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UNIVERSITÀ DEGLI STUDI DI PADOVA

A new approach to investigating the spatially heterogeneous driving forces of urban waterlogging

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Outline

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Research organization

Research organization

Background and justification

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 the city.



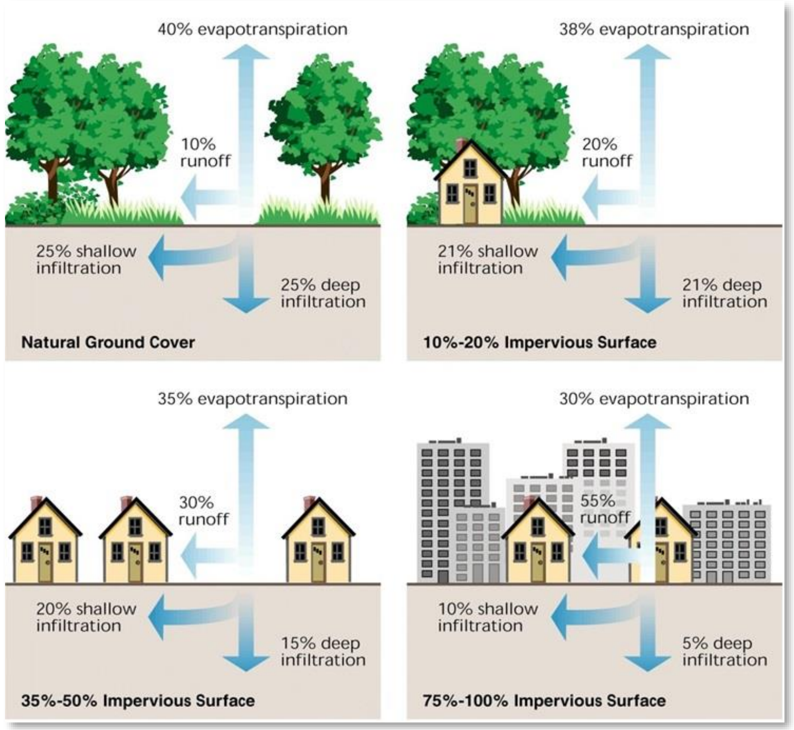

Research organization

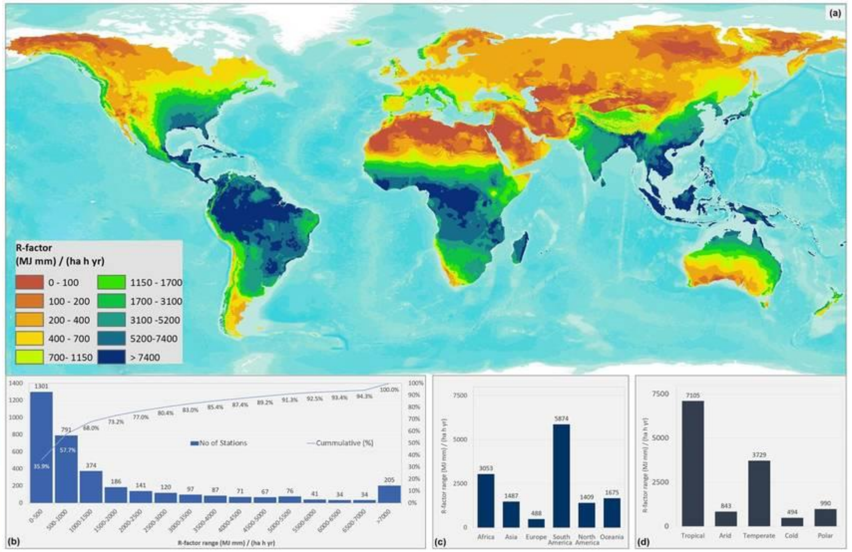
Background and justification

◆ Causes of urban waterlogging

- Meteorological conditions — **Environmental factor**
- Topographic conditions
- Land cover features
- Drainage facilities

(Topographic conditions, Land cover features, Drainage facilities) — **Anthropogenic factor**





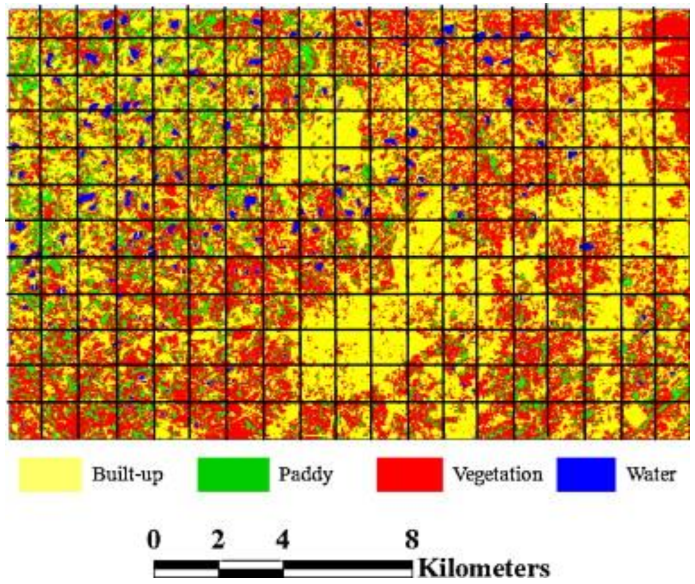
Research organization

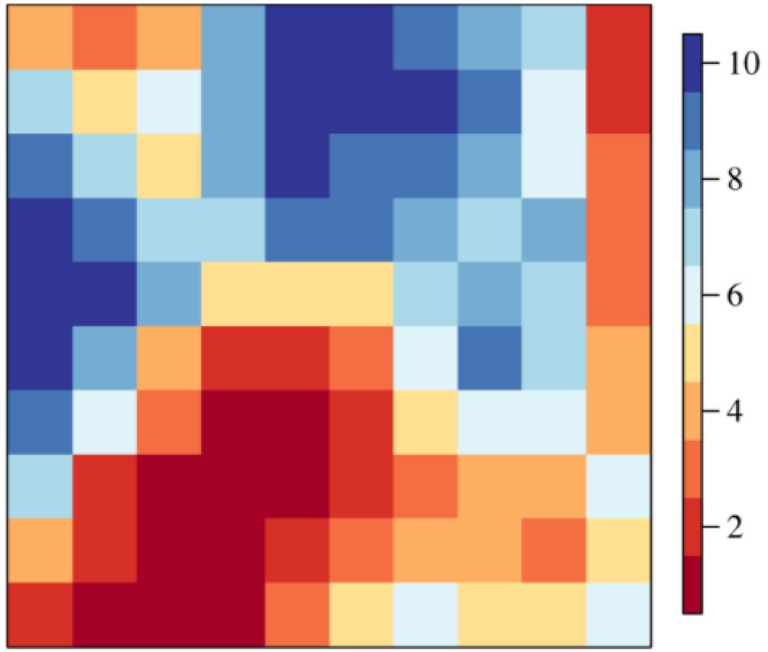
Research questions and objectives

◆ Site-specific urban waterlogging mechanism

In highly urbanized areas, the distribution of urban landscape elements (*DEM, land cover features, drainage facilities*) and their functional attributes are characterized by **spatial heterogeneous** and **dynamic**.

- The **relationship** between landscape elements and urban waterlogging may vary with different spatial locations, which is known as **spatial non-stationarity**.
- It hints that the **driving factors** or the **mechanism** of urban waterlogging may **vary with the change of spatial location**.
- Limited local authorities from developing more **site-specific** urban waterlogging mitigation strategies for **different local conditions**.





Research organization

Research questions and objectives

<u>Zhang, Q.</u>, Wu, Z., Guo, G., & Tarolli, P. (2022). A new approach to investigating the spatially heterogeneous driving forces of urban waterlogging. *Under review*. **[Q1]**

11 SUSTAINABLE CITIES AND COMMUNITIES

Target 11 Sustainable cities and communities

13 CLIMATE ACTION

Target 13 Climate action

Hence, the specific objectives are as follows:

1. developed a **new method** to investigate the **spatial non-stationarity** effects of landscape elements on urban waterlogging;
2. **spatially quantify** the urban waterlogging **driving forces**;
3. identify the **waterlogging dominant factors**, consequently, facilitate the implementation of more **targeted and effective mitigation strategies**.

Research methodology

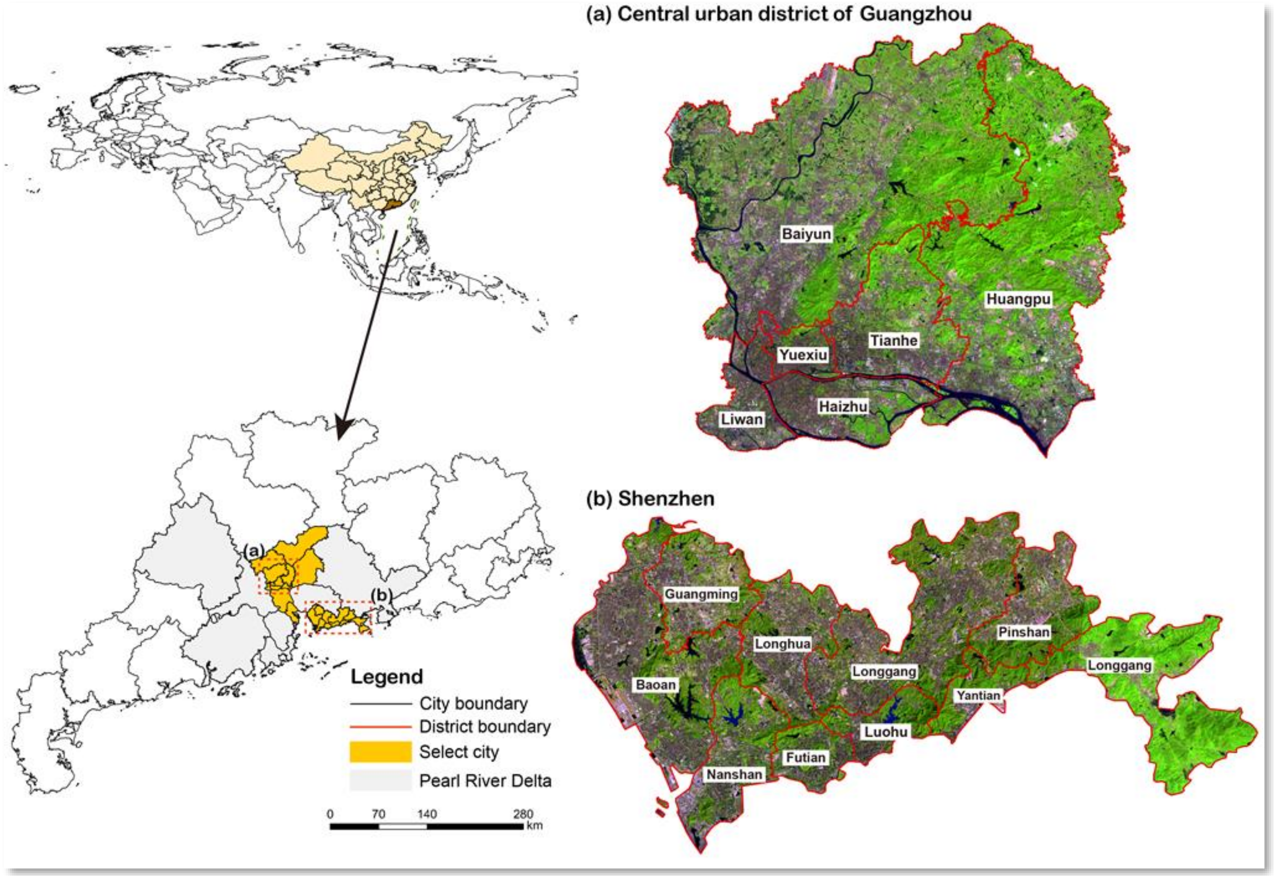
CHAPTER 3

3.2 Study area

- Two major metropolitan coastal cities in the **Guangdong-Hong Kong-Macao Greater Bay Metropolitan Region**, **Guangzhou and Shenzhen cities**, were selected for this study.

- The two cities are among the four **national cities** in mainland China, with a *permanent resident population* of *15.31 million* (Guangzhou) and *13.44 million* (Shenzhen) respectively in 2019, which account for 47% of Guangdong's GDP in 2019 *($756 billion*).

- The local climate of Guangzhou and Shenzhen are classified as a **subtropical monsoon climate**. The average annual precipitation is 1720.6 mm and 1933.3 mm, respectively.



The location of the Guangzhou central urban districts and Shenzhen city

CHAPTER 3

3.3 Methodology (1/2)

- Environmental and anthropogenic factors

This study selects **environmental factors** (*urban topography, precipitation*) and **anthropogenic factors** (*land cover characteristics, urban drainage facilities*) as waterlogging potential explanatory factors.

Environmental Factors

- Elevation (**DEM**), the *standard deviation* of elevation (**DEM.std**), slope, the *standard deviation* of slope (**Slope.std**), and the proportion of urban lowland (**Dep**) were selected to represent **topographic features**.
- The average accumulated precipitation (**Pre**) was used to illustrate the spatial distribution pattern of **precipitation** during the period.

Anthropogenic Factors

- The *area proportion* of impervious surface (**ISA**) and urban green infrastructure (**UGI**) in each watershed unit.
- The normalized differential vegetation index (**NDVI**) to describe the biophysical parameters of green areas.
- The linear density of the drainage network (**DD**) of each watershed unit was extracted as the anthropogenic factors.

CHAPTER 3

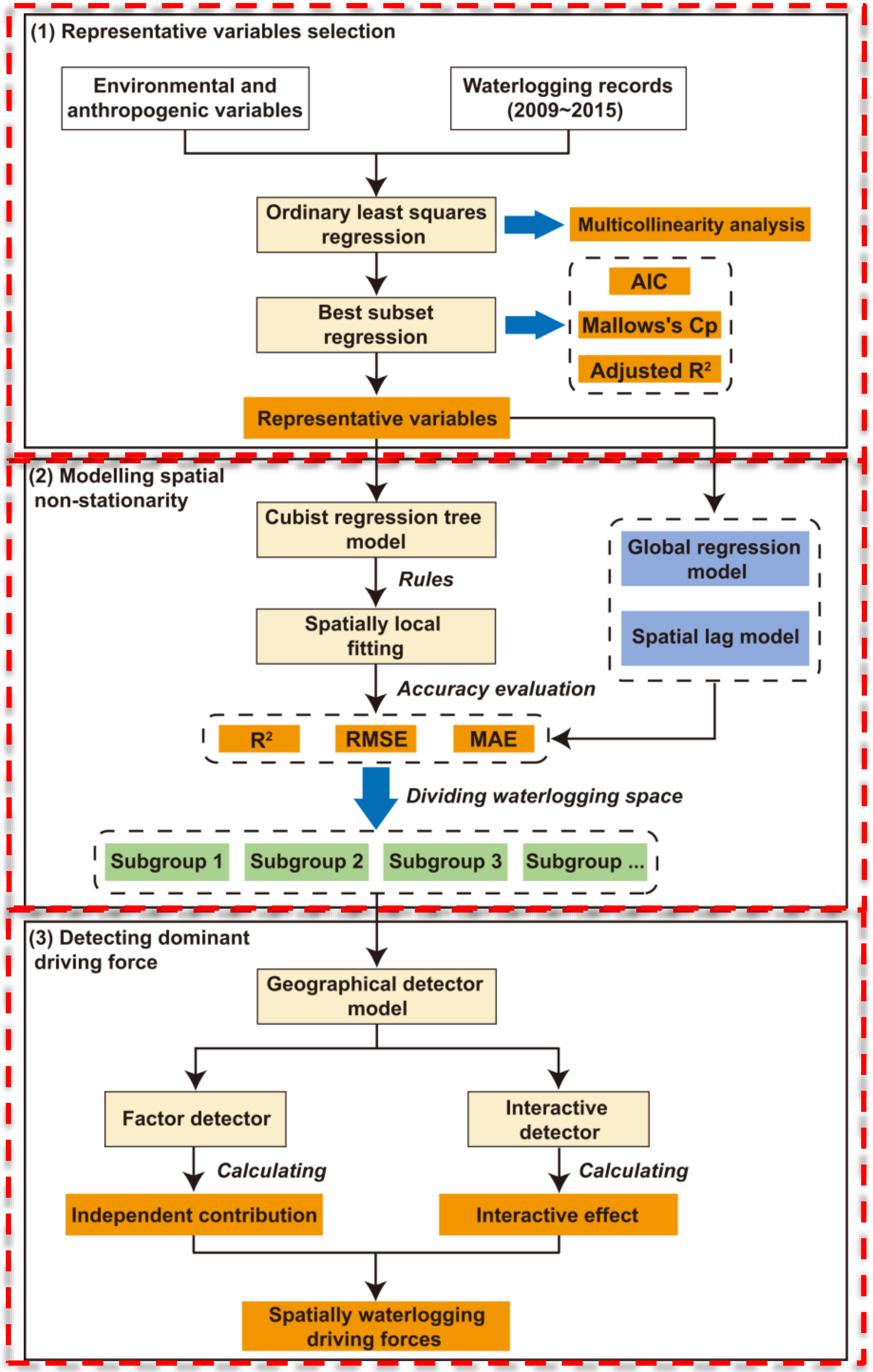
3.3 Methodology (2/2)

- Research framework

We proposed a novel approach (**cubits regression tree**) to effectively **detect the local driving forces** of urban waterlogging in **different spatial locations**.

There are **three main steps** to achieve these goals:

1. Select representative variables
2. Model spatial non-stationarity relationship to detect local driving forces
3. Identify waterlogging dominant factors with different local conditions.



Research results

CHAPTER 3

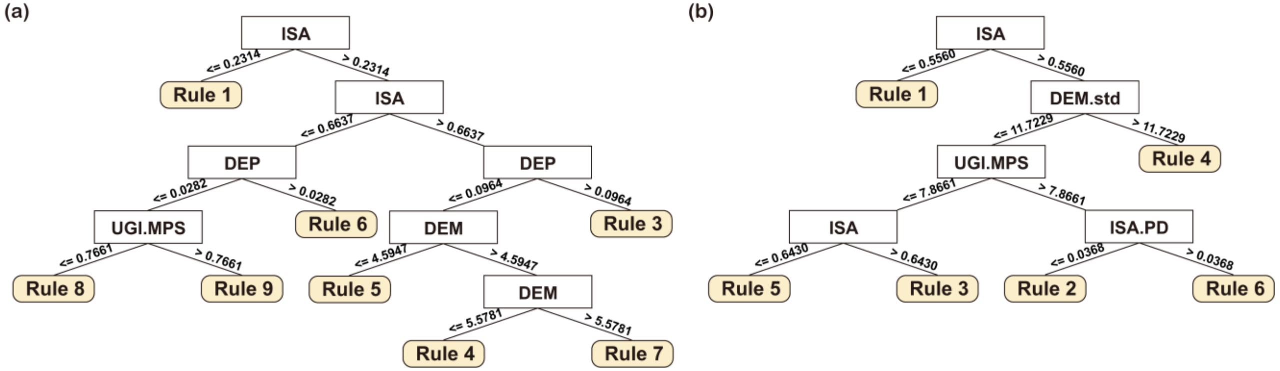
3.4 Results (1/2)

Local driving forces

The **proposed method** divides the urban waterlogging space into **different subgroups**.

- The **waterlogging spaces of Guangzhou** are divided into **9 subgroups**.
- The **waterlogging spaces of Shenzhen** are divided into **6 subgroups**.
- The cubist regression tree obtains the **local driving forces** in **different subgroups**.

The divided rules for Guangzhou (a) and Shenzhen (b)



The local driving forces for Guangzhou and Shenzhen

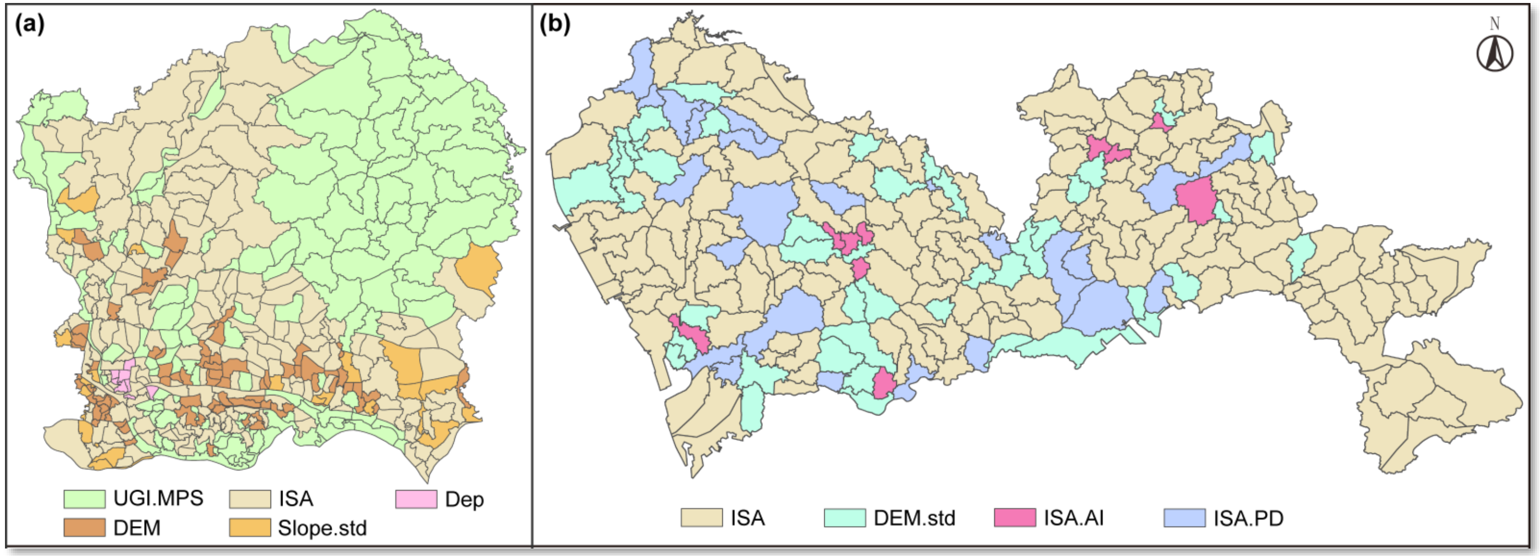
Guangzhou	Shenzhen
Rule 1: [99 cases] If ISA <= 0.2314 Expression: WD = -0.0974 + 0.63 ISA - 0.03 UGI.MPS + 0.0005 DEM	***Rule 1: [110 cases]*** If ISA <= 0.5560 Expression: WD = 0.2628 + 0.53 ISA + 0.0025 UGI.MPS - 0.0035 ISA.AI - 0.23 ISA.PD + 0.0021 DEM.std
Rule 2: [125 cases] If Dep <= 0.0282 and ISA > 0.2314 and ISA <= 0.6637 Expression: WD = -0.7701 + 16.84 Dep + 2.32 ISA + 0.0053 DEM - 0.06 UGI.MPS	***Rule 2: [24 cases]*** If DEM.std <= 11.7229 and ISA > 0.5560 and ISA.PD <= 0.0368 and UGI.MPS > 7.8661 Expression: WD = -2.1749 + 0.1346 DEM.std - 27.09 ISA.PD + 4.3 ISA - 0.0169 UGI.MPS - 0.0034 ISA.AI
Rule 3: [8 cases] If Dep > 0.0964 and ISA > 0.6637 Expression: WD = 7.8973 + 0.46 UGI.MPS - 1.07 ISA – 0.35 DEM + 0.91 Dep	***Rule 3: [10 cases]*** If DEM.std <= 11.7229 and ISA > 0.6430 and UGI.MPS <= 7.8661 Expression: WD = 0.7646 + 1.37 ISA + 0.06767 DEM.std - 0.0092 ISA.AI - 0.22 ISA.PD
Rule 4: [21 cases] If DEM > 4.5947 and DEM <= 5.5781 and Dep <= 0.0964 and ISA > 0.6637 Expression: WD = 28.9743 - 34.37 ISA + 1.17 Slope.std + 0.76 UGI.MPS – 2.42 Dep + 0.0086 Per	***Rule 4: [48 cases]*** If DEM.std > 11.7229 and ISA > 0.5560 Expression: WD = -6.9184 + 2.63 ISA - 0.0825 ISA.AI - 2.12 ISA.PD - 0.0086 UGI.MPS + 0.0019 DEM.std
Rule 5: [34 cases] If DEM <= 4.5947 and ISA > 0.6637 Expression: WD = 17.0543 - 3.9251 DEM - 0.44 UGI.MPS - 1.375 Dep + 0.0171 Per	***Rule 5: [24 cases]*** If DEM.std <= 11.7229 and ISA > 0.5560 and ISA <= 0.6431 and UGI.MPS <= 7.8661 Expression: WD = 10.0279 - 10.42 ISA - 0.0342 ISA.AI - 0.82 ISA.PD - 0.0031 UGI.MPS + 0.1346 DEM.std
Rule 6: [74 cases] If Dep > 0.0282 and ISA > 0.2314 and ISA <= 0.6637 Expression: WD = 70.6914 - 0.0334 Per - 3.3 Dep + 0.15 ISA - 1.25 Slope.std – 1.27 DEM	***Rule 6: [20 cases]*** If DEM.std <= 11.7229 and ISA.PD > 0.0368 and UGI.MPS > 7.8661 Expression: WD = -0.7601 + 0.0676 DEM.std + 0.85 ISA + 0.0169 UGI.MPS – 0.0825 ISA.AI
Rule 7: [20 cases] If DEM > 5.5781 and Dep <= 0.0964 and ISA > 0.6637 Expression: WD = 0.5679 + 9.68 Dep + 0.94 ISA + 0.675 DEM	
Rule 8: [24 cases] If ISA <= 0.6637 and Dep <= 0.0282 and UGI.MPS <=0.7661 Expression: WD = 6.0651 + 2.14 ISA - 0.26 UGI.MPS - 3.32 Slope.std - 0.0028 Per	
Rule 9: [25 cases] If ISA <= 0.6637 and Dep <= 0.0282 and UGI.MPS > 0.7661 Expression: WD = 3.9305 - 5.01 DEM + 8.47 ISA + 0.28 UGI.MPS – 0.41 Slope.std +1.22 Dep	

CHAPTER 3

3.4 Results (2/2)

■ Dominant factors

The spatial distribution of dominant factors



Guangzhou

- Subgroups **1 and 5**: urban green infrastructure (Mean patch size)
- Subgroups **2, 4, 7, and 9**: impervious surface
- Subgroups **3, 6, and 8**: are greatly affected by topographical factors, whose dominant factors are the urban lowland, DEM, and Slope.std.

Shenzhen

- Subgroups **1 and 4**: impervious surface
- Subgroups **3 and 5**: impervious surface (Aggregation Index) and impervious surface (Patch Density)
- Subgroups **2 and 6**: are mainly influenced by topographic factors (Slope.std).

Discussion and conclusions

CHAPTER 3

3.5 Summary

1. The proposed **cubits regression tree** can fully quantify the **spatial non-stationarity effect** of landscape elements on urban waterlogging and **spatially explicit** the driving forces **with different local conditions**.

2. The **driving force** of urban waterlogging **varies with the local site conditions**. Understanding the complex **site-specific mechanism** of urban waterlogging will help us implement more **targeted and effective mitigation strategies**, rather than a **"one-size-fits-all" policy**.

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Earth Surface Processes and Society

THANK YOU!

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