2025_“ShuWei Cup”

Problem C：Urban Seawater Intrusion Risk Assessment and Governance Planning

(I) Background

In recent years, extreme weather events have struck frequently, with natural disasters occurring repeatedly and exerting far-reaching impacts worldwide. From October to December 2024, many coastal areas in China encountered a rare seawater intrusion crisis: cities including Panjin, Yingkou, and Dalian in Liaoning Province experienced the most severe extreme inundation events in nearly half a century. Tianjin, Ningbo in Zhejiang Province, Shenzhen and Huizhou in Guangdong Province, and Beihai in Guangxi Zhuang Autonomous Region also suffered heavy losses. Coastal regions in Shandong and Fujian Provinces also saw seawater intrusion to varying degrees, seriously threatening the life and property safety of coastal residents, the stability of the ecological environment, and the sustainable economic development, as shown in Figure 1.

Figure 1 Actual Scenes of Seawater Intrusion

Sources: Douyin accounts - China Business Journal, Exploring the World, Yubao Military News, Nuanyi Xiaomei Theater

Seawater intrusion refers to the phenomenon where seawater invades inland rivers, lakes, or groundwater through natural or anthropogenic factors. It is common in low-lying coastal areas or estuarine regions. In recent years, rising sea levels and the impacts of extreme tides or storm surges have led to water levels higher than those in coastal areas [1]. Additionally, excessive groundwater extraction by humans has caused a tendency of land subsidence, increasing the risk of seawater intrusion.

An in-depth exploration of the causes, mechanism of action, and extensive impacts of seawater intrusion enables more accurate prediction and assessment of potential risks. It provides a solid scientific basis for urban planning and disaster management systems [2-3]. The intensification of seawater intrusion is mainly attributed to multiple factors, including sea-level rise caused by global warming, frequent extreme tides and storm surges, and land subsidence resulting from excessive human groundwater extraction. In-depth research on the formation mechanism, risk assessment, and governance strategies of seawater intrusion is not only an urgent need to address current disaster challenges. It is also a key measure to ensure the ecological security of coastal cities, optimize urban planning, and build sustainable development systems. Through precise modeling and analysis, it can provide scientific support for disaster early warning, risk prevention and control, and governance planning, minimizing disaster losses. This research holds important practical significance and strategic value.

(II) Specific Problems

Problem 1: Analysis of the Causes of Seawater Intrusion

Please use Datasets 1 and 2 to predict the future sea level heights in the coastal areas of various cities. Combine the Appendix Video and Datasets 3 – 7 to establish a mathematical model, analyze the causes of seawater intrusion, determine the critical inundation point (the threshold causing a certain level of economic losses) for each coastal city, and further assess the probability of seawater intrusion occurring in each typical coastal city over the next 10 years.

Problem 2: Losses from Seawater Intrusion in Various Cities

Seawater intrusion not only threatens the life safety of residents in coastal cities but also causes significant economic losses. In the short term, the operations of service industries such as catering, accommodation, tourism, and retail will be directly affected, and the life and property safety of residents in disaster-stricken areas will face severe challenges. In the long run, the problem of soil salinization caused by seawater intrusion will become increasingly serious [4], leading to crop yield reduction, ecosystem damage, and impacting the sustainable development of cities. Please, from both short-term and long-term perspectives, combined with the risks posed by seawater intrusion and with reference to Datasets 6–9, conduct a comprehensive assessment of the losses caused by seawater intrusion in each city to formulate more targeted response strategies.

Problem 3: Comprehensive Urban Risk Grading Based on Causes and Loss Assessment

Constructing a comprehensive risk grading and early warning system for urban seawater intrusion is an important measure to address complex environmental disasters and ensure urban safety. On the basis of fully considering the risk of urban seawater intrusion, the system integrates the degree of disaster losses in different cities, aiming to effectively respond to the dual uncertainties brought by climate change and human activities. Please build a comprehensive risk evaluation model based on the inundation risk and seawater intrusion losses of each city, conduct risk grading for the seawater intrusion disaster risk of each city, and provide strong support for subsequent disaster prevention and mitigation work.

Problem 4: Construction of Seawater Intrusion Prevention Dykes — Taking the City with the Highest Risk Level as an Example

Cities at risk of seawater intrusion inundation will suffer huge economic losses if the scale of seawater intrusion expands in the future. According to the topography along the urban coast, reasonable planning of dyke construction will prevent seawater intrusion at the lowest cost. Please, based on the city with the highest risk level selected in Problem 3, use information such as the distribution of its various

infrastructure facilities and the regional information of urban inundation risk, and considering the cost of dyke construction [5], reasonably plan the construction of urban waterproof dykes.

Problem 5: Future Urban Construction for Seawater Intrusion Prevention — Taking the City with the Highest Risk Level as an Example

When the scale of seawater intrusion reaches a certain level and the urban disaster-stricken area is large, relying solely on dyke construction will be difficult to meet the protection needs and will be costly. At this time, planning future urban construction and relocation plans becomes a more feasible option. Please take the city with the highest risk level as an example, use information such as the distribution of its various infrastructure facilities, the distribution of urban cultivated land area, and urban elevation data, combined with relevant literature, to establish a mathematical model and determine the inundation threshold for urban relocation. Comprehensively consider economic costs, social impacts (resettlement of residents and employment security), and ecological protection (cultivated land protection and wetland restoration) to plan the relocation plan of urban functional areas (such as the spatial reconstruction of residential areas, industrial areas, and agricultural areas); put forward disaster prevention optimization suggestions for future urban construction (such as raising ground elevation, constructing sponge city facilities, and optimizing water conservancy systems, etc.).

References

[1]. DE DOMINICIS M, WOLF J, JEVREJEVA S, et al. Future Interactions Between Sea Level Rise, Tides, and Storm Surges in the World's Largest Urban Area[J/OL]. Geophysical Research Letters, 2020, 47(4): e2020GL087002.

[2]. Fu Cifu, Yu Fujiang, Dong Jianxi, et al. Cause Analysis of Seawater Intrusion Events Along the Coasts of the Bohai Sea and the Yellow Sea in October 2024 Based on Numerical Simulation[J]. Marine Forecasts, 2025, 42(01): 1-10.

[3]. Wang Hui, Shi Suixiang, Li Wenshan, et al. Analysis of the Frequent Occurrence of Seawater Intrusion Events Under the Background of Sea Level Rise—A Case

Study of the High-Tide Flood Event Along the Coast North of the Yangtze River in October 2024[J]. Climate Change Research, 2025: 0.

[4]. Zhang Dongming, Zhang Wen, Zheng Daojun, et al. Spatial Variability Characteristics of Soil Salinity in Farmland Affected by Seawater Intrusion[J]. Soils, 2016, 48(3): 621-626.

[5]. Petheram C, McMahon T A. Dams, dam costs and damnable cost overruns[J]. Journal of Hydrology X, 2019, 3: 100026.

Appendix

Note: When citing data, please adhere strictly to the official format specifications of the source web pages and relevant documents.

Video 1

Sources: WeChat Channels - Huihuang Suiyue 235, Changjiang Cloud News, Zhongqi Ai Zenme Shuo, Feiyang Shipin, Xiaoxiang Morning News, Hubei Daily, Laowang Xianhua, Mr. Mocha's Coffee, Fei Yao Shuo

Dataset 1: Average Sea Level Data

(https://mds.nmdis.org.cn/pages/dataViewDetail.html?type=1&did=&dataSetId=5)

Dataset 2: Storm/Extreme Tide Water Level Increase

(https://www.nmdis.org.cn/hygb/zghyzhgb/)

Dataset 3: Land Subsidence Volume

(https://data.tpdc.ac.cn/zh-hans/data/4dd29727-dda6-4e15-8903-0efe94b489dd)

Dataset 4: Permeability Coefficient

Dataset 5: Soil Type Data of Each City

Dataset 6: SHP Data of Each City's Outline

Dataset 7: DEM of Each City

Dataset 8: Infrastructure Data of Each City

Dataset 9: Land Type Data of Each City