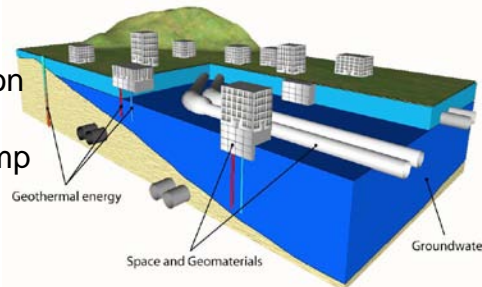
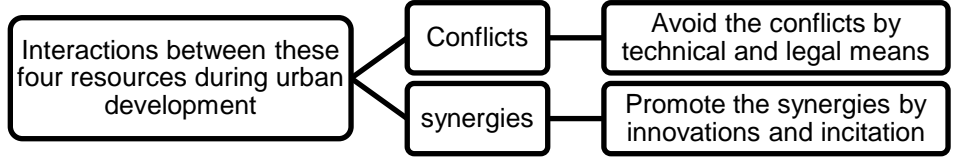


## UNDERGROUND RESOURCES MANAGEMENT

- There are four main natural resources below the urban surface for exploitation:
- Subsurface space: infrastructure and equipment constructions (examples on the left).
    - ❖ Values: surface open space preservation, efficient land use combined to conventional spatial planning, energy use reduction, environmental protection...
  - Excavated soil and rock material: recycling and reuse for in-situ construction needs.
    - ❖ Values: reduce landfill in urban area, natural mining and material transportation
  - Groundwater: drinking water use.
    - ❖ Values: meet the needs from increasing population
  - Geothermal energy: shallow ground source heat pump for building heating and cooling.
    - ❖ Values: renewable energy, reduce GHG



## FOR URBAN SUSTAINABLE DEVELOPMENT

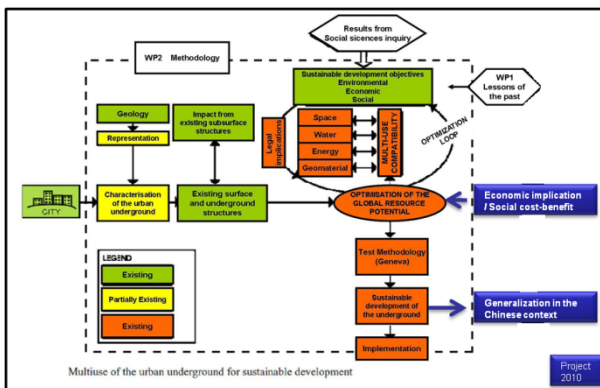


- ✓ Global potential evaluation by spatial analysis → understand the 3D territory
- ✓ Scenarios stimulation by multi-criteria analysis → aid the decision-making process
- ✓ Economic evaluation by cost-benefit analysis → justify long term investment
- ✓ Applicability experimentation by project testing → identify the various obstacles
- ✓ Coordination management by capacity building → reinforce the governance
- ✓ Sustainable urban planning by integrating underground dimension → maximize the locational and functional benefits, increase social networking, reduce environmental issues

### Contribution of urban underground infrastructure to the adaptation and mitigation for climate change:

- Adaptation to climate change impacts: stable temperature and secure place for natural hazards
- Mitigation of greenhouse gas emission: energy efficient services (metro, multi-purpose collectors)

## COMPARATIVE STUDY BETWEEN SWISS AND CHINESE CONTEXTS



Main conflicts from urban underground resources exploitation in Chinese big cities	Solutions proposed to urban planners
<b>Underground space congestion:</b> <ul style="list-style-type: none"> <li>• over-development of shallow subsurface by urban facilities and infrastructures</li> <li>• under-consumption of deep underground</li> </ul>	<ul style="list-style-type: none"> <li>• comprehensive underground space use planning</li> <li>• define subsurface property rights</li> <li>• create land registration system (3D cadastre) to favor subsurface land market emergence</li> </ul>
<b>Environmental issues:</b> <ul style="list-style-type: none"> <li>• groundwater contamination caused by pollutant infiltration during excavation operation</li> <li>• increasing landfill of excavated material from construction</li> </ul>	<ul style="list-style-type: none"> <li>• technical waterproofing methods during underground construction</li> <li>• define groundwater protection zones for drinking water to restrict the engineering operation</li> <li>• valorization of excavated material</li> </ul>
<b>Geological disasters:</b> <ul style="list-style-type: none"> <li>• land subsidence caused by engineering and water extraction</li> <li>• salt water intrusion in coastal area</li> </ul>	<ul style="list-style-type: none"> <li>• groundwater protection policy and risk control system</li> <li>• exploitation planning based on resource potential</li> </ul>

## PROJECT « DEEP CITY » FROM SWITZERLAND TO CHINA