Hydrological restoration of sponge cities in terms of source control standards under climate change conditions

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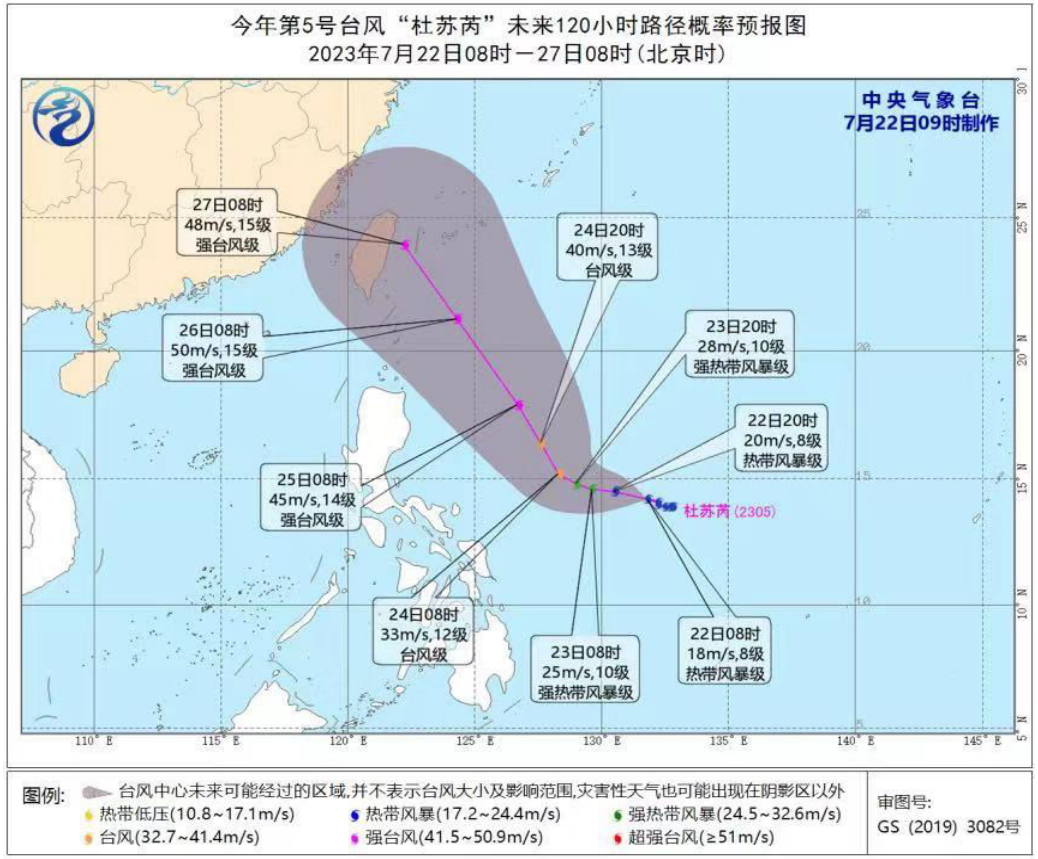
Report outline

01. Impact of climate change on source control facilities

02. Can source control facilities restore hydrologic conditions under climate change?

Climate change leading to heavy precipitation events

➢ Super Typhoon Doksuri



Global climate change has become one of the major concerns. The precipitation events due to climate change have increased significantly in many countries.

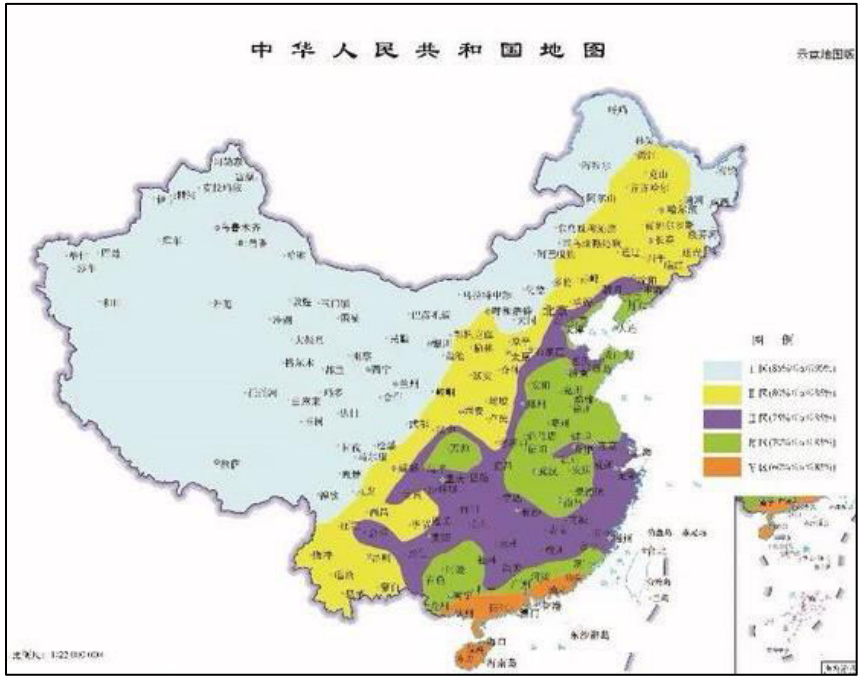
For example, the super typhoon "Doksuri", which occurred in July this year, has caused serious damage to many provinces and cities in China.

Impact of climate change on source control facilities

- **Climate change impacts on rainfall may affect the performance of stormwater facilities in sponge cities.**

The **Volume capture ratio of annual rainfall (VCRar)** is the ratio of the controlled rainfall volume to the annual rainfall volume per unit area per year.

The **design rainfall** is an essential indicator of determining the size of the rainfall source control facility.



The **corresponding relationship** between the VCR and the design rainfall is based on historical 24-h daily rainfall data according to the calculation method in the Technical Guide for Sponge City Construction.

Impact of climate change on source control facilities

The entire rainfall sequence is divided into three groups

Firstly, the daily rainfall less than 2 mm should be removed because it is believed that no runoff will be produced by this rainfall.

Next, when the daily rainfall is more than the **design rainfall**, the source control facility can only capture less than or equal to the design rainfall.

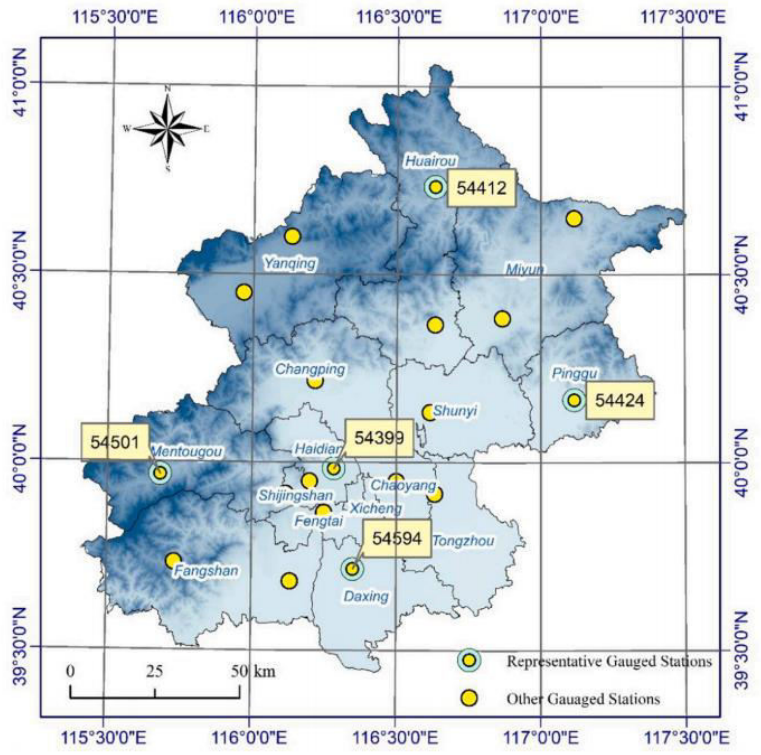
Finally, when the daily rainfall between 2 mm and the design rainfall, the source control facility can capture the total rainfall.

The ratio of the captured rainfall to the total rainfall is the VCR of annual rainfall.

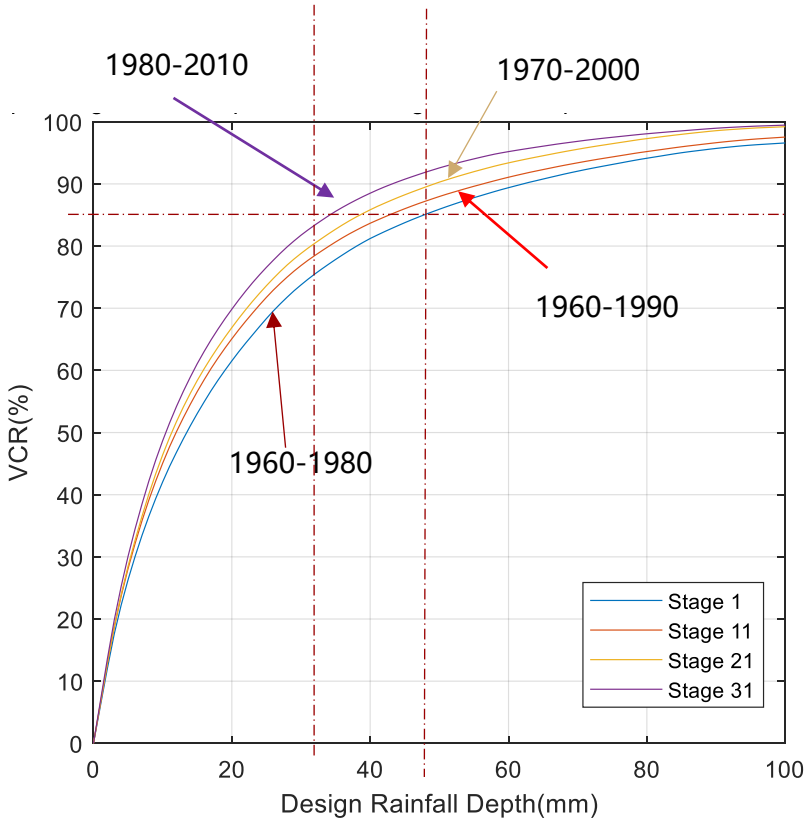
Based on **VCR** and actual **rainfall data**, we can calculate the corresponding **design rainfall**, which can be used to determine the size of the stormwater source control facility. They are closely related.

Impact of climate change on source control facilities

- However, global climate change has altered rainfall patterns, affecting the construction of source control facilities.



20 Meteorological Stations in Beijing 1960 - 2010



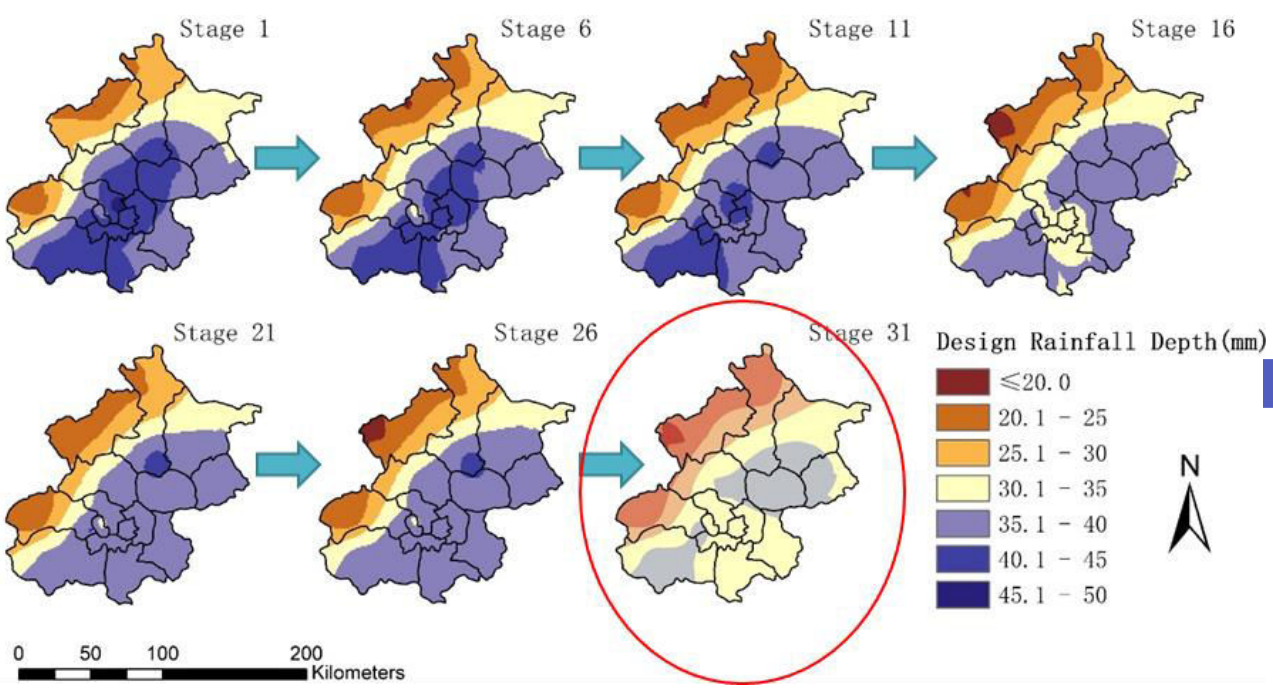
The corresponding relationships between Design rainfalls and VCRs

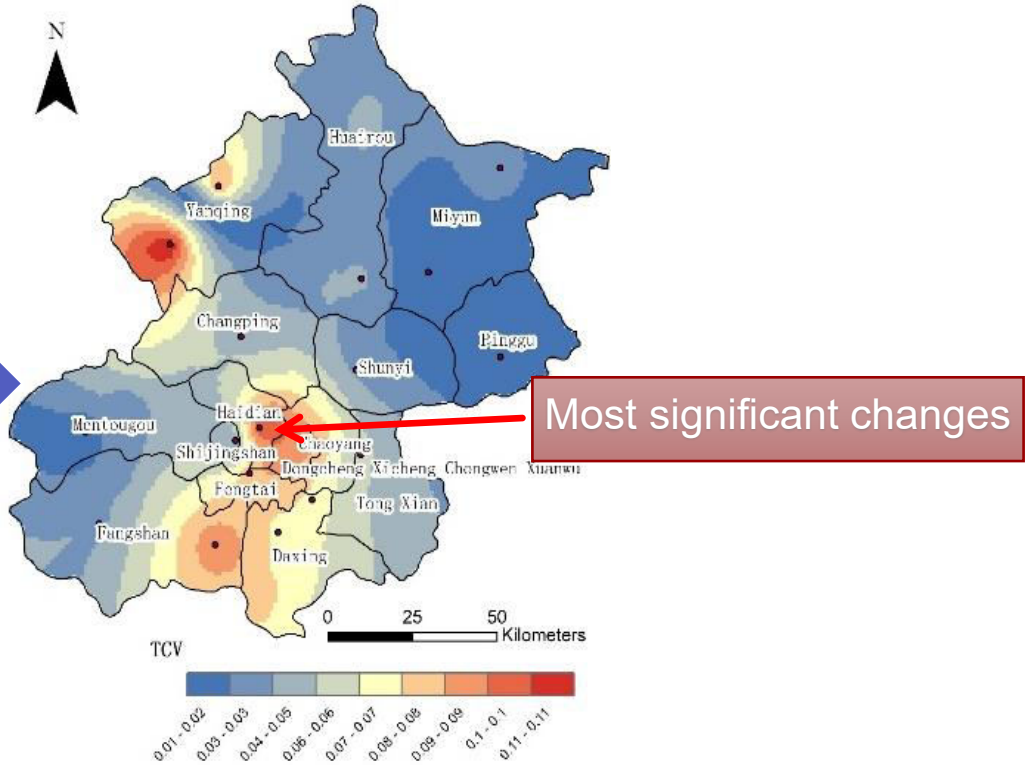
We explored the relationship between VCR and design rainfall in Beijing.

Because of the change of rainfall characteristics in different stages, the VCR corresponding to the same design rainfall will also change. The design rainfall corresponding to the same VCR is also different.

Impact of climate change on source control facilities

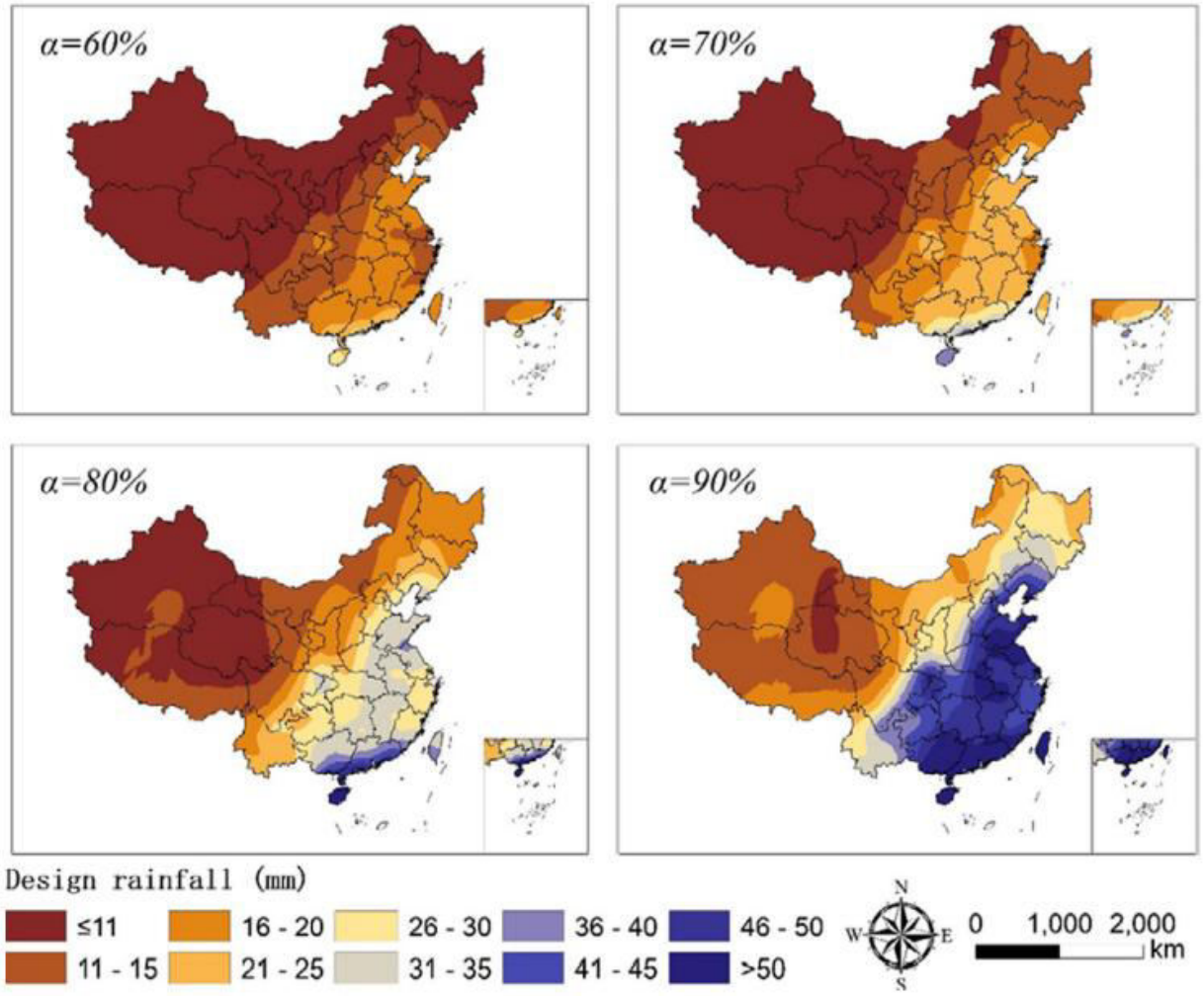
- Specifically, different areas are impacted to different degrees. For source control standards, some areas are sensitive and some are not. In the case of Beijing, sensitive areas are concentrated in the central city and in the south.





The process of the design rainfall corresponding to 85% VCR of annual rainfall in different stages.

Impact of climate change on source control facilities



Geographical distributions of design rainfall depths in China corresponding to volume capture ratio of annual rainfall of 60%, 70%, 80% and 90%.

Furthermore, we calculated the relationship between VCR and design rainfall in different areas of China.

In terms of rainfall source control, when VCR is low, corresponding design rainfall in each region does not change much. When VCR is large， corresponding design rainfall increases greatly with VCR.

Report outline

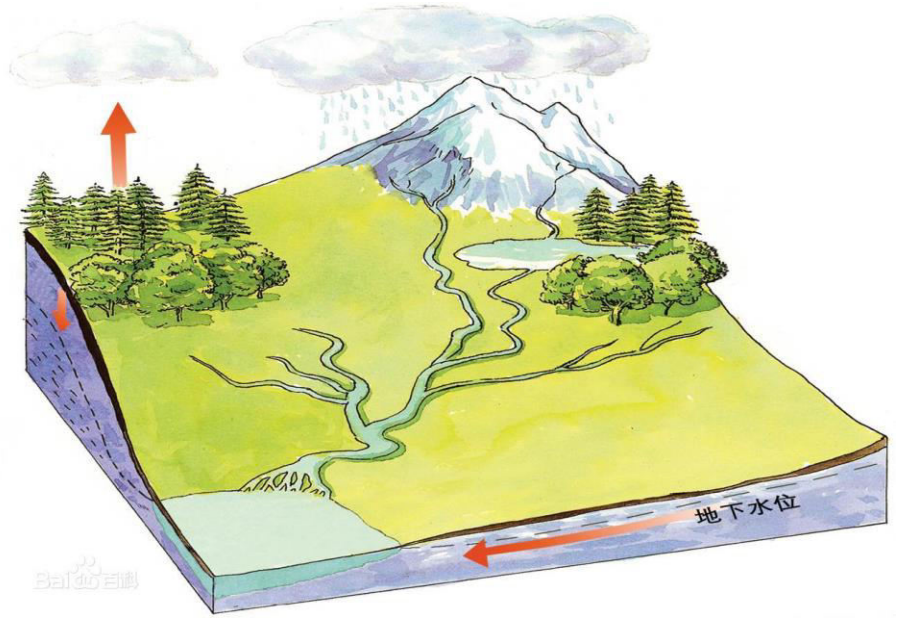
01. Impact of climate change on source control facilities

02. Can source control facilities restore hydrologic conditions under climate change?

Can source control facilities restore hydrologic conditions?

We used the changes in annual runoff depth at different stages to determine whether the source control facility could restore hydrologic conditions.

Runoff depth is the value obtained by dividing the total amount of runoff passing through a specified section of the river at a given time by the area of the river basin above that section and is often used to assess runoff changes in the river basin.



Schematic representation of runoff depth

Based on the **VCR** and **historical rainfall data**, we can calculate the **design rainfall** and calculate the annual **runoff depth** for each area.

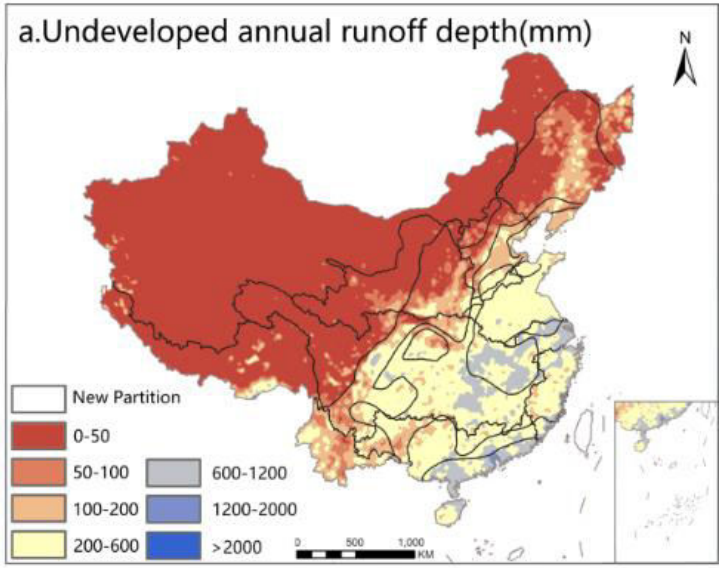
Can source control facilities restore hydrologic conditions?

We set three scenarios to compare the effect of sponge city construction on the restoration of hydrological conditions. Scenario 1 is the undeveloped annual runoff depth; scenario 2 is the annual runoff depth before sponge city construction; and scenario 3 is the annual runoff depth after sponge city construction.

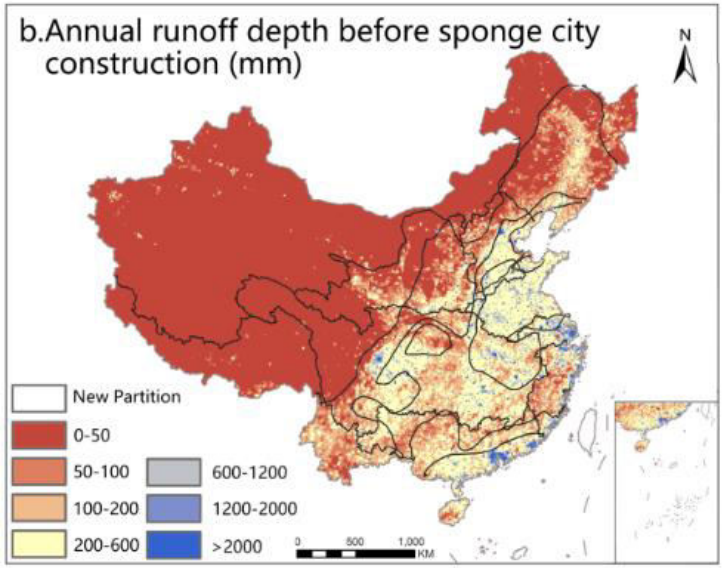
Scenario	Details	Year of rainfall data	Calculation methods
1	Undeveloped annual runoff depth	1980	Calculated from rainfall and each land-use runoff coefficient
2	Annual runoff depth before sponge city construction	2015	Dataset of Runoff Coefficient and Runoff Depth in Belt and Road Region (2015)
3	Annual runoff depth after sponge city construction	1986–2015	Calculated from the volume capture ratio of annual rainfall (VCRAR)

Three scenarios and the year of rainfall data used in each scenario and the calculation methods.

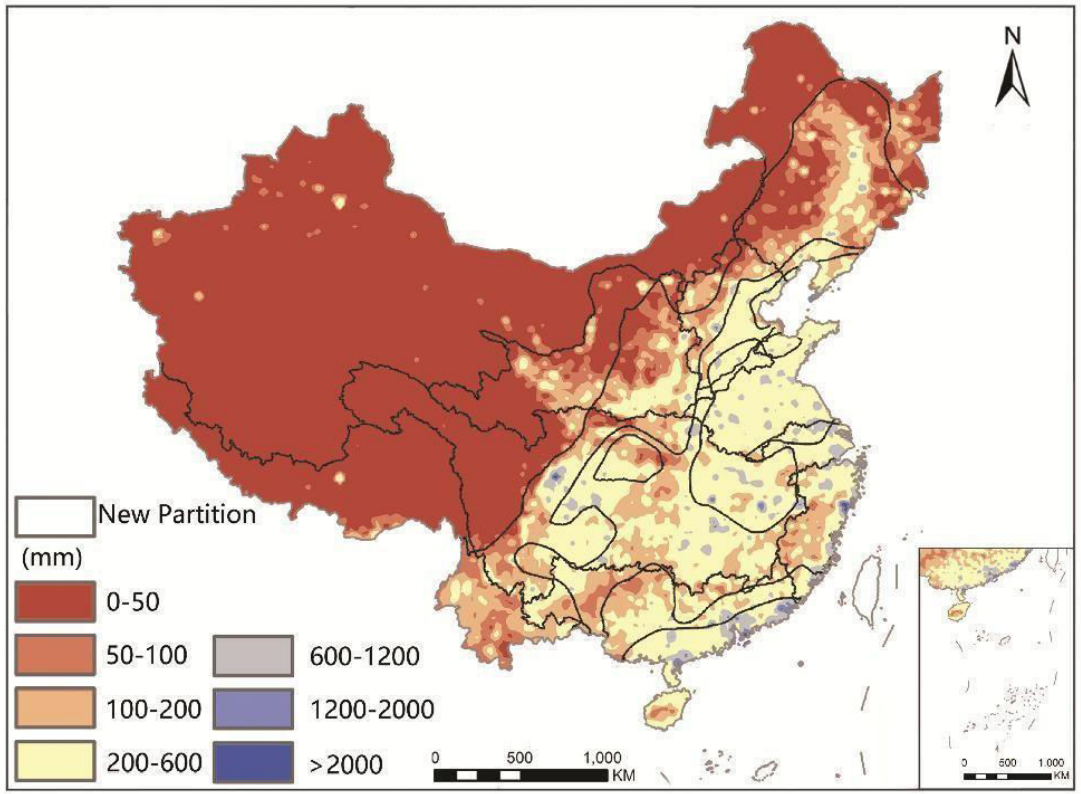
Can source control facilities restore hydrologic conditions?



Scenario 1



Scenario 2

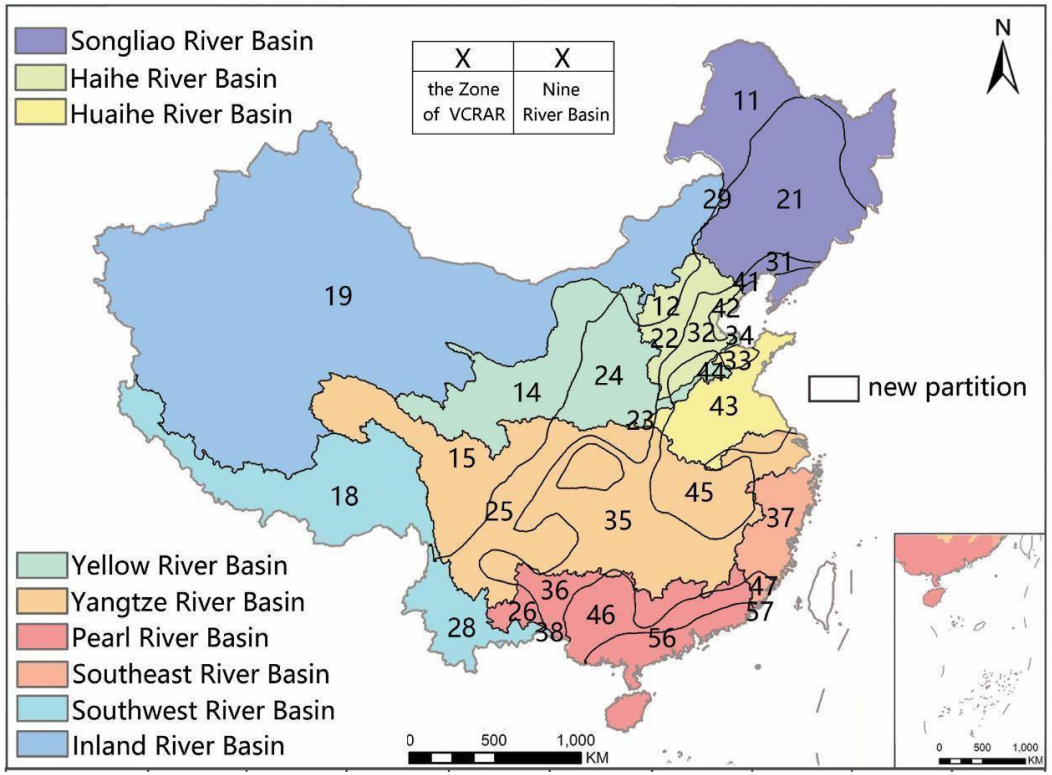


Scenario 3

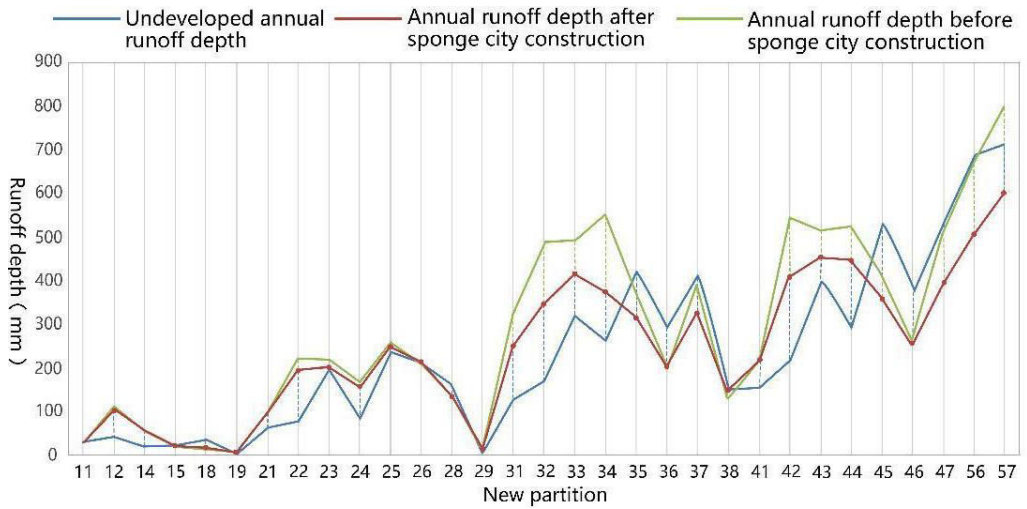
- The trends of three scenarios are the same. They gradually increase from northwest to southeast.
- The sponge city construction cannot restore the current hydrology to the undeveloped state, however, it benefits the overall hydrology recovery.

Can source control facilities restore hydrologic conditions?

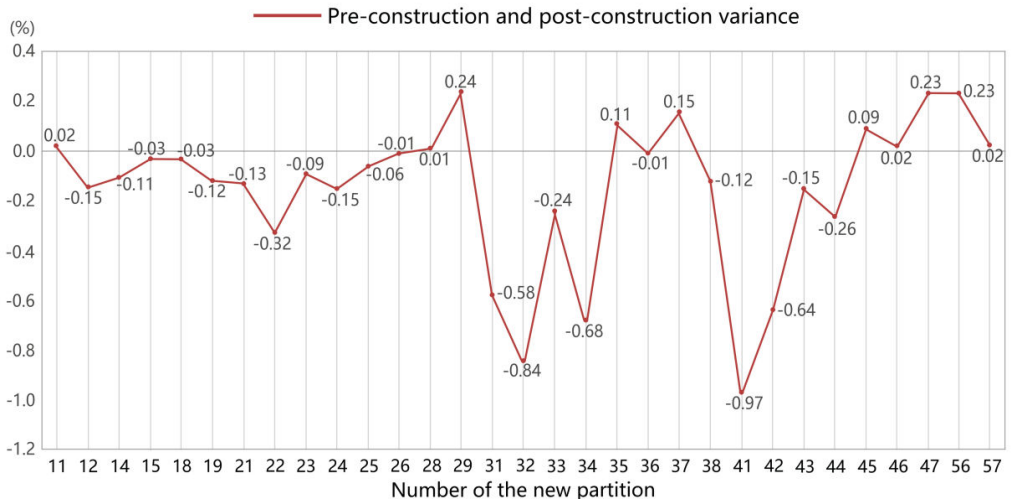
In order to more clearly reflect the changes in the runoff depth at different stages, the study area was reclassified into 31 zones. Hydrologic conditions with lower change rates of annual runoff depth are closer to undeveloped conditions.



Partitioning results based on the new partitioning method



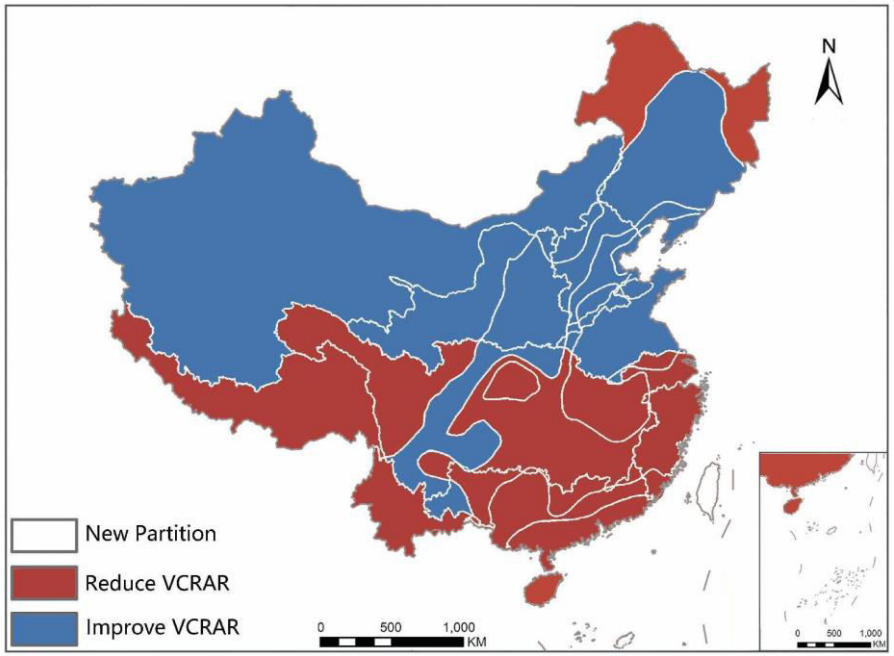
Comparison of undeveloped annual runoff depth and annual runoff depth before and after sponge city construction in the new partition

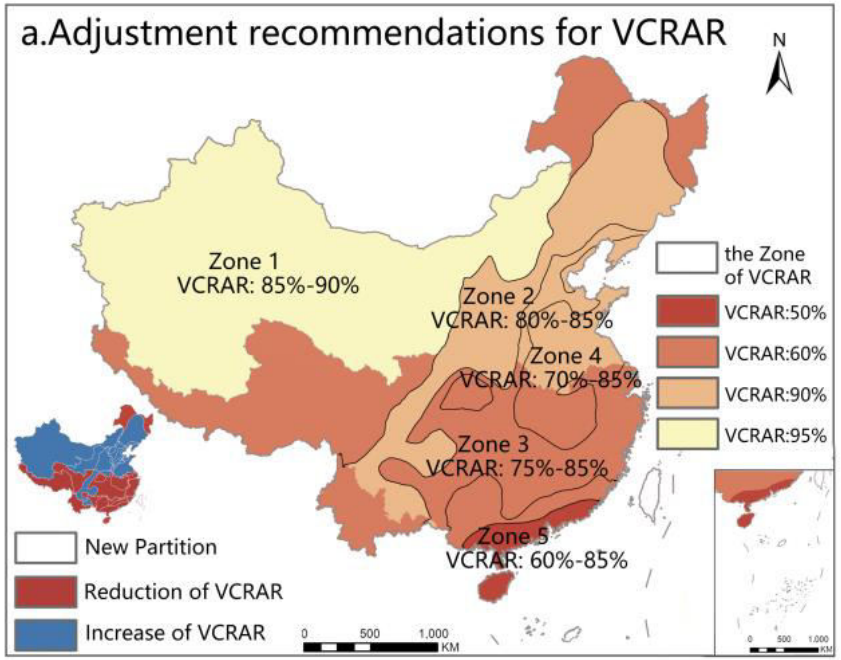


Difference between undeveloped annual runoff depth and annual runoff depth before and after sponge city construction in the new partition

Can source control facilities restore hydrologic conditions?

Based on the changes in VCR before and after river basin development, we propose adjustment recommendations for VCR.





Adjustment recommendations for VCRar

- In the north, the VCR increases in most areas and decreases in a few areas; in the south, the VCR decreases in most areas and increases in a few areas.
- The corrected annual runoff depth is unchanged in most areas and has a significant correction in the eastern and south-eastern coastal areas, with a correction range of 15–25%.


Thank you