@EarthSurfS

Characterizing the dominant conditioning factors of urban waterlogging in highly urbanized coastal cities

Qifei Zhang[1], Zhifeng Wu[2], Hui Zhang[3], Giancarlo Dalla Fontana[1], Paolo Tarolli[1]

[1] University of Padova, Dept. of Land, Environment, Agriculture and Forestry, University of Padova, Agripolis, 35020 Legnaro (PD), Italy

[2] Guangzhou University, School of Geographical Sciences, Guangzhou University, 510006 Guangzhou (Guangdong), China

[3] North China University of Water Resources and Electric Power, School of Surveying and Geo-informatics, 450046 Zhengzhou (Henan), China

EGU General Assembly 2020

Online | 4–8 May 2020

EGU2020-3682

https://doi.org/10.5194/egusphere-egu2020-3682

Abstract

Urban waterlogging disasters are affected by natural conditions and human activities. Few, however, have comprehensively revealed the relative contributions of the natural and anthropogenic factors to urban waterlogging concerning different scales of analysis. To overcome this limitation, a novel method that integrates the stepwise regression model with hierarchical partitioning analysis is presented. The purpose is to investigate the complex mechanism of urban waterlogging by identifying the relative contribution of each natural and anthropogenic factor and the stability linking waterlogging to influencing factors at multiple scales of analysis (i.e. 1 km, 2 km, 3 km, 4 km, and 5 km). We consider waterlogging events in the central urban districts of Guangzhou (PR China) from 2009 to 2015 as a case study. The results show that the spatial distribution of waterlogging events in the central urban area presents a strong agglomeration pattern. Under all analysis scales, we find that the percent cover of urban green spaces (44.74%), percent cover of residential area (41.03%) and slope.std (36.85%) have a dominant contribution to urban waterlogging. This suggests that the importance of land cover composition in determining urban waterlogging. This result also confirms that holding the proportion of land cover features constant, the urban micro-topography also affects waterlogging magnitude effectively. However, the relative contribution and dominant factor of waterlogging varied noticeably among different analysis scales, which presents a strong scale effect. Under a small analysis scale, the influence of topography factors (slope.std and relative elevation) on waterlogging magnitude is greater than other factors; however, with the increase of analysis scale, the contribution of topographic factors gradually declines, while the land cover composition (green space, residence area, grassland) and land cover spatial configuration (LPI, AI, Cohesion index) become the dominant factors.

Introduction

Urban waterlogging is a stagnant water disaster occurring in the urban area, which mainly refers to the phenomenon that short-term heavy rainstorms or continuous precipitation exceed the drainage capacity of a city (Yin et al., 2011; Hammond et al., 2015; Xue et al., 2016). Urban waterlogging is a complex phenomenon, which is the result of the joint action of natural conditions and human activities. However, which is the dominant conditioning factors of urban waterlogging? Does the influencing factor have different effects under different analysis scales? Which is the appropriate analysis scale for urban waterlogging studies? Answering these questions is vital for expanding our scientific understanding of the linkage between urban waterlogging and its natural and anthropogenic influencing factors.

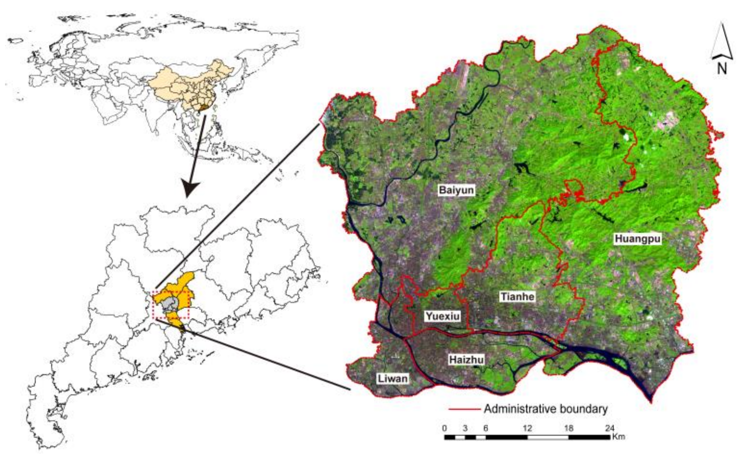

Fig.1 The geographic location of Guangzhou Central Urban Districts

Research Objectives

The aim of this research is to investigate the complex mechanism of urban waterlogging by identifying the relative contribution of each influencing factor and the stability linking waterlogging to influencing factors at multiple analysis scales.

Methodologies

- The influencing factors were categorized as four dimensions: urban topography, land cover characteristics (composition and spatial configuration), urban drainage facilities, and urban morphology.
- The kernel density and the Anselin Local Moran's I were utilized to explore the spatial pattern of urban waterlogging events.
- The Pearson correlation was firstly used to reveal the binary correlation of each factor across all analysis scales.
- The stepwise regression model was used to avoid the multicollinearity problem and confirmed the significant explanatory variables that retain from the model.
- The hierarchical partitioning method was utilized to clarify which factor had the dominant effect on waterlogging, which investigated the relative contributions of each factor for the entire hierarchy of models using all combinations of variables that retained from the stepwise regression model.

Results & Analysis

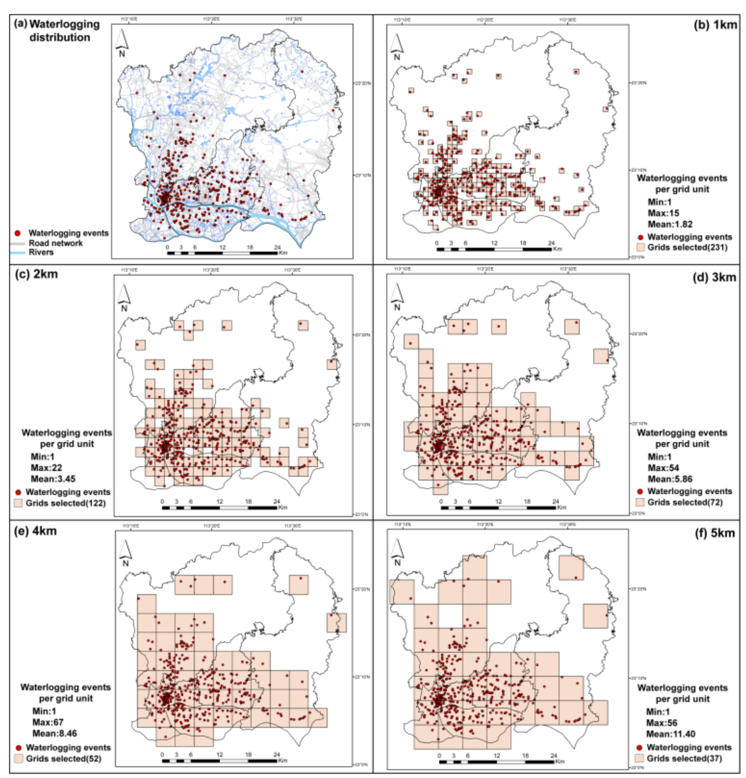

Fig.2 The spatial distribution of urban waterlogging events (a) and five different grid scales of 1 km, 2 km, 3 km, 4 km, and 5 km (b~f)

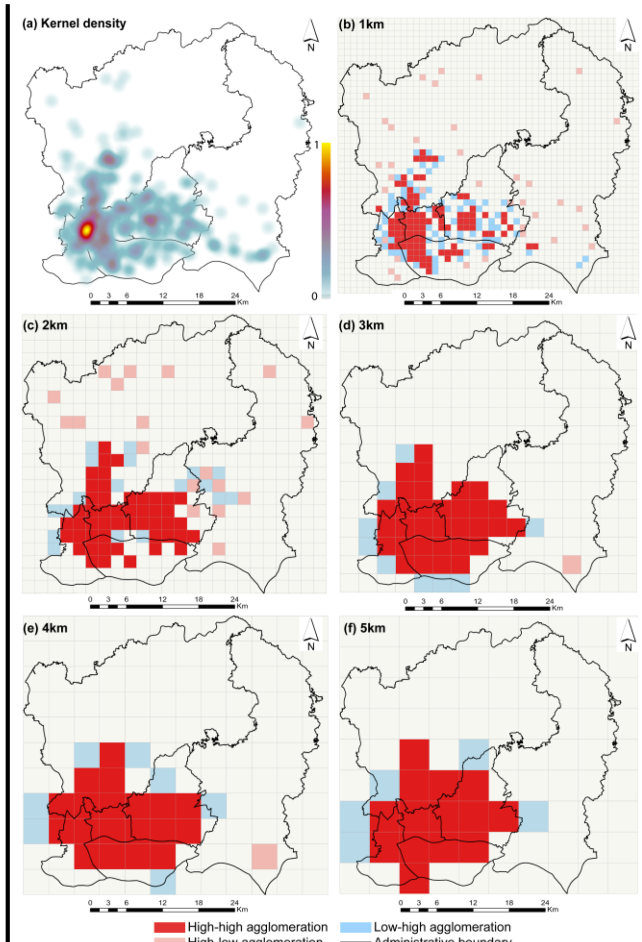

Fig.3 The kernel density of urban waterlogging events (a) and the spatial agglomeration map across different analysis scales (b~f)

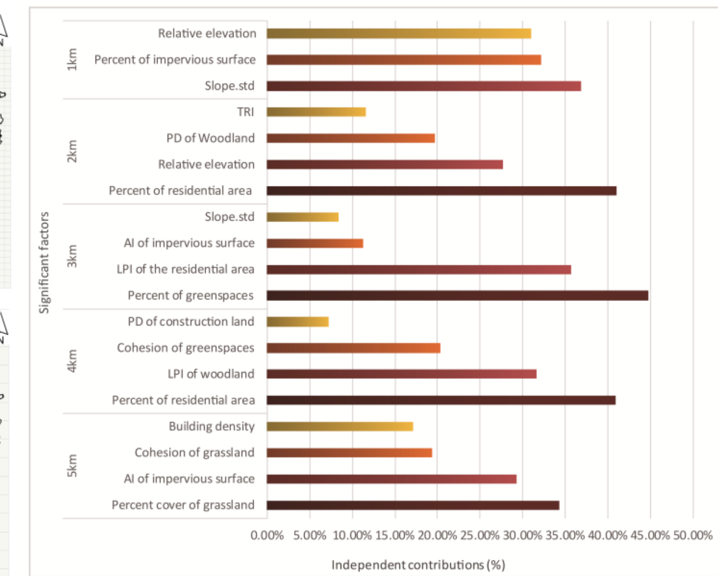

Fig.4 The relative contributions of significant factors affecting urban waterlogging across five analysis scales

Table 1 Stepwise regression results for influencing factors

Analysis Scales	Significant explanatory variables	Adj R^2	F	Sig
1 km	Slope.std, relative elevation (RE) and percent cover of impervious surface	0.319	21.273	0.000
2 km	Relative elevation, TRI, the percent cover of residential area and PD of woodland	0.560	19.423	0.000
3 km	Slope.std, percent cover of green spaces, LPI of the residential area, and AI of impervious surface	0.772	14.481	0.000
4 km	Percent of residential area, LPI of woodland, PD of construction land, and cohesion of urban green spaces	0.680	16.853	0.000
5 km	Percent cover of grassland, AI of impervious surface, cohesion of grassland, and building density	0.609	24.139	0.000

References

- M.J. Hammond, A.S. Chen, S. Djordjević, D. Butler & O. Mark (2015) Urban flood impact assessment: A state-of-the-art review, Urban Water Journal, 12:1, 14-29, DOI: 10.1080/1573062X.2013.857421.
- Xue F., Huang M., Wang W., & Zou L. (2016). Numerical simulation of urban waterlogging based on flood area model. Advances in Meteorology, 2016, 1-9. DOI:10.1155/2016/3940707.
- Yin, Z., Yin, J., Xu, S., & Wen, J. (2011). Community-based scenario modelling and disaster risk assessment of urban rainstorm waterlogging. Journal of Geographical Sciences, 21(2), 274–284. DOI:.10.1007/s11442-011-0844-7.

Final Remarks

- The urban waterlogging hot spots in Guangzhou are mainly concentrated in the historical urban areas of Guangzhou (Liwan, Yuexiu, Haizhu district), presenting a single-core aggregation pattern.
- The percent cover of urban green spaces (44.74%), percent cover of residential area (41.03%) and slope.std (36.85%), have a dominant influence on the urban waterlogging magnitude in all analysis scales.
- Not only does the composition of land cover features significantly affect the magnitude of urban waterlogging, but so does the configuration of those features.
- The optimal analysis scale for urban waterlogging study should be determined by the characteristics of study areas, due to changing dominant factors in various scales.