Sponge City Practice in Neighborhood Scale

220203

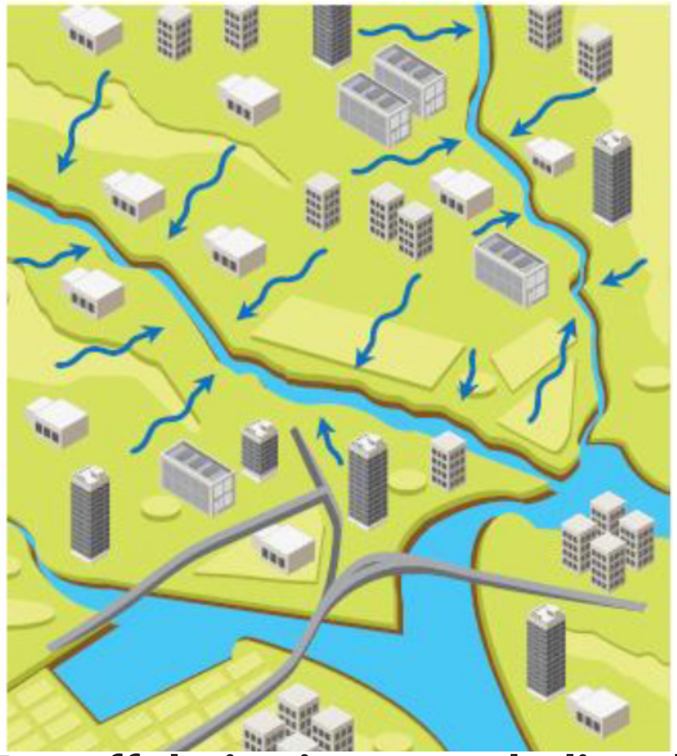
Motivation:

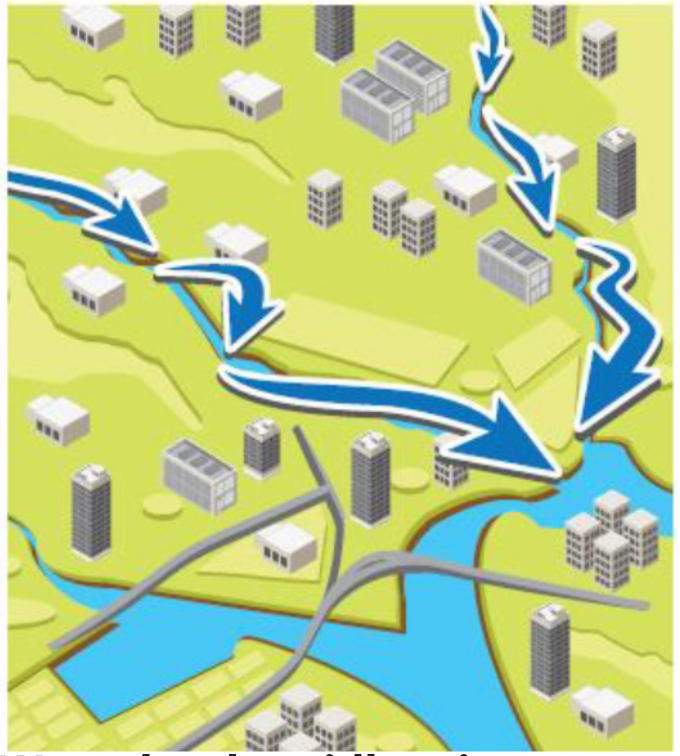
As one of the biggest top-down national policy in China, Sponge City Practice has been initiated in over 30 citied and invested over billion of dollars. However, after over seven years of practice, many cities in China are still suffering from severe water logging. Especially Zhengzhou, Henan, who has spent more than $80 million in SCP since 2016, was overwhelmed by record-breaking flooding in July this year. It caused 53.2 billion yuan(about $8.38 billion) in economic losses and took 292 lives.
The effectiveness and practice of SCP are facing unprecedented challenges and doubts. It is a wake-up call for us and an important question raised worth introspecting on —how can we improve the SCP in this situation and make it more effective?

General Concept

Without SCP


Rainfall


Runoff drains into trench directly


Water level rapidly raises

With SCP


SCP intervention


SCP slow down the rainfall


Water level raise gradually

Indicators:

Key indicator:

1. Volume capture ratio of annual rainfall (with accordingly design rainfall)

2. Volume capture ratio of annual urban diffuse pollution

3. The ratio of rainwater resource utilization

Individual indicator:

1. Sunken green space rate and Sinking depth

2. Permeable pavement rate

3. Green roof rate

4. Other

Needs for appropriate SCP sizing:

1. To make sure the sponge city system reaches certain design targets. (e.g. peak discharge, runoff volume, or pollutant loading reduction)

2. To select the best combination of SCPs that result in the most cost-effective and practical management strategy possible for the location of interest.

Existing Indicators decomposetion process:

1. **Volume-based Method:**

   $V = 10H\varphi F$ (4-1)

2. **Flow-based Method:**

   $Q = \psi q F$ (4-2)

3. **Water Balance Method:**
4. **Stormwater Modeling (SWMM model)**

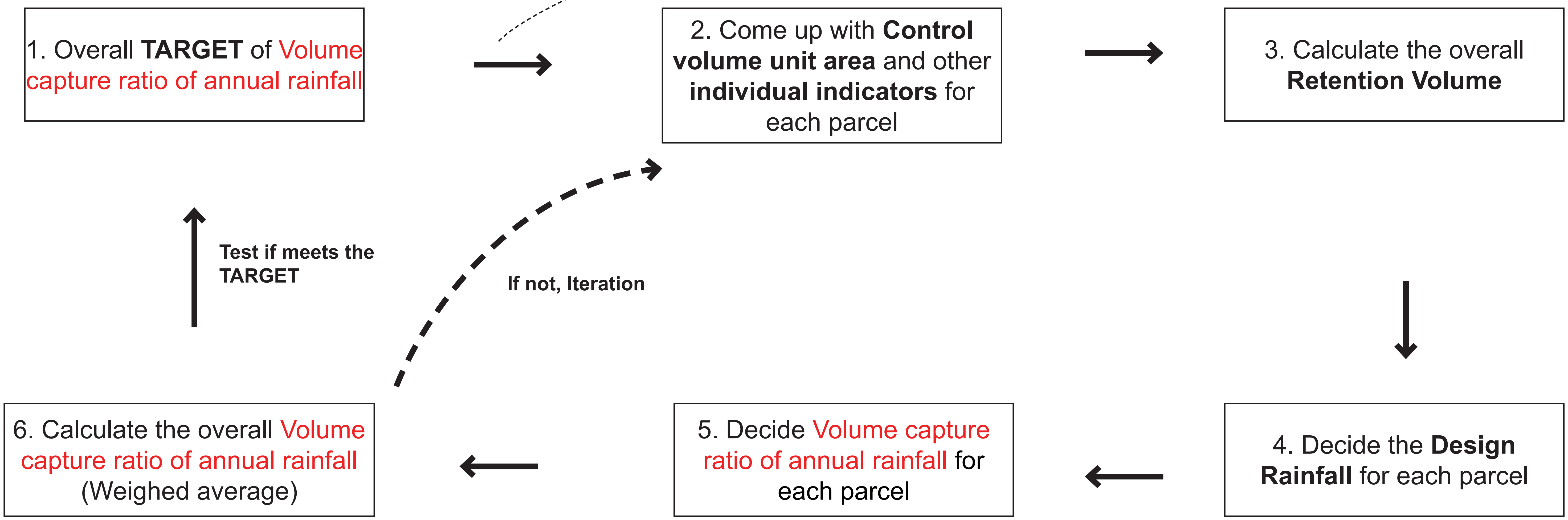


表 4.2.4　海绵城市系统控制指标分类表

规划层级	控制目标与指标	赋值方法
城市总体规划、专项（专业）规划	控制目标： 年径流总量控制率及其对应的设计降雨量	年径流总量控制率目标选择可根据附录 B 结合当地实际情况确定，可通过统计分析计算得到年径流控制率及其对应的设计降雨量
详细规划	综合指标： 单位面积控制容积	根据总体规划阶段提出的年径流总量控制率目标，结合当地块绿地率等控制指标，计算当地块的综合指标—单位面积控制容积
	单项指标： 1)下沉式绿地率及其下沉深度 2)透水铺装率 3)绿色屋顶率 4)其他	根据当地块的具体条件，通过技术经济分析，合理选择单项或组合控制指标，并对指标进行合理分配。指标分解方法：方法 1：根据控制目标和综合指标进行试算分解； 方法 2：模型模拟

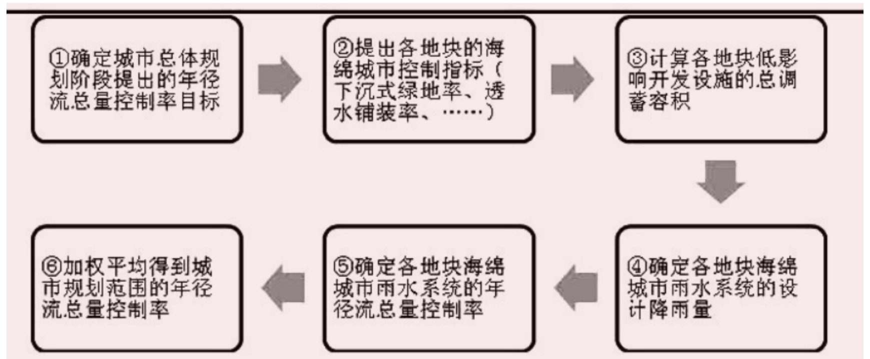
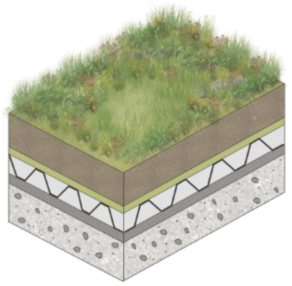


图 4.2.2　指标分解的步骤

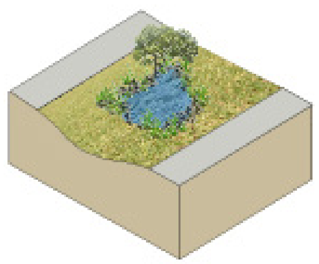
Sponge City Overview

Infiltration

- Permeable Pavement



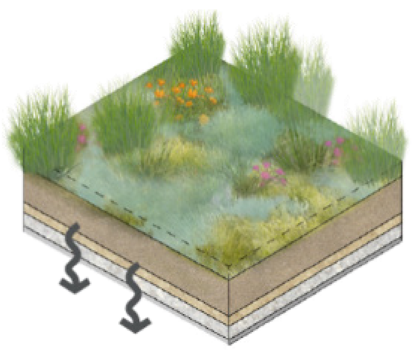
- Green Roof



-Sunken Green Space

- Infiltration Pool

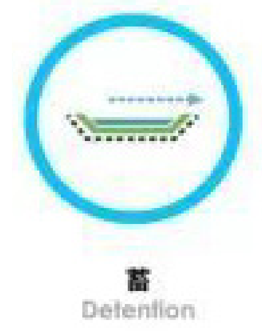
Retention

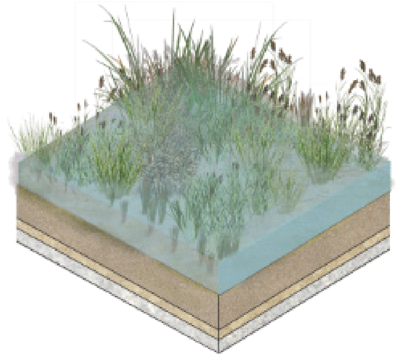


- Bioretention

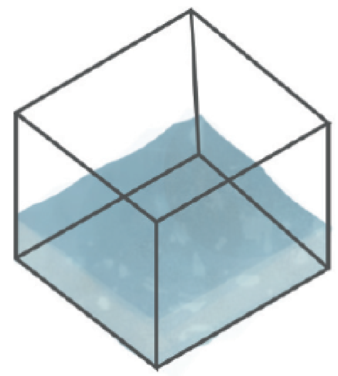
- Adapting Tank

Detention





- Rain garden/Artificial wetland



- Pool

-Stormwater Harvesting Tank

- Rainfall Tank

Cleansing

Cleansing Biotope

Reuse

- Groundwater

- Artificial waterscape

Drainage

- Bioswale

- Infiltration trench

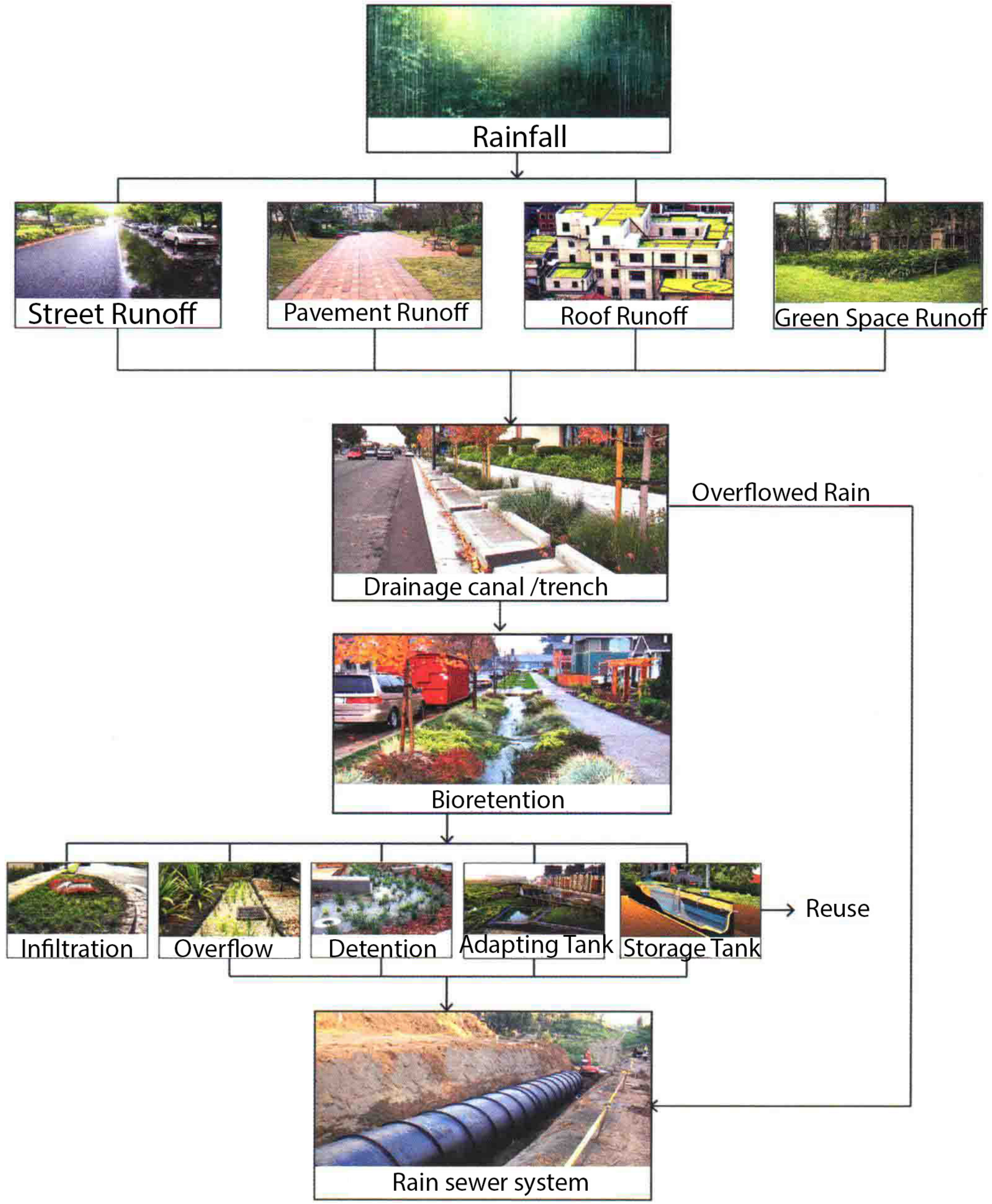
- Pump

- Drainage canal

✓ Suitable
✗ Unsuitable
○ Ok

		Building & Neighborhood	Urban Street	Plaza& Green Space	Urban Water	Culture Asset	SS% Volume capture ratio of annual urban diffuse pollution
Infiltration	- Permeable Pavement	✓	✓	✓	○	○	80-90%
	- Green Roof	✓	✗	✗	✗	✗	70-80%
	-Sunken Green Space	✓	✓	✓	○	○	
	- Infiltration Pool	✓		✓	✗	✗	
Retention	- Bioretention	✓	✓	✓	✓	✗	70-95%
	- Adapting Tank	○	○	○	✗	○	
Detention	- Rain garden/Artificial wetland	✓	✓	✓	✓	✗	
	- Pool	✓	○	✓	✓	✗	50-80%
	-Stormwater Harvesting Tank	○	✗	○	✗	✗	80-90%
	- Rainfall Tank	✓	✗	○	✗	✗	80-90%
Cleansing	Vegetation Buffer	✓	✓	✓	✓	✗	50-75%
Drainage	- Bioswale	✓	✓	✓	○	○	35-90
	- Infiltration trench	✓	✓	✓	○	○	35-70%
	- Pump	✓			✓	✗	

Neighborhood SCP framework



Neighborhood SCP framework

SCP facility detention volume

Overall Detention Volume

Planning Volume capture ratio of annual rainfall

Design Rainfall

Site Design Rainfall Volume

$$V = 10 h_y F$$

V——设计控制雨量（日值），m3；
hy——设计控制雨量（日值），取18.5 mm
F——汇水面积，hm2。

Underlying surface coefficient

Site overall Runoff coefficient

$$\varphi = \frac{\sum F_i \varphi_i}{F} \quad \text{公式（1）}$$

$$= \frac{4713.8 \times 0.9 + 8300.8 \times 0.9 + 1315.28 \times 0.15 + 8118.32 \times 0.15 + 667 \times 1}{23195.2}$$

$$= 0.60$$

Design Rainfall Volume

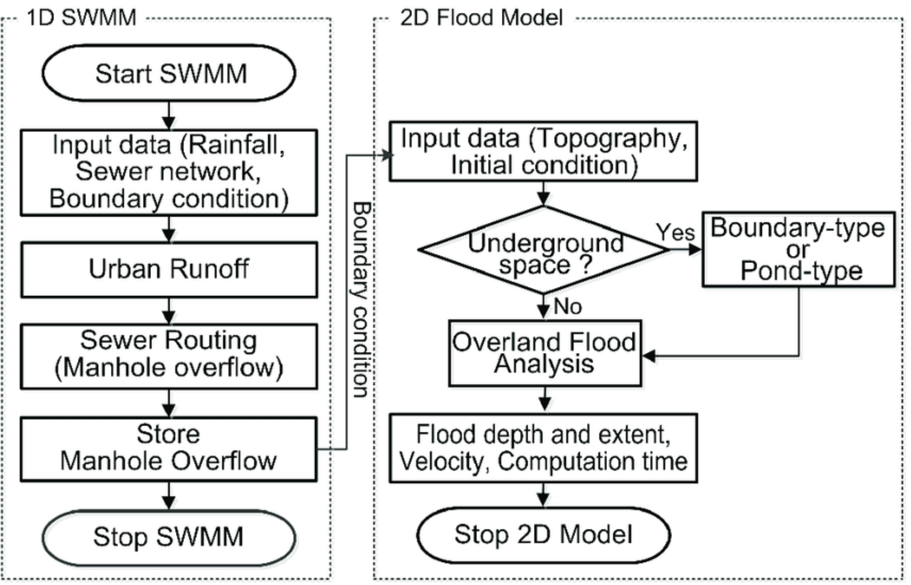
$$V1 = V \times \psi$$

Volume capture ratio of annual rainfall

Current Model

1. Storm Water Management Model (SWMM)

EPA's Storm Water Management Model (SWMM) is used throughout the world for planning, analysis, and design related to stormwater runoff, combined and sanitary sewers, and other drainage systems. It can be used to evaluate gray infrastructure stormwater control strategies, such as pipes and storm drains, and is a useful tool for creating cost-effective green/gray hybrid stormwater control solutions. SWMM was developed to help support local, state, and national stormwater management objectives to reduce runoff through infiltration and retention, and help to reduce discharges that cause impairment of waterbodies.



2. Hydrological Simulation Program Fortran Model (HSPF)

3. System for Urban Stormwater Treatment and Analysis Integratration (SUSTAIN)

SUSTAIN is a decision support system that assists stormwater management professionals with developing and implementing plans for flow and pollution control measures to protect source waters and meet water quality goals. SUSTAIN allows watershed and stormwater practitioners to develop, evaluate, and select optimal best management practice (BMP) combinations at various watershed scales based on cost and effectiveness.

Research Purpose?

- Optimize the decomposition of key indicator into individual indicators in Neighborhood scale?

- Desicion support tool to Enhance the SCP design social benefits?

Initial Data Process

Data

- 12.5m DEM

- Sentinel 2

- Cencus of Neighborhood Spreadsheet (with age group)

- Neighborhood shp

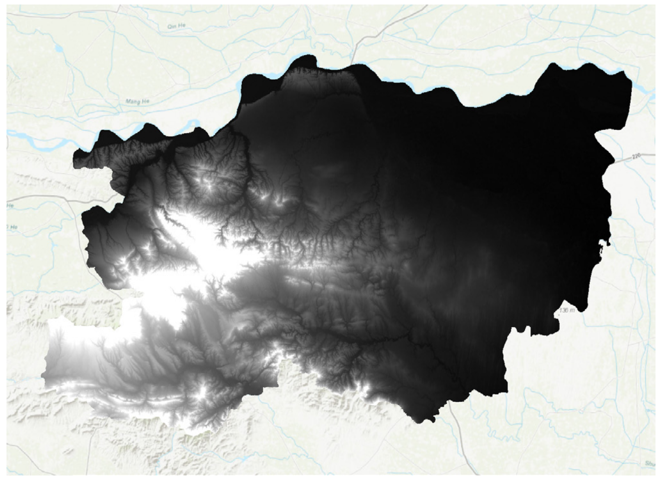
- Street Vector

- Building Footprint

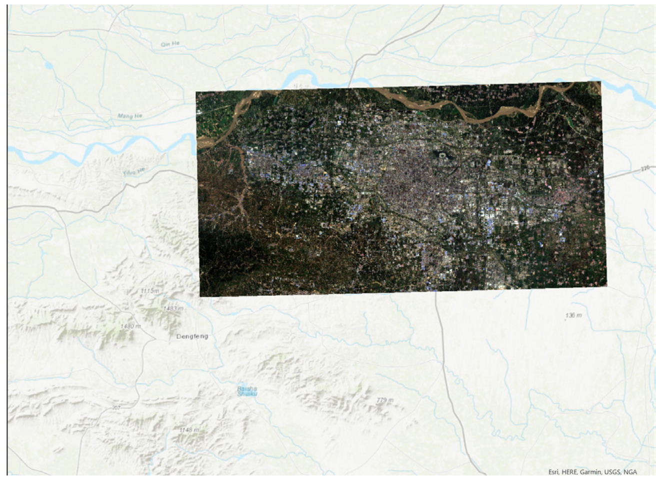
- Global landcover 2020 10m

- SCP facility key indicator

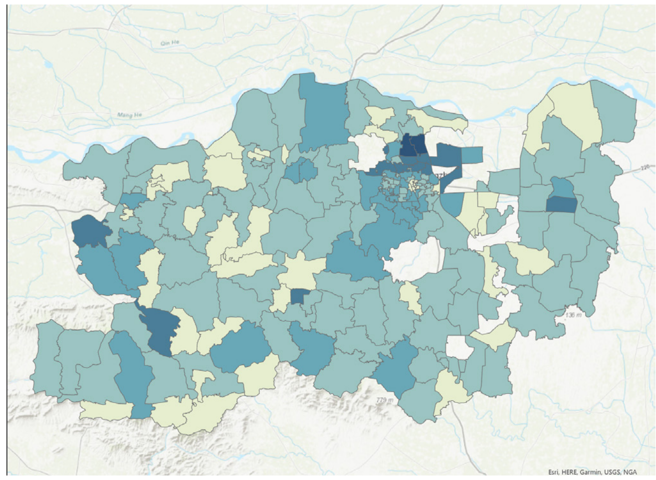
- Percipitation (3hrly)



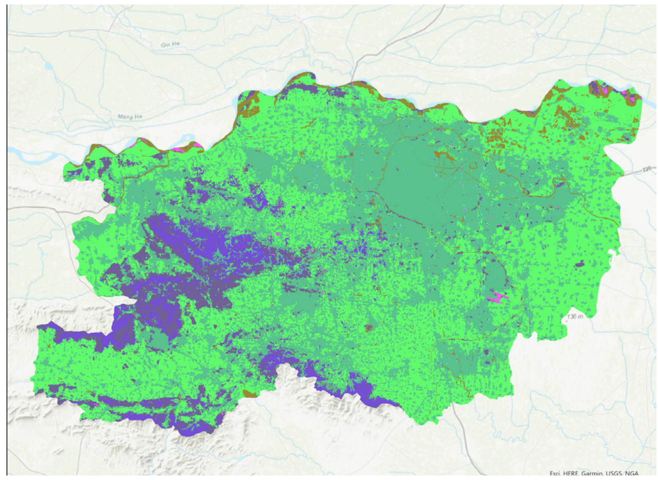
12.5m DEM



Sentinel 2

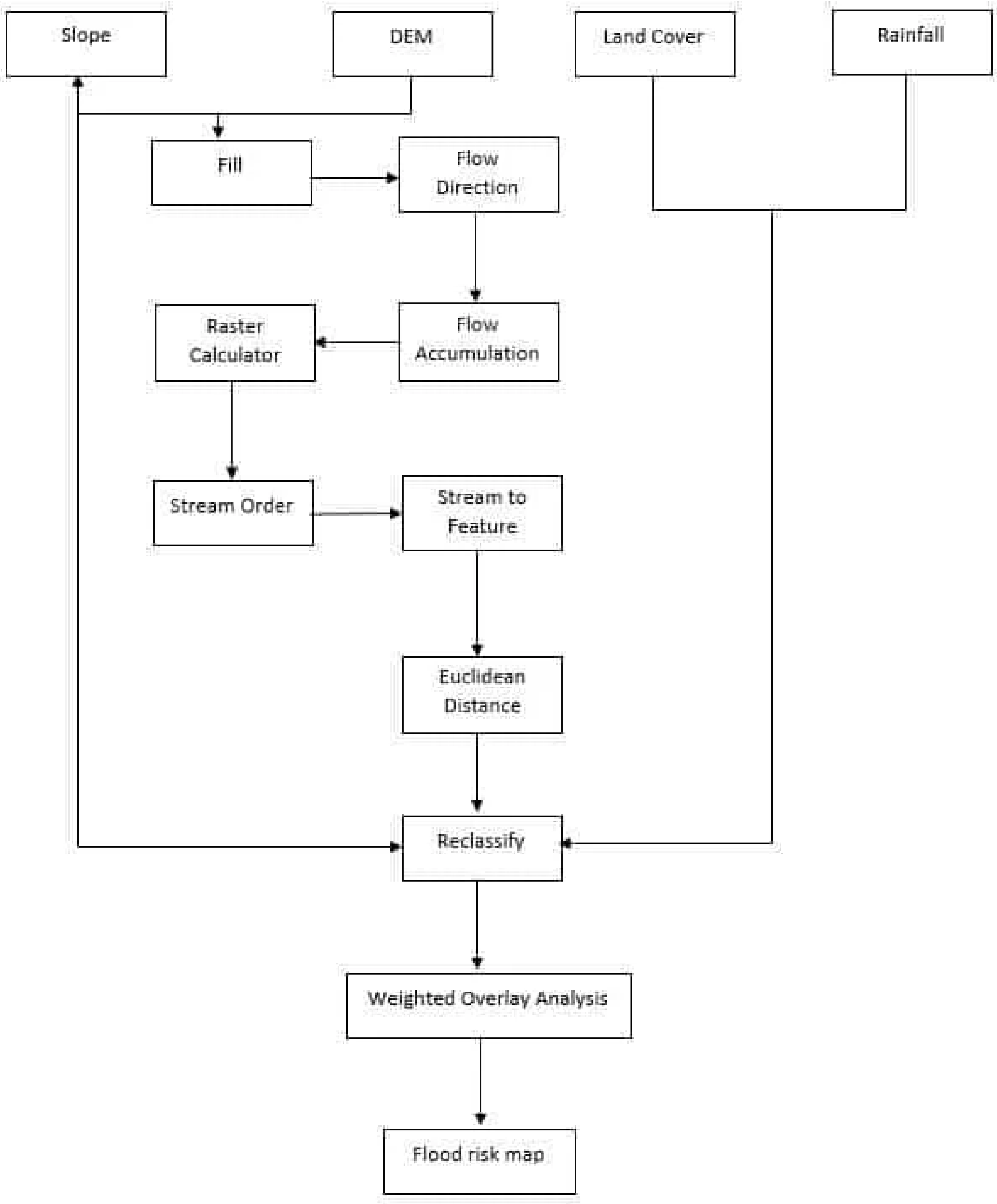


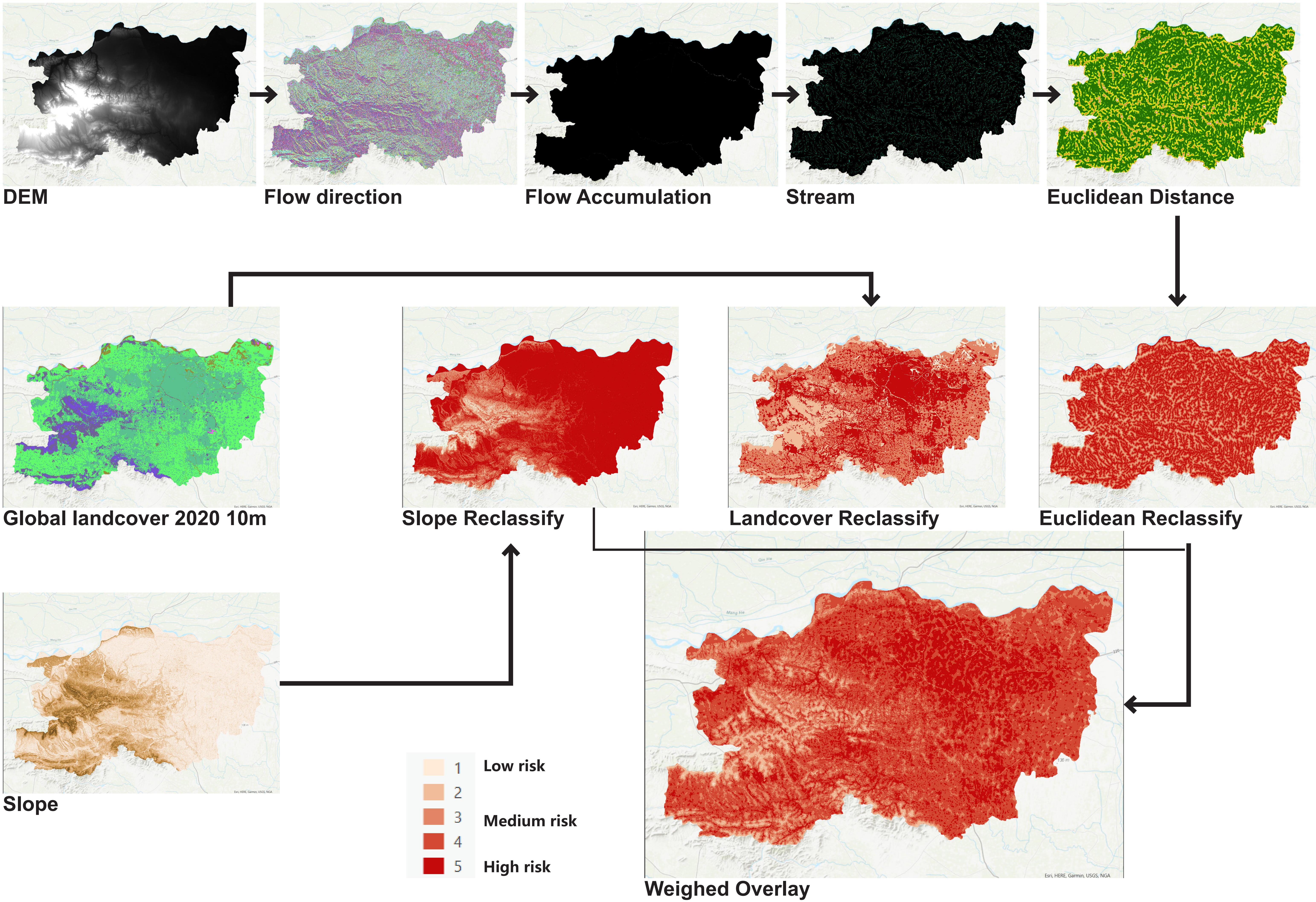
Cencus Tract



Global landcover 2020 10m

Floop map Susceptibility





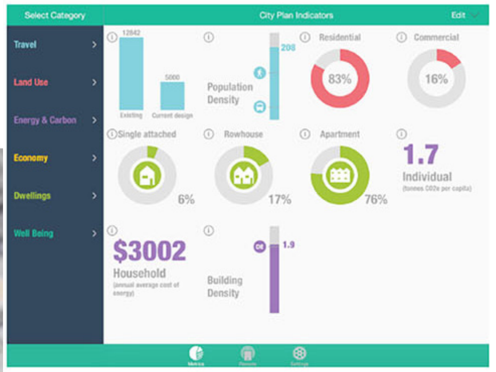
DEM
Flow direction
Flow Accumulation
Stream
Euclidean Distance
Global landcover 2020 10m
Slope Reclassify
Landcover Reclassify
Euclidean Reclassify
Slope
1
Low risk
2
3
Medium risk
4
5
High risk
Weighed Overlay

An interactive Tool?/ Intelligent Control system?

UD Co-Spaces

Cynthia Girling

Ron Kellett



Data visualizations

UD Co-Spaces is a prototype urban design visualization and engagement tool for engaging diverse audiences of planners, designers and the public in generating and testing urban planning and design options. This tool includes a large touch screen user interface set into a standing height table, and both projected and hand-held display interfaces. Custom software links four independent applications: online maps, elements**db**, 3D visualizations and an indicators dashboard.

Designed for rapid experimentation by small groups of people, users can test ideas for urban design. The user simply drags images of selected "cases" from elements**db**, for example a residential building, from a sidebar onto the digital map on the work-surface. The indicators dashboard immediately reports on metrics such as numbers of dwellings, floor areas, energy usage, while a 3D view appears on the wall projection. Records of every iteration can be captured for later reference and comparison. We are currently modifying the networking and moving source mapping and 3D visualizations to ESRI online mapping.