Investigation, Evaluation and Countermeasures of Flood Disaster in Rural Grassroots in Plain Area

Guangming He 1, *, Xiangdong Hou 1, Xiangjun Liu 1, Xinshi Wang 1, You Zhang 2, Weilin Wang 3

1 Haihe River, Huaihe River and Xiaoqinghe River Basin Water Conservancy Management and Service Center of Shandong Province, Shandong, China
2 SHUIFA TECHNOLOGY GROUP co., LTD, Shandong, China
3 School of Water Conservancy and Environmental, Jinan University, Jinan, China

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

Abstract. In view of the complex causes of flood disasters at the grass-roots level in the plains and the difficulty of defense, this study proposes a point-to-surface flood disaster survey and evaluation method in the plains: First, the villages in the plains are divided into low-lying villages based on the causes of the disaster. And the villages affected by river floods; secondly, the two types of villages are used as the unit to investigate the basic situation of village flood disasters, starting from the three-level flood control and drainage system of the drainage system in the village, the main drainage canal outside the village, and the middle and small rivers to complete the investigation of the flood disaster; The calculation methods of the village’s critical rainfall index, critical rainfall index and river flood control capacity are put forward to quantitatively assess the village’s flood disaster risk and engineering flood control and drainage capacity; finally, corresponding countermeasures are proposed from the engineering and non-engineering perspectives based on the investigation situation, which is for plain areas. Flood disaster prevention work provides a reference.

1. Introduction
With the long-term impact of global climate change and abnormal phenomena such as El Niño, the frequent flood disaster situation in the plain area has become more and more severe [1-2]. At the same time, the rapid social and economic development in the plain area and the strong population mobility put forward higher requirements for the rural flood control work [3].

Compared with flood disaster in hilly area, flood disasters in plains [4] have the characteristics of dam constraints, water network connectivity, and large human interference factors. The causes of disasters are complex. Therefore, the investigation and evaluation of flood disasters in plains is relatively more difficult.

In 1996, Zou Shanghui [5] applied remote sensing monitoring to the plain flood disaster monitoring, and used the vegetation index method to evaluate the disaster situation and estimate the production reduction of the "1991.07" storm in the Jianghan Plain; Zhang Lei and Xi Zhansheng [6] studied the calculation method of flood depth in the plain enclosed area from the physical cause, generalized the plain enclosed area into a hydrological model, and calculated the flood depth in the enclosed plain area.
using the ratio of design flood to historical typical flood; Xu Wang [7] adopted wavelet analysis, comparative analysis and other methods, The temporal and spatial distribution of flood disasters and the degree of disaster were studied; Liu Yang [8] used disaster frequency analysis method and measured water surface line inverse method to evaluate low-lying villages prone to stagnant water and villages threatened by river flooding, and formulated early warning indicators for rainfall and water level.

In summary, the current investigation and evaluation technology for flood disasters in plain areas is not yet mature, and further standardization and application research are needed [9]. With the development of projects such as the construction of rural grassroots flood control forecasting and early warning systems, it is imminent to establish an investigation and evaluation method suitable for flood disasters in plain areas [10]. This study analyzes the flood disaster risk and influencing factors of villages and regions in plain areas from a systematic perspective, calculates the critical rainfall of villages and regions, and determines their flood control capabilities, which can provide technical support for improving the ability of flood control forecasting and early warning at the grassroots level in rural areas and improving the level of comprehensive flood protection.

2. Technical route for investigation and evaluation of rural grassroots flood disasters

There are many factors influencing flood disasters in the plains, and the disaster-causing factors can be divided into macro and micro aspects. Therefore, this research system investigates and evaluates the flood disasters in the plains from the perspective of villages and regional drainage systems.

(1) Establish a flood disaster survey system in plain areas with villages as units, flood control and drainage system as the main line, from points to areas.

1) Based on the causes of flood disasters in the plains, the villages are divided into low-lying villages and villages threatened by river floods, investigate the basic situation and historical disasters in the village, and count the population and households threatened by floods;

2) Investigate the multi-level flood control and drainage systems such as the drainage system in the village, the main drainage canal outside the village, and the confluence of rivers;

3) Investigate regional hydrological conditions, investigate the distribution of regional wading projects and flood disasters, and analyze the causes of regional flood disasters from a macro perspective.

(2) Based on the results of flood disaster investigations, analyze the characteristics of heavy rain and flood disasters in plain areas, determine their flood control capabilities, divide dangerous areas, and formulate early warning indicators for rainfall and water level (flow).

![Fig. 1 Technical Route for Investigation Evaluation of Flood and Waterlogging Disasters in Rural Areas](image1.png)

![Fig. 2 Judgment curve of critical rainfall for flood disaster](image2.png)
3. Methods for Investigation of Flood Disaster in Plain Areas

3.1. Classification of Flood Type in Plain Area

Based on the causes of flood disaster in villages in the plain area, the flood disaster in the plain area is divided into two categories: low-lying and vulnerable flood, river flood threatening.

(1) Villages affected by low-lying terrain

Villages affected by low-lying terrain refer to the villages where flood and water-logging in the low-lying areas cannot be discharged or flood and water-logging is too much due to the rainstorm.

(2) Villages threatened by river flooding

Villages threatened by river flooding refer to those villages caused by embankment overflowing or pouring of levees such as small and medium-sized rivers and lakes.

(3) Villages threatened by both river flooding and low-lying terrain

The villages threatened by both river flooding and low-lying terrain are defined as comprehensive villages. Under the influence of drainage capacity and drainage time, there is a dynamic transition between water-logging and river flooding.

3.2. Basic Information Survey

The process of "in-house investigation in general, on-the-spot investigation in detail," is adopted to carry out flood disaster investigation on villages.

(1) In-house Investigation

First of all, based on the image map for rough search, the area may be affected by the preliminary delineation; Secondly, the occurrence of historical flood disasters in villages, population affected by disaster and households in villages, and the reservoir and river systems involved in the disaster were investigated in detail; the person in charge of flood control in the village needs to be investigated; taking the hydrological division or county administrative division as the unit, the basic data of Hydrometeorology are collected and sorted out, focusing on the collection of rainstorm data and statistical parameters (mean value $X$, coefficient of variation $Cv$, $Cs/Cv$).

(2) On-the-spot Investigation

The key villages were investigated in depth, the threat of flood disaster was investigated on the spot, and the historical flood disaster risk areas and population distribution were investigated.

1) Investigation of Historical Mountain Flood Disaster

The historical flood and water-logging disasters of villages were investigated, including disaster type, time, rain situation, drainage situation, and the affected population in the inundated area, and the historical maximum flood level was determined by the flood mark.

2) Hazardous Investigation

①Demarcated risk area: For villages affected by low-lying terrain, the altitude of houses in the villages was measured to preliminarily determine the scope of water accumulation, and the dangerous areas were identified with the historical flood disasters. In view of the villages threatened by river flooding, the altitude of houses along the river was measured to preliminarily determine the flooded path and range after the flood overflowing and breach, and the dangerous areas were identified by the historical flood disaster situation.;

②On the basis of demarcating the dangerous area, the disaster prevention objects such as the residents in the dangerous area, enterprises and public institutions were investigated, and their spatial location information was measured;

③Investigation of the evacuation route and resettlement site of residents in the dangerous area in case of flood disaster;

④Based on the investigation results, the population distribution map of flood hazard area was drawn.

3.3. Investigation of Flood control and drainage system

For villages affected by low-lying terrain, track the confluence path of water-logging water, and investigate drainage ditches and holding ponds in villages, as well as main and branch canals at all levels.
outside villages, to determine the drainage capacity of villages. In view of the villages threatened by river flooding, the middle and small rivers near the threatened villages were investigated, and the design standards of embankment, slope protection and the current flood control capacity were investigated.

(1) Investigation of Drainage System in the Village

The investigators identified the sources of flood water in villages affected by low-lying terrain, delineated the main watershed areas and drainage channels in the villages, investigated the distribution of existing drainage ditches and holding ponds in the villages, and measured the ditches and holding ponds to assess their drainage capacity and storage capacity.

(2) Investigation of Main and Branch Canals at All Levels outside Villages

Taking the key low-lying water-logging villages as the unit, this study tracked the flow path and rivers of the water-logging water outside the village, investigated the flow direction and distribution of the multi-stage main canals outside the village, and measured the cross section of the main canal to calculate its drainage capacity.

(3) Investigation on Flood Control and Drainage of Middle and Small Rivers

The study investigated the relevant middle and small rivers in the region, including planning flood control and drainage standards, design water level of river course, river embankment and other engineering conditions; investigated whether there are dangerous sections, channel deposition, bayonet and other problems; in this study, we take control section and cross section of a typical river to measure quantitatively calculate its flood control and drainage capacity based on the survey results.

3.4. Investigation Index System in Plain Area

Tab. 1 Index system of flood and waterlogging disaster investigation in plain area

| Classification                  | Index layer          | Unit   | Indicators show                                      |
|---------------------------------|----------------------|--------|-----------------------------------------------------|
| Disaster causing factors        | 6 hours of rainfall; | mm     | Statistics of typical rainfall periods              |
| (hydrological and meteorological elements) | 24-hour rainfall      | mm     |                                                     |
|                                  | 3 days of rainfall   | mm     |                                                     |
|                                  | Average flood rise   | h      | Reflect flood characteristics                       |
|                                  | Historical flood     | /      |                                                     |
|                                  | frequency            |        |                                                     |
| Vulnerability (hazardous areas) | Regional composite  | /      | Assessment of waterlogged or riverine topography    |
|                                  | topographic index    |        |                                                     |
|                                  | Village population   | person |                                                     |
|                                  | Population at risk   | person |                                                     |
|                                  | Distance from village| m      |                                                     |
|                                  | to river             |        |                                                     |
|                                  | Distance from village| h      |                                                     |
|                                  | to river             |        |                                                     |
|                                  | Economic level       | /      | Available GDP or per capita income indicators       |
| Response capacity (flood control and drainage system) | Drainage ditch and pond drainage capacity | / | Evaluate the relative value of drainage capacity, including the distribution of drainage system, whether there are drainage blind areas. |
|                                  | Drainage capacity at | /      | Assessment of the relative value of drainage capacity, including distribution of main drains, drainage levels and discharge, and whether it is affected by external river top supports. |
|                                  | all levels outside   |        |                                                     |
|                                  | the village          |        |                                                     |
|                                  | Flood discharge      | /      | Assessment of design flood discharge capacity of small and medium-sized rivers, including drainage criteria, current status of the river and whether it is affected by downstream top support. |
|                                  | capacity into small and medium rivers |        |                                                     |
|                                  | Flood Control Capacity| /      | Assess the flood discharge capacity of small and medium-sized rivers, including design criteria, whether they are affected downstream, and whether there are hazardous sections. |
|                                  | of Small and Medium Rivers |        |                                                     |
|                                  | Flood Control Capacity| /      | Whether the water conservancy project is complete, and whether the operation is intact. |
|                                  | of Small and Medium Rivers |        |                                                     |
Based on the investigation results of flood disasters, the representative indicators are selected to establish the investigation index system combining point with area in plain area, and classified according to disaster-inducing factors, vulnerability of disaster bearing body and emergency response capacity, as shown in Table 1.

4. Analysis and Evaluation Method and Application of Flood and Waterlogging Disasters in Plain Rural Areas

The main task of the analysis and evaluation of the rural grassroots level in the plain area is to find out the characteristics of the regional rainstorm and flood, determine the current flood control capacity of the village, and determine the rainfall early warning indicators and water level early warning indicators.

4.1. Early warning rainfall calculation

Critical rainfall means that when rainfall reaches or exceeds a certain magnitude and intensity within a certain period of time in an area (or a disaster prevention object), the area will have flood disasters. The rainfall at this time is called the regional critical rainfall.

(1) Frequency analysis of disasters

According to the "Water Conservancy and Hydropower Engineering Design Flood Calculation Manual" (SL44-93) requirements, design storm rainfall calculations for river basins or regions. Based on the survey results, analyze the frequency of flood disasters, assume that disasters and rainfall have the same frequency, and take the same rainfall design value as the initial value of the critical rainfall.

(2) Disaster Case Investigation Method

Collect 2~3 typical historical flood disasters, count the rainfall in different periods of each disaster, analyze the corresponding period of rainfall before the disaster occurs and the regular rainfall interval of the process, and determine the historical rainfall period caused by the flood. The minimum rainfall in each period and process of typical disaster rainfall is regarded as the initial value of critical rainfall.

(3) Critical rainfall determination curve method

Based on multi-year rainfall data, sliding statistical time period rainfall, and calculating the previous impact rainfall at the same time, constructing the flood disaster characteristic period rainfall and previous impact rainfall status space, draw a scatter diagram of the rainfall in the previous period and the rainfall in the period, and use the pattern recognition algorithm to establish a critical relationship model between the rainfall in the period and the rainfall in the early period, identify the relationship between rainfall in different periods of flood disaster occurrence and previous impact rainfall, and calculate the critical rainfall early warning index according to the equation, as shown in Figure 2.

4.2. Early warning water level calculation

Critical water level refers to the water level of the threatening river in or outside the village where flood disaster occurs, and can be used as a key indicator of flood disaster prevention.

(1) Outer flood threatens the critical water level of the village

For single or multiple external flood threatened villages, a certain hydrological section in the upper reaches of the river affected by it can be selected as the early warning section, based on the hydraulic model to establish a quantitative hydraulic relationship between the water level of the upstream section and the inundation information of the threatening village, and according to the inundation water level of the village, reverse the warning water level at the upstream section.

(2) Low-lying and prone to waterlogging threatened village early warning water level

Based on the early warning water level in the village, the early warning section can be selected in the upstream of the regional backbone drainage river/main canal to quantitatively evaluate the drainage path and drainage capacity of the village inside and outside the village; and analyze its restrictive factors; Based on the analysis and evaluation results, the correlation analysis method or hydraulic method is used to establish the relationship between the village inundation information and the water level of the regional drainage river, and determine the early warning water level of the regional drainage river.
4.3. Flood prevention capacity calculation
(1) Low-lying and flood-prone village
Regarding the flood disaster event as a random event, based on years of flood disaster survey data, the flood disasters are evaluated and graded, the frequency of flood disasters is calculated, and the changes in the drainage system of the villages along the river are considered to comprehensively determine the flood control capacity.

Determine the number of flood disasters \( n \) occurred in \( m \) years in the survey object's history through on-site investigations and access data, analyze and calculate the frequency of flood disasters:

\[
P = \frac{n}{m + 1}
\]

In the formula: \( P \): frequency; \( n \): the number of floods; \( m \): statistical years.

(2) Outer flood threatens the village
Based on the flood control planning and design data of small and medium rivers adjacent to the villages threatened by external floods, combined with historical flood disaster investigations, the weak points of the river's embankment and shoreline were determined. In addition, the bridges, overflow bridges, and barrages in the river section were investigated to comprehensively determine the impact of external floods on the flood control capacity of the villages.

4.4. Analysis and evaluation results
Based on the analysis and calculation results of early warning indicators and flood control capabilities, regional early warning indicators and flood control and drainage capabilities are determined.

Comprehensive warning indicators
Based on the results of village early warning indicators, statistical analysis of regional critical rainfall:

\[
R_{\text{imin}} = \min(R_i), i = 1, 2, \ldots, S
\]

\[
R_{\text{imax}} = \max(R_i), i = 1, 2, \ldots, S
\]

Where \( R_i \) — The critical rainfall value of the \( i \)-th village; \( R_{\text{imin}} \) — Minimum critical rainfall value; \( R_{\text{imax}} \) — Maximum critical rainfall value. When the rainfall in a region exceeds \( R_{\text{imin}} \), floods may occur in the region. When there is an area where the rainfall exceeds \( R_{\text{imax}} \), floods may occur in the area, and when it exceeds, there will be large-scale floods in the area. When there is an area where the rainfall exceeds, floods may occur in the area, and when it exceeds, there will be large-scale floods in the area. Therefore, as long as the rainfall is in the range of \( (R_{\text{imin}} \sim R_{\text{imax}}) \), there is a high probability of flooding in the area.

(2) Comprehensive flood control capability analysis
The regional flood control and drainage system is a continuous and complete system, and its flood control and drainage capability depends on the weakest link.

\[
C = C_{\text{imin}} = \min(C_i), i = 1, 2, \ldots, S
\]

Where \( C_i \) — Flood control capability of the \( i \)-th node, \( C_{\text{imin}} \) — Minimum flood protection capacity, \( C \) — Flood control capacity value.

4.5. Investigation and Evaluation Practice
Based on the flood disaster investigation and evaluation method in plain areas combined with point and surface, the flood disaster investigation and evaluation practice was carried out. Danbei Village and Zhaibu Village were selected as typical villages. The analysis is as follows:

(1) Villages affected by river floods and low-lying terrain
Danbei Village is affiliated to Gaoji Town, Dong'e County, with 972 people. The terrain is high in the south and low in the north. The central river is located in the east of the village. The design flood control standard is once in 20 years.

On August 9, 2010, there was a long period of rain. On the one hand, the low-lying area in the village was heavily waterlogged; on the other hand, the village's flooded water could not be discharged into the central river, and the central river poured back into the northern drainage ditch, causing disasters in the east of the village. The danger zone is shown in the figure.

1) Flood control capacity: Based on field surveys and historical flood disaster statistics, combined with the experience and suggestions of local water conservancy staff, the village’s flood control capacity is determined to be once every eight years;

2) Critical rainfall index: Using the typical historical flood disaster analysis method, combined with local experience, it is determined that the 12h rainfall warning index in Danbei Village is 146mm and the 24-hour rainfall index is 180mm.

3) Critical water level index: Taking Liuwentian Hydrological Station upstream of the Central River as the control section, considering the hydraulic connection between Liuwentian Station and Danbei Village, the critical water level is calculated as 31.1m using hydraulic methods.

Villages affected by low-lying terrain

Zhaibu belongs to Weiji Town, Huimin County. The terrain in the village is high in the south and low in the north. The total population of the village is about 350. The overall terrain of the village is basin-shaped, and the village relies on road drainage. When heavy rains are encountered, parts of the west of the village are affected.

In the 68 years since 1949-2017, there have been 42 floods in Zhaibu. Among them, from August 10 to 11, 2019, affected by the "Lichma" typhoon, two households experienced water leakage in their houses and cracks in the retaining walls in the courtyard. The road area in the village was 0.3m.

Flood control capacity: Based on historical flood disaster statistics, frequency analysis is used to determine the village's flood control capacity as once every two years;

2) Critical rainfall index: Using the critical rainfall determination curve method, combined with flood control experience, the rainfall index value of Zhaibu is determined. The 12-hour critical rainfall is 100mm and the 24-hour critical rainfall is 140mm.

5. Conclusions and recommendations

(1) This paper uses plain villages as the survey and evaluation unit, and proposes a point-to-surface flood disaster survey and evaluation method in the plain; proposes a flood disaster early warning rainfall and water level calculation method, comprehensively determines the flood control capacity of the village, and proposes the plain A comprehensive method for regional analysis and evaluation results, and practiced with Danbei Village and Zhaibu Village as examples. The results show that the method is reasonable, the survey and evaluation results are basically reasonable, and it can reflect the regional flood disaster situation.
(2) The influencing factors of rural grass-roots flood disasters are complex. Although this study proposes a variety of critical rainfall and critical water level calculation methods, it is still necessary to use big data analysis methods to continuously improve the preliminary rainfall and water level indicators based on actual conditions. Better guide local flood disaster prevention and control work.

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