



# Sustainable 3D urban governance: The DEEP CITY concept from Switzerland to China

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Huan-Qing Li, EPFL, Suisse

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## OUTLINE

## DEEP CITY

- **UUS- Urban Underground Space (Subsurface)**
  - 3D urbanism concept
  - Economic viability
  - Institutional feasibility
  
- **UUR- Urban Underground Resources**
  - Four main components
  - Interactions (synergies and conflicts)
  - Sustainable resources exploitation for urbanization

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# 1. URBAN SUBSURFACE



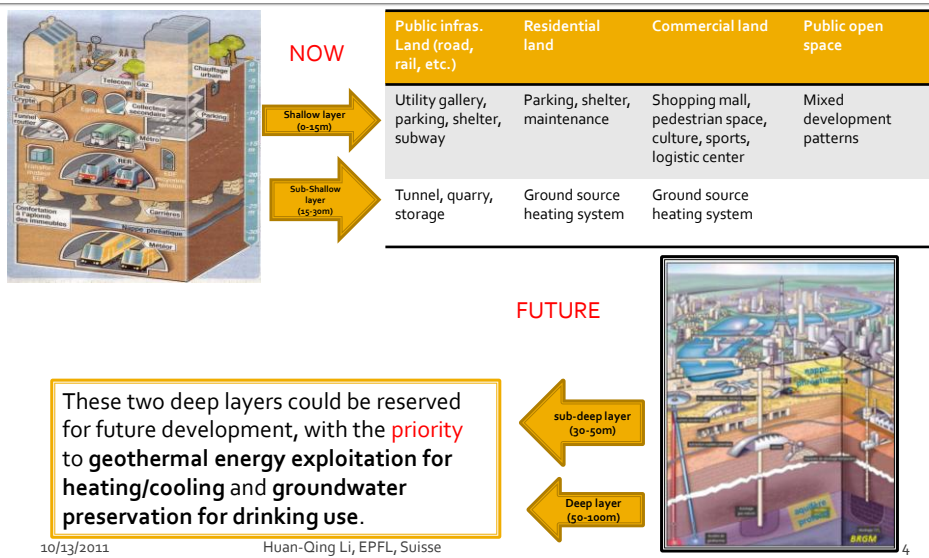
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# 1. URBAN SUBSURFACE

## 3D urbanism concept: integrated land use planning



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# 1. URBAN SUBSURFACE

## Build a 3D city with economic viability

### steps:

- A. From « the provision capacity of space resources » to « the need of urbanization »
  - comprehensive **evaluation of subsurface**
- B. Coordination with surface urban planning
  - integrated assessment taking into account **socio-economic context**, planning regulations and policies
- C. Strategic decision-making process for investors
  - **multi-criteria analysis** to justify investment

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## Build a 3D city with economic viability

### step A: comprehensive evaluation of subsurface

#### Construction difficulty determinants and spatial restrictions

- ✓ geotechnical properties
- ✓ geological hazards
- ✓ hydrogeological conditions
- ✓ existing underground infrastructures
- ✓ potential archeological sites
- ✓ protected groundwater layer for drinking use etc.



**QUALITY:**  
Engineering difficulty index



**QUANTITY:**  
Available volume for excavation



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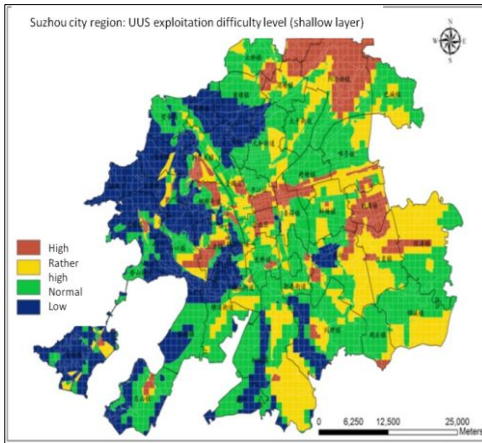
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# CASE STUDY IN CHINA

## Suzhou city: subsurface quality and quantity

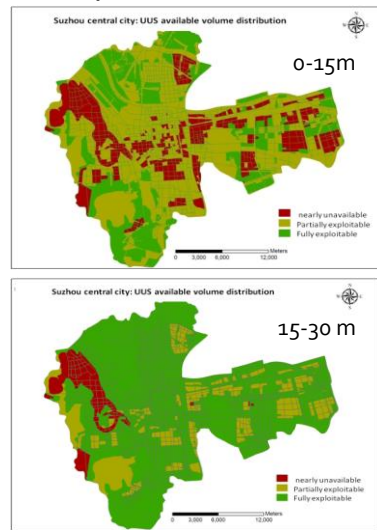
Quality for construction:



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Quantity for future use:



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## Build a 3D city with economic viability

### step B: integrated assessment with surface planning

Socio-economic factors

- ✓ population density
- ✓ land prices
- ✓ land use types
- ✓ rail transit system planning
- ✓ development priority zones
- etc.



**VALUE:**  
Commercial potential index



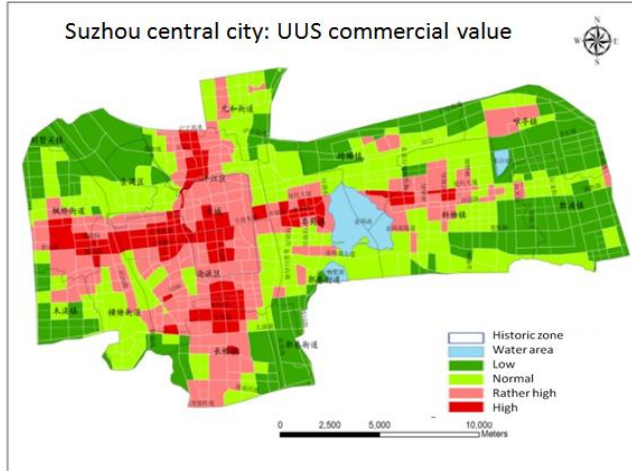
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# CASE STUDY IN CHINA

## Suzhou city: subsurface commercial value



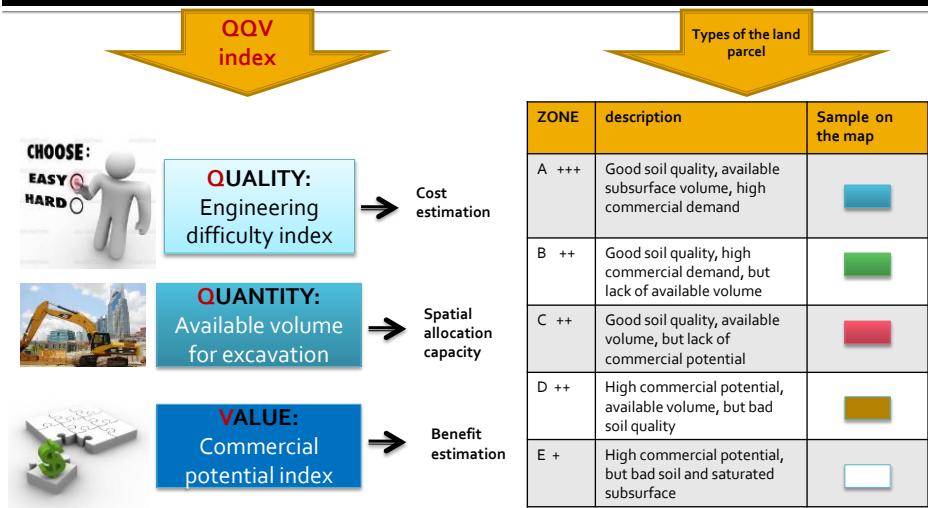
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### Build a 3D city with economic viability

#### step C: Multi-criteria decision-making process for subsurface development project management



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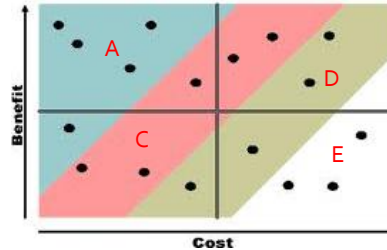
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## Build a 3D city with economic viability step C: Multi-criteria decision-making process for subsurface development project management

- **Definition of cost**
  - Direct cost for construction (including drainage cost)
  - Excavated material treatment cost
  - Operational and maintenance cost
- **Definition of benefit**
  - Direct benefit for investors
  - Indirect benefit for public welfare
- **Impact of spatial availability:**
  - Induce additional cost for land preparation or acquisition
  - Cause compensation payment to nearby property owners

Conceptual demonstration :



What will be a best strategy for a relevant type of project, taking into account urban welfare and private interest?  
→ From RANDOM to RATIONAL!

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## Build a 3D city with economic viability step C: Multi-criteria decision-making process for subsurface development project management

Examples of project typology

|  | 1   | 2   | 3   | 4  |
|--|---|---|---|--|
|  |   |   |   |  |
| case (a)                                   | case (b)  | case (c)  | case (d)  | case (e)   |
| Traditional use; Simply above ground space | Normal use, making full use of above ground space and underground space | Reduce the height of buildings above ground; proper functions not sensitive to the sunshine is moved to underground space | Keeping the height of buildings, cut density above ground; proper functions not sensitive to the sunshine is moved to underground space | Reduce the height of buildings and cut the density above ground; most of proper functions not sensitive to the sunshine is moved to underground space. |
|  |   |   |   | From Prof. Zhu, Tsinghua Uni.  |

Subsurface development projects could meeting stakeholders' interests, including private and public sectors.  
→ From PLANNING to PERSONALIZATION!

✓ Decision matrix:

|        | Project 1 | Project 2 | Project 3 | Project 4 |
|--------|-----------|-----------|-----------|-----------|
| Zone A | -         | +         | +         | +         |
| Zone B | +         | +/-       | -         | o         |
| Zone C | -         | -         | +         | +         |
| Zone D | o         | -         | +/-       | o         |
| Zone E | o         | o         | +         | -         |



✓ BCOR analysis:  
Benefit, Cost, Opportunity, Risk

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## 1. URBAN SUBSURFACE institutional feasibility for implementation

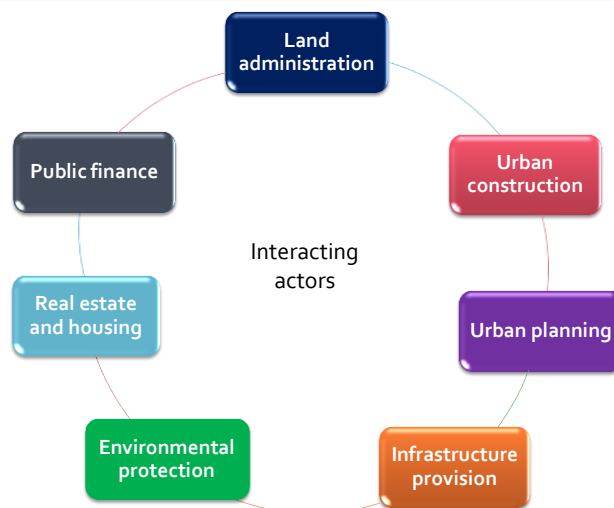
- **Constraints:**
  - +++ property rights and vertical ownership limits
  - ++ construction cost
  - + insufficient market information for investment
- **Objectives:**
  - For public stakeholder: optimize urban land use (long-term benefits)
  - For private stakeholder: business profits (short-term benefits)

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## 1. URBAN SUBSURFACE institutional network for implementation

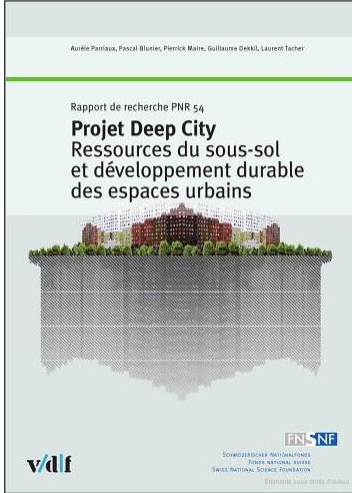


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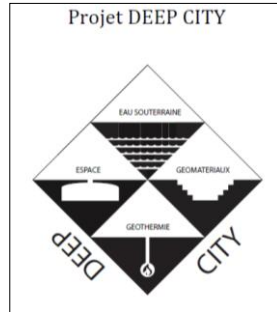
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## 2. UUR- Resources management international research projects



PROJECT N°1: Swiss national fund  
 PROJECT N°2: Sino Swiss Scie.& Tech. Cooperation

→ From theoretical development to practical application in 3D land planning!

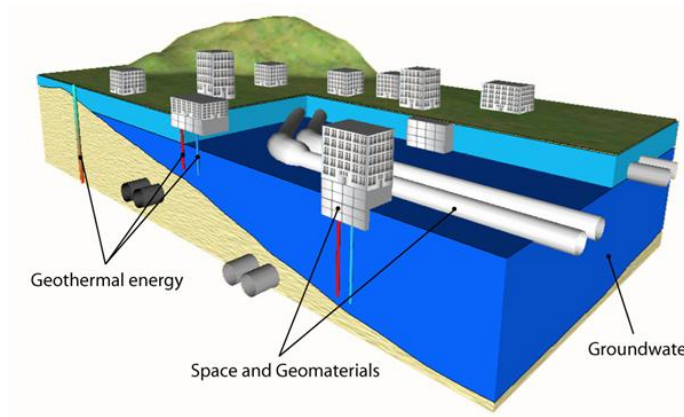


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## 2. UUR- Resources management Four main resources in the subsurface



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## 2. UUR- Resources management Issues

### Underground space use:

- Over-congested shallow subsurface
- Land subsidence with unplanned construction

### Groundwater exploitation:

- Over-exploitation of groundwater
- Pollution induced by underground construction

### Geomaterial excavation:

- Over quantity for landfill, wasting land resources
- Under-estimated potential for material reuse

### Geothermal energy:

- Disorder of geothermal probes (deep to 100m)
- Under-estimated potential for energy use

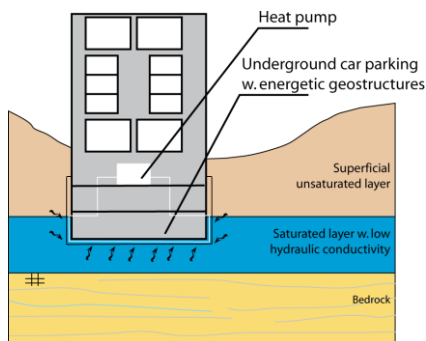
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## 2. UUR- Resources management Systemic thinking and governance

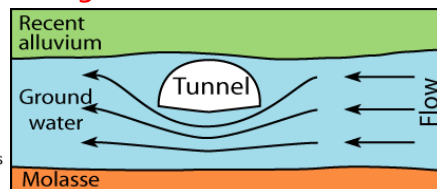
- Synergies : space and geothermic



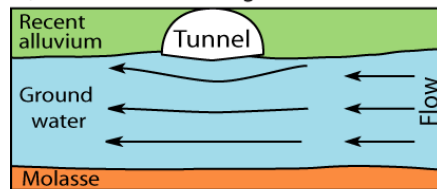
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- Conflicts: space and groundwater



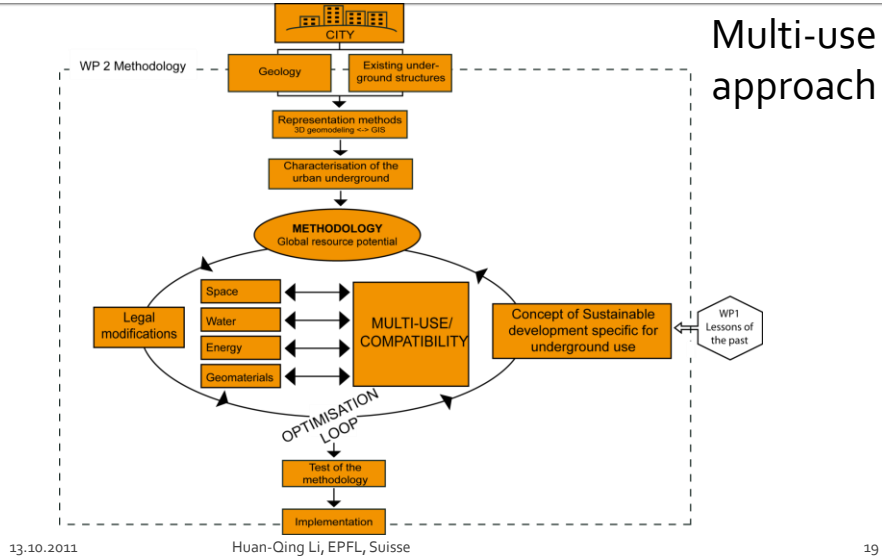
a) Tunnel is below the groundwater table



b) Tunnel is above the groundwater table

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# DEEP CITY METHODOLOGY



Thanks for your attention !