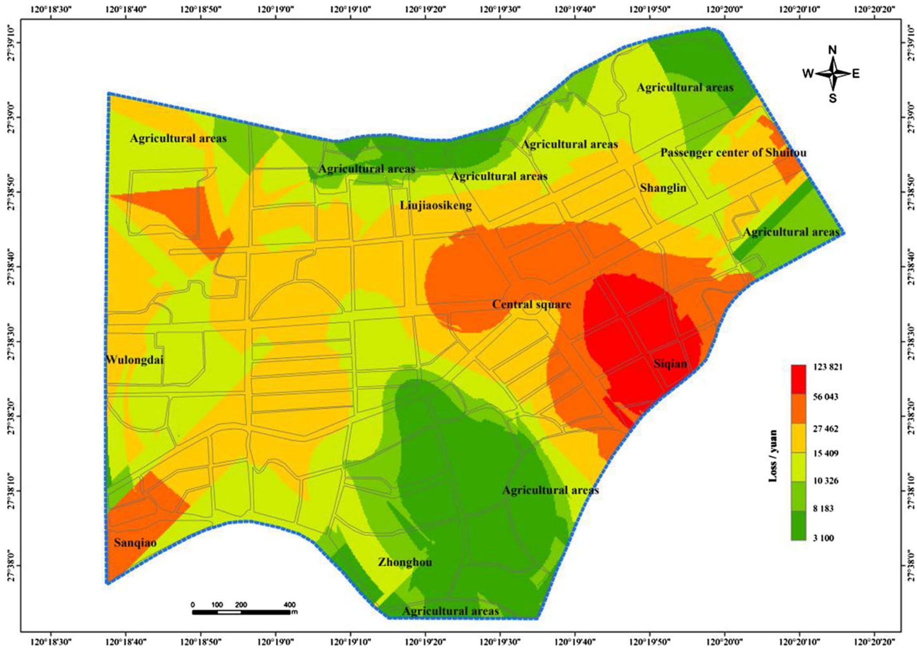


Fig. 5 Spatial distribution of flood losses in the Typhoon Morakot scenario

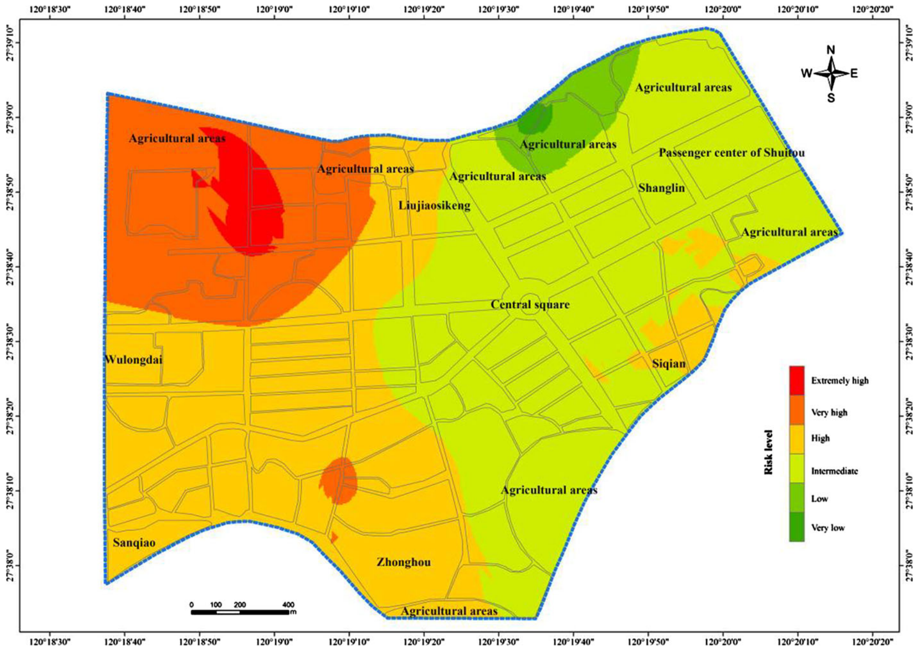


Fig. 6 Spatial distribution for the risk of exceeding a 50-year (Typhoon Morakot scenario) flood

Table 2 Grading of disaster risk and warning signals for the Typhoon Morakot flood

Grade	Category	Standards			Warning signal
		Flood depth (m)	Loss rate (%)	Loss (yuan)	
0	No risk	≤0.5	≤0	≤0	
1	Extremely low	0.5–1.0	0–10	0–3,000	
2	Very low	1.0–1.5	10–20	3,000–5,000	
3	Low	1.5–2.0	20–30	5,000–10,000	
4	Intermediate	2.0–2.5	30–50	10,000–20,000	
5	High	2.5–3.0	50–60	20,000–30,000	
6	Very high	3.0–3.5	60–70	30,000–50,000	
7	Extremely high	≥3.5	≥70	≥50,000	

Employed in the present study to determine classification criteria, the Jenks Natural Breaks classification (or optimization) system is a data classification method designed to optimize the arrangement of a set of values into "natural" classes (Jenks 1967). This is carried out by minimizing the average deviation from the class mean, while simultaneously maximizing the deviation from the means of the other groups, with the method thus ultimately reducing variance within classes and maximizing variance between classes. The Jenks Natural Breaks in the data are then utilized to provide more meaningful visualization of map data based on the "natural breaks" in the data identified by the iterative process. The natural breaks (Jenks) tool in the ArcGIS software program was employed here as one of the main data classification methods.

3 Results and discussion

3.1 Hazard distribution

The spatial distribution of flood submergence is a comprehensive expression encompassing regional rainfall, topography, and other factors. During the 0908 Morakot event, flood submergence depth in the study area varied between 1.73 and 3.57 m, with the 2.30–2.92 m depth class covering the largest area and accounting for 60 % of the total (Table 3). Although more than 65 % of the study area was submerged under less than 2.7 m of water, around 20 % or 0.4 km^2 experienced a flood depth of over 3 m. (Table 3).

An obvious "west high–east low" submergence depth distribution pattern can be observed in Shuitou (Fig. 3). Severe waterlogging regions are distributed in the northwest of the town, with an average depth of more than 3 m (Fig. 3), followed by a depth range of between 2.5 and 2.8 m in the southwest. Northern Shuitou experienced the lowest waterlogging levels, with an average depth of less than 2.1 m (Fig. 3).

3.2 Vulnerability distribution

Survey revealed the areas most vulnerable to flood hazard to be residential housing and business assets. An area's flood loss rate is a comprehensive reflection of submerged depth, property value, and hazard vulnerability. Because of the presence of tertiary industry (leather, belts, and pet products) in Shuitou, agricultural losses were rare. Disaster loss rate values ranged between 25 and 76 %, with the 35–45 % and 55–65 % classes predominant, respectively accounting for 35 and 22 % of the total area (Table 4).

Table 3 Spatial area statistics for Typhoon Morakot rainstorm–flood depth

Classification (mm)	Area (km^2)	Area ratio (%)	Cumulative area ratio (%)
1.73–1.98	0.06	3.03	3.03
1.98–2.15	0.11	5.67	8.70
2.15–2.30	0.19	10.42	19.12
2.30–2.43	0.26	13.64	32.77
2.43–2.58	0.37	19.79	52.56
2.58–2.76	0.27	14.60	67.15
2.76–2.92	0.21	11.15	78.30
2.92–3.14	0.15	7.81	86.11
3.14–3.37	0.12	6.33	92.44
3.37–3.57	0.14	7.56	100.00
Total	1.87	100.00	–

Table 4 Spatial area statistics for Typhoon Morakot flood loss rate

Classification (mm)	Area (km^2)	Area ratio (%)	Cumulative area ratio (%)
24–25	0.00	0.06	0.06
25–35	0.34	18.01	18.07
35–45	0.65	34.96	53.03
45–55	0.25	13.17	66.20
55–65	0.41	22.17	88.37
65–76	0.22	11.63	100.00
Total	1.87	100.00	–

Table 5 Spatial area statistics for Typhoon Morakot flood loss

Classification (mm)	Area (km^2)	Area ratio (%)	Cumulative area ratio (%)
3,100–8,183	0.28	14.75	14.75
8,183–10,326	0.18	9.56	24.31
10,326–15,409	0.52	27.71	52.02
15,409–27,462	0.57	30.74	82.76
27,462–56,043	0.24	13.06	95.82
56,043–123,821	0.08	4.18	100.00
Total	1.87	100.00	–

The spatial distribution of flood vulnerability reflects that of housing assets and commercial shops. Hence, the study region can be divided into two main areas by a line running northwest–southeast, with high values in the southwest half and low values in the northeast (Fig. 4). Loss rates in the villages of Wulongdai, Sanqiao, and Zhongwei were thus higher than those recorded in the northeast.

3.3 Disaster loss distribution

The value of property in the study region ranges from 8,000 to 480,000 Yuan, with those in the 40,000–100,000 Yuan class accounting for 47.87 % of the total. Higher-value properties are distributed in the intensive commercial areas in the southeast (Siqian, Shuitou central square, etc.), with those of lower value located in the agriculture-based areas in the southwest (Zhonghou, Wulongdai, etc.)

Flood loss values were derived from the obtained investigation statistics (Appendix 2). Losses ranged between 1,300–123,821 Yuan, with the 10,000–27,000 Yuan class accounting for 58.45 % of the total area (Table 5). Around 50 % of individual flood losses were lower than 15,000 Yuan, with less than 5 % of Shuitou inhabitants experiencing losses of more than 50,000 Yuan (Table 5).

Significant flood loss was observed in Shuitou central square, as well as in the villages of Siqian and Liujiaosikeng, all areas associated with higher-value assets (Fig. 5). Lower losses were recorded in agricultural areas, such as Zhonghou and the north of Shanglin and Liujiaosikeng (Fig. 5). As can be seen in Fig. 5, areas with the highest loss rate account for a low proportion of Shuitou. In cases of a disaster loss rate of more than 30 %, property values may better reflect the potential hazard level in small-scale areas.

3.4 Disaster risk distribution

Compared to large- and medium-scale areas, the typical disaster risk in small-scale regions can be characterized using a principal component index. In the present study, the following three indicators were employed: submerged depth, which reflects the risk of future flood submersion; the disaster loss rate, which reflects the vulnerability of hazard-bearing areas; and flood loss, which reflects the risk of potential socioeconomic losses. For frequent rainstorm–flood areas, the flood inundation depth can be employed as a comprehensive indicator of risk grades and distribution (Fig. 6).

Extremely high-submersion-risk and very high-submersion-risk regions in Shuitou are distributed in the northwest, specifically along the GongYuan and Yuanlin roads (Figs. 2 and 6), and cover an area of 0.33 km^2 (Table 6). High-risk areas are found west of the Fengwei road (Figs. 2 and 6) and cover 0.67 km^2 (Table 6). Intermediate-risk areas are widely distributed across central and eastern Shuitou (Fig. 6), accounting for 0.81 km^2 (Table 6). Low-risk and very low-risk regions represent 3.3 % of the total study area (Table 6). In addition, areas of greater vulnerability are located in the western region of Wulongdai, with local agriculture and housing subject to increased flood loss rates. High-loss-risk areas are also found in the center and east of the central square and Siqian.

No risk does not mean risk-free, but cannot evaluate due to special reasons or not reached the unacceptable risk value. For general area, no risk can be understood as hazard, vulnerability, and disaster loss are zero, or the possibility of disaster is zero. For regular waterlogging area, threshold of “no risk” is higher. In this study, the no risk standards were flood depth less than 0.5 m. The reason is that the residents already have some flood defenses capabilities through practical response to floods. Flood depth less than 0.5 m not causes any personal injury and property damage. However, the standard is only a reference for the region. The standards of no risk could be corrected with the characteristics of global change and regional response.

Overall, the flood depth and property damage reflect the characteristics of risk from different perspectives. For the medium- and large-scale regions, disaster potential losses and the probability of occurrence are essential to characterize the risk value. Rainstorm and floods often cause direct or indirect economic losses. As the small-scale area (town, community) is concerned, personal safety is the more important than property damage, that is, the greater the depth of the submerged area, the larger the risk of people trapped or death, which is the main significance of the small-scale regional disaster risk assessment, namely disaster immigrants plan.

Table 6 Spatial area statistics for Typhoon Morakot flood risk

Grade	Area (km^2)	Area ratio (%)	Cumulative area ratio (%)
Very low	0.01	0.29	0.29
Low	0.06	3.01	3.30
Intermediate	0.81	43.20	46.50
High	0.67	35.93	82.44
Very high	0.29	15.26	97.69
Extremely high	0.04	2.31	100.00
Total	1.87	100.00	–

As discussed previously (Wang et al. 2013a), small-scale disaster risk assessment is generally based on the principles of regional characteristics, case accumulation, and a long-term record, with the evaluation results focusing on absolute risk (submersion or losses). Single (typical) indicators may be employed as an alternative method. However, the scientific accuracy of the obtained results can be affected by the selected survey methods (e.g., written or oral responses), questionnaire design (simple or full), interviewer quality (professional or non-professional), and available resources (money, equipment, safety, etc.). As the present study was limited in terms of time and investigation numbers, the results reflect only the characteristics of risk for the town of Shuitou.

The data obtained here indicate that the combination of rapid oral interviews and an in-depth questionnaire (Appendix 1) represents a fast and effective method for post-flood risk assessment. However, members of small-scale investigation groups should undergo specialized training prior to conducting the research. Empirical studies should also be carried out on broader and larger scales in order to improve the significance of the risk analysis in terms of both theory and application.

4 Conclusions

An empirical study was carried out examining a frequent rainstorm–flood area: the town of Shuitou, Pingyang County, Wenzhou, China. The study focused on the definition of data acquisition for three different risk indicators, with post-flood research the main method employed to obtain first-hand statistical data. The inverse distance weighted (IDW) method of interpolation analysis was used in the ArcGIS software program for the estimation of nearby spatial values and their distribution. The Natural Breaks (Jenks) method was employed for risk classification. Risk characteristics were expressed in terms of three principal component indicators: submergence depth, loss rate, and loss value. The modeled Typhoon Morakot scenario was defined as the risk of exceeding a 50-year hazard.

Under the analyzed Typhoon Morakot rainstorm–flood scenario conditions, the average flood depth was 1.5 m. Areas subject to more than 2.5 m submergence covered 1.12 km^2 and accounted for 60 % of the total study region. Severe waterlogging regions were distributed in the northwest, where the flood depth reached 3 m. The submergence depth in the southwest ranged between 2.5 and 2.8 m. The flood loss rate of residential property and business assets varied between 25 and 76 %. Spatial distribution of vulnerability exhibited a southwest high—northeast low trend. The flood loss of more than 75 % of investigation data points reached 10,000 Yuan. Overall, high-risk regions (including those at high, very high, and extremely high risk) cover 1 km^2 or 53.47 % of the total study area. High-risk areas in Shuitou are predominantly located in the northwest, specifically along the GongYuan and Yuanlin roads.

The present paper is one of a series of disaster risk spatial down-scaling studies. Risk analysis is being carried out based on scenarios investigating the possibility for and reliability of risk characterization, with the results expressed in terms of the spatial distribution of risk index values and risk grades. Future research will involve the development of multi-scale flood risk applications, examining topics such as large-scale risk warning, mesoscale risk reduction, small-scale risk migration, and a risk atlas.

Acknowledgments This work was financially supported by the National Natural Science Foundation of China (NSFC) (No. 51174142, No. 51422404, and No. 41101507), National Science Support Panning of China (No. 2009BAB48B02), Program for New Century Excellent Talents in University of Chinese Ministry of Education (No. NCET-11-1036), the Fok Ying Tung Education Foundation (No. 132023), Program for the Top Young Academic Leaders of Higher Learning Institutions of Shanxi (TYAL), Program for the Philosophy and Social Sciences Research of Higher Learning Institutions of Shanxi (PSSR) (No. 2014314), Shanxi Meteorological Bureau Fund Project (No. SXKYBFW20147822), Shanxi Soft Science Fund Project (No. 2013041041-05), the Qualified Personnel Foundation of TaiYuan University of Technology (No. TYUT-RC201110A), Youth Foundation of Taiyuan University of Technology (No. 2013w023 and 2013w024). We gratefully acknowledge the thoughtful comments of the editor and reviewers.

Appendix 1

See Table 7.

Table 7 Typhoon Morakot rainstorm–flood loss questionnaire for the town of Shuitou

Flood loss table for housing property and business assets				
Number				
Spatial location	Latitude		Longitude	
Type of land	Residential houses		Commercial shops	
Number of floors				
First floor height (m)				
Flood depth (m)				
Submerged time (h)				
Type of property	House itself	Specific property	Shop itself	Business assets
Value (Yuan)				
Loss (Yuan)				
Flood control measures	Insurance participation		Warning	
	Transfer of property		Disaster prevention awareness	
Comments and suggestions				

Appendix 2

See Table 8.

Table 8 Basic information for the 47 survey points in Shuitou

Number	Latitude	Longitude	Flood depth (m)	Location description (store name)	Loss (Yuan)	Property value (Yuan)	Loss rate (%)
1	120.3320	27.6464	2.60	Xingmao hotel	1,000.00	5,400.00	18.52
2	120.3320	27.6461	2.30	Floor business	5,000.00	20,000.00	25.00
3	120.3310	27.6458	2.70	Small shop	0.00	0.00	0.00
4	120.3320	27.6470	2.40	Leather industry company (Zhejiang Baole)	20,000.00	150,000.00	13.33
5	120.3310	27.6467	2.30	Noodle room	1,500.00	5,000.00	30.00
6	120.3290	27.6469	2.40	Clothing and hardware stores (Shishishi Taisheng)	5,000.00	11,000.00	45.45
7	120.3260	27.6457	2.40	Residential housing	0.00	0.00	0.00
8	120.3260	27.6498	1.40	Belt buckle business	0.00	0.00	0.00
9	120.3260	27.6495	1.50	Residential housing	0.00	0.00	0.00
10	120.3250	27.6494	2.20	Leather industry	0.00	0.00	0.00
11	120.3240	27.6492	1.75	Residential housing	0.00	0.00	0.00
12	120.3230	27.6491	2.80	Residential housing	200.00	2000.00	10.00
13	120.3230	27.6488	3.20	Catholic church (Jiaoentang)	400.00	1,000.00	25.00
14	120.3230	27.6478	2.60	Catholic church (Jiaoentang)	20000.00	108,000.00	18.52
15	120.3230	27.6471	1.90	Housing districts (Shuilong)	0.00	0.00	0.00
16	120.3250	27.6443	2.00	First primary school kindergarten	0.00	0.00	0.00
17	120.3300	27.6453	2.50	Lamps square (Longxin)	4000.00	5000.00	80.00
18	120.3300	27.6450	2.50	Hardware grocery store	10,000.00	10,000.00	100.00
19	120.3290	27.6447	2.25	Tire shop	20,000.00	45,000.00	44.44
20	120.3290	27.6444	2.35	Security doors shop	0.00	0.00	0.00
21	120.3280	27.6441	1.59	Hongyan hotel	0.00	0.00	0.00
22	120.3270	27.6433	2.16	Cabinet shop	10,000.00	18,182.00	55.00
23	120.3270	27.6426	2.15	Motorcycle shop	1,000.00	2,000.00	50.00
24	120.3270	27.6419	2.25	Commodity store	2,500.00	10,000.00	25.00
25	120.3270	27.6419	2.70	Internet bar	25,000.00	262,150.00	9.54

Table 8 continued

Number	Latitude	Longitude	Flood depth (m)	Location description (store name)	Loss (Yuan)	Property value (Yuan)	Loss rate (%)
26	120.3290	27.6421	2.70	Video store	35,000.00	140,000.00	25.00
27	120.3300	27.6428	2.40	Zhengda car repair shop	300,000.00	800,000.00	37.50
28	120.3290	27.6405	2.60	Chinese herbal medicine shop	10,000.00	50,000.00	20.00
29	120.3280	27.6390	2.40	Grocery store	0.00	0.00	0.00
30	120.3270	27.6385	2.15	Tanneries	66,000.00	250,000.00	26.40
31	120.3260	27.6376	2.50	Scrapyards	300.00	1000.00	30.00
32	120.3250	27.6358	2.20	Dry goods store	300.00	1,000.00	30.00
33	120.3240	27.6352	2.40	Waste leather recycling station	2,000.00	2,000.00	100.00
34	120.3220	27.6352	2.70	Fruit shop	0.00	0.00	0.00
35	120.3210	27.6358	3.00	Fruit shop	3,000.00	5,000.00	60.00
36	120.3190	27.6364	3.15	Rice shop	0.00	0.00	0.00
37	120.3190	27.6372	3.35	Store	1,000.00	1,200.00	83.33
38	120.3190	27.6381	3.11	Leather industry	15,000.00	30,000.00	50.00
39	120.3200	27.6389	2.40	Paint shop (Hongbang)	10,000.00	50,000.00	20.00
40	120.3220	27.6396	2.30	Flooring processing room	200.00	200.00	100.00
41	120.3240	27.6411	2.15	Solar water heater store	0.00	0.00	0.00
42	120.3250	27.6424	2.35	Residential area	0.00	0.00	0.00
43	120.3230	27.6429	2.20	Glass business	80,000.00	300,000.00	26.67
44	120.3210	27.6428	2.25	Flower and bonsai shop	1,500.00	2,200.00	68.18
45	120.3190	27.6426	2.50	Home appliance store	0.00	0.00	0.00
46	120.3160	27.6425	3.10	Store	0.00	0.00	0.00
47	120.3140	27.6396	2.30	Factory	5,000.00	6,250.00	80.00

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