"DEEP CITY" FOR URBAN SUSTAINABILITY

- ECONOMIC AND STRATEGIC ASPECTS

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OUTLINE

- The project — Deep City

- The concept — 3D urbanism

- The methodology — Integrated management framework

- The results — International case studies

1. THE PROJECT: DEEP CITY

Phase 1: 2006-2009

Research initiation

-Environment and underground resources

-Sociology and perception to use subsurface in urban area

-Subsurface building cost and life cycle cost estimation

Phase 2: 2009-2012

Concept specialisation

-Sustainability strategies for urban subsurface development

-Integrated planning process for policy implementation

-Economic implications and decision-making analysis

from theoretical development to practical application on urban planning → Multi-level

from urban sciences to strategic management → Multi-discipline

from 1 city to 2 cities, and more… → Multi-scale

2. THE CONCEPT: 3D URBANISM

a visionary solution to renew urban centers → regulation between densification and revitalisation

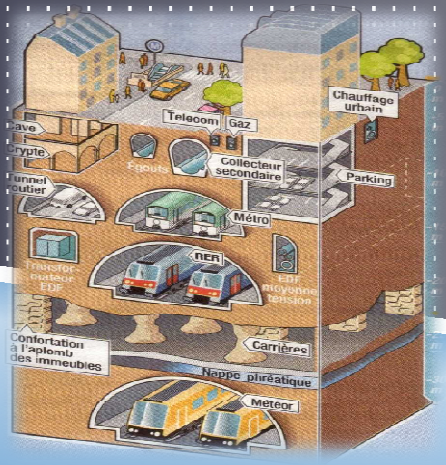
Urbanisation drawbacks:

population growth → Land scarcity → Land use competition (among residential, commercial, infrastructure, park, etc.)

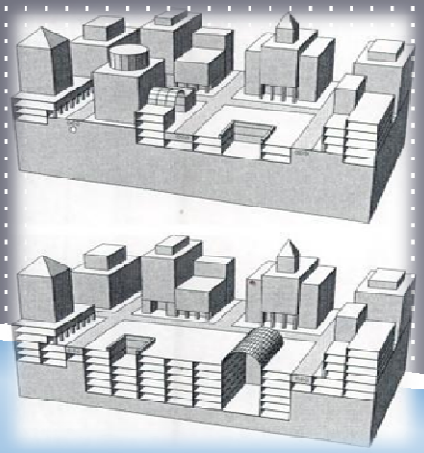
Challenges?

- Public infrastructures (utility, transport)
- Commercial and recreational space
- Housing and office space supply
- Public space and greenery

Underground infrastructures × Underground buildings = Densification + Revitalisation

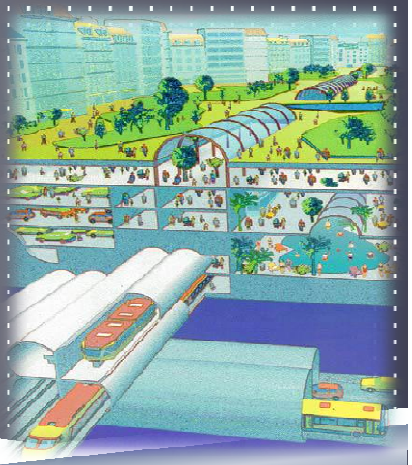


(Duffaut, Paris, 2010)



(Carmody, US, 1993)

(Montreal, Canada)



(Sapporo, Japan)

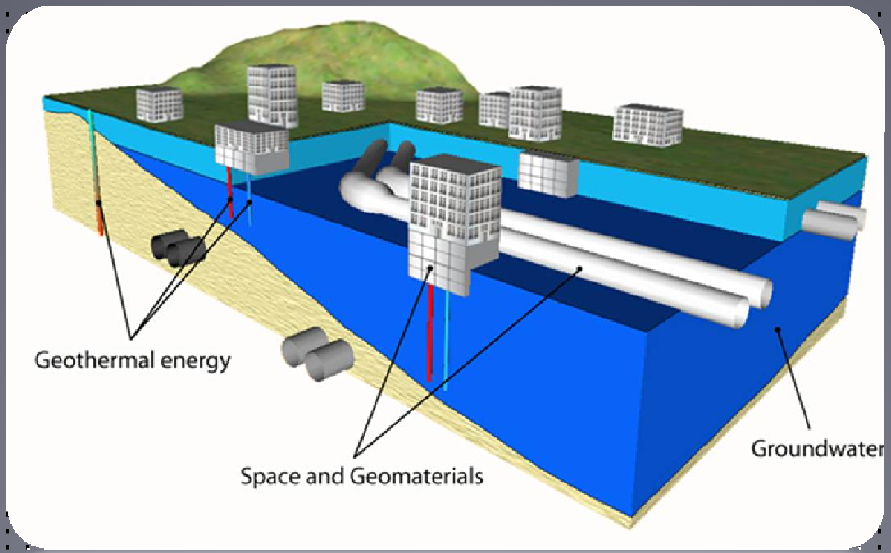
2. THE CONCEPT: 3D URBANISM

- Resources-based 3D urbanism:

identify "resources reservation area", no construction project authorized "resources zoning"(groundwater, ground source, aggregate extraction)

- Institution-based 3D urbanism:

identify urban demand potentials, involve public and private stakeholders, create value chain, formulate underground project development strategies, stimulate economic growth

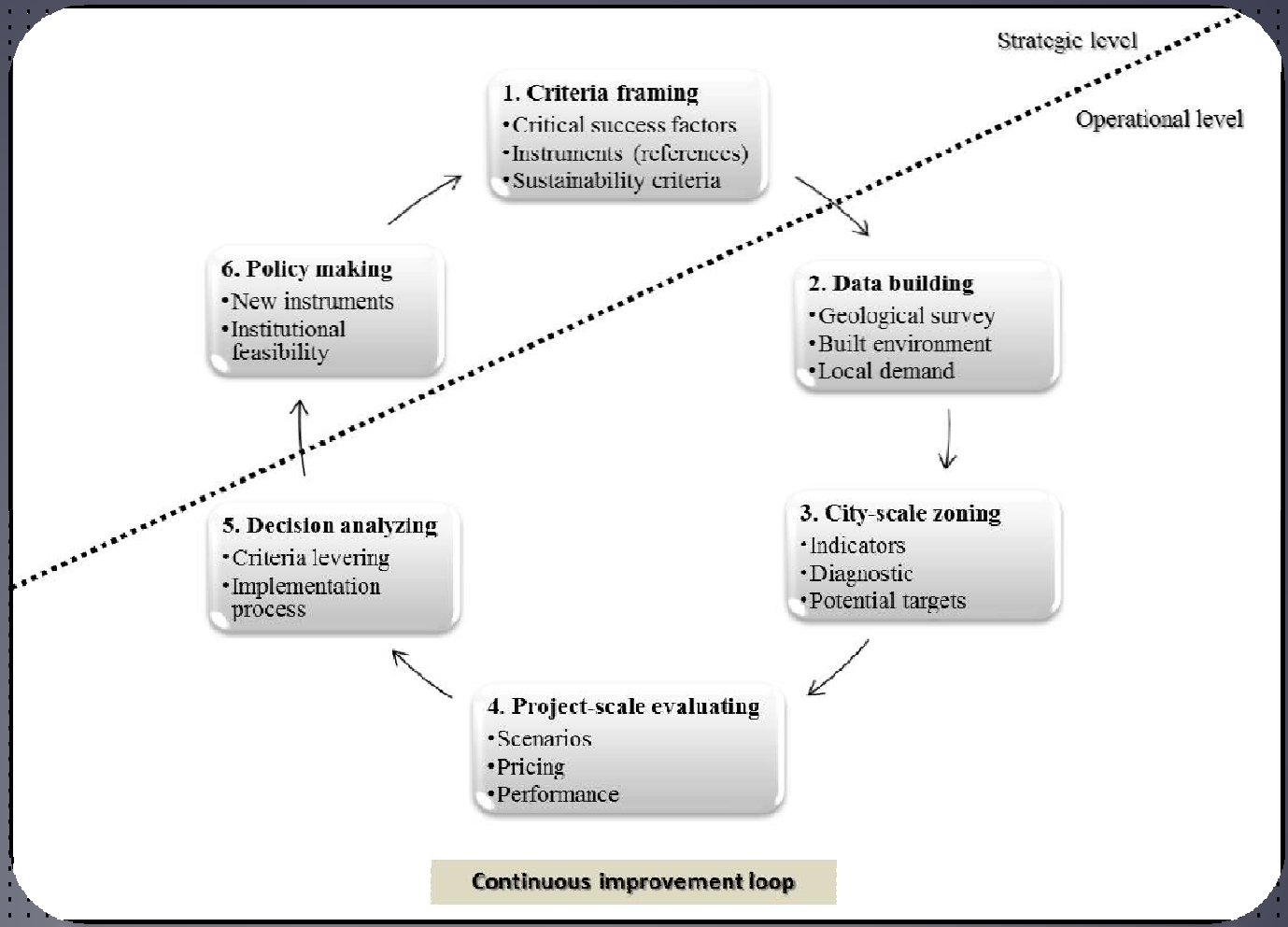


(Parriaux A., Deep City project)

3. THE METHODOLOGY: INTEGRATED MANAGEMENT FRAMEWORK

Interative process

- Critical factors
- Local diagnostic
- Potential zoning
- Project indicators
- Scenario analysis
- Policy instruments



3. THE METHODOLOGY: INTEGRATED MANAGEMENT FRAMEWORK STEP1 FACTORS

5 cities are selected to represent underground management trend around the world:

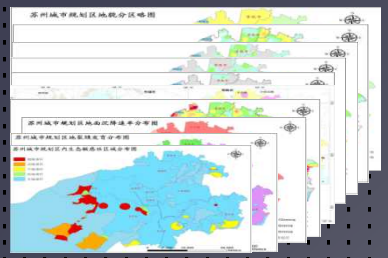
Cities	Amsterdam 1.5 million hab. (2011) Density: 3561 hab./km2 GDP/capita: $46'914 (2011)[1]	Montreal 3.8 million hab. (2011) Density: 4517 hab./km2 GDP/capita: $46'235 (2011)	Tokyo 13 million hab. (2011) Density: 6030 hab./km2 GDP/capita: $42'831 (2011)	Helsinki 1.3 million hab. (2011) Density: 2755 hab./km2 GDP/capita: $44'512 (2011)	Paris 11 million hab. (2011) Density: 3640 hab./km2 GDP/capita: $39'459 (2011)
Strategic plans	AMFORA (Alternative Multifunctional Underground Space Amsterdam)(Rein 2009)	Indoor City Master plan (Boisvert 2004)	Deep Space Utilization Law (Nishioka, Tannaka et al. 2007)	Underground Master Plan (VÄHÄAHO 2009)	Development Program (Ville 10D) (Labbé 2011)
Milestones	• 1998 policy initiation for assessing "undergroundisation" possibility(Monnikhof, Edelenbos et al. 1998) • 1999 policy application on Great Randstad spatial planning revision(Monnikhof, Edelenbos et al. 1999) • 2008 mainstream into Amsterdam Action Plan Healthy City	• 1960s conception and initiation • 1970s network expansion (RESO) • 1980s maturity with functions (commerce, mobility, institution, office, culture)(El-Geneidy, Kastelberger et al. 2011) • 1992 adoption of Master Plan • 2002 revision of Master Plan	• 1955 construction of large volumes of underground shopping arcades • 1965 "Golden age" • 1980 regulation restriction • 1988 promotion of effective land use with subsurface • 2000 new legal system(Japan Tunnelling, Takasaki et al. 2000)	• 1955 database building (Real Estate Department 2005) • 1996 initiation of feasibility study for underground space(Rönkä, Ritola et al. 1998) • 2006 working group on 3D property cadastral system • 2009 adoption of rock space Master Plan	• 1972 initiation study for underground urbanism(Utudjian 1972) • 1995 feasibility research for underground urbanism(Barles and Guillerme 1995) • 2005 policy initiation for sustainable subsurface use • 2010 action plan of "Ville 10D"
Large projects	• Planned 50km long 6-level tunnel space under city canal, 1 million m2 floor space per layer, integrated with heat pump system, zero energy input for heating and cooling, zero surface land use	• Existing indoor pedestrian network, 32km long, connecting 56 buildings and 10 stations • Planned continuous expansion with International District (QIM)	• "Geo-grid" project, hybrid underground city plan(Miyake and Denda 1993) • Central district regeneration with underground space use(Omura and Kawachi 2007)	• Central car park extension linking transport to commercial area • Large water plant facility under resident area(Ilkka 2011)	• Planned Metro Arc Express project (Paris) • Renewal project of central station complex Les-Halles(Geburtig 2011)
Capacity building and collaborations	• COB (Netherlands Knowledge Center for Underground Space and Construction) • TUD (Delft University of Technology) • RPD (National Physical Planning Service) • Ministry of Housing, Spatial Planning and Environment(Edelenbos, Monnikhof et al. 1998)	• OVI (L'Observatoire de la Ville Intérieure) • University of Montreal • City Council of Montreal • Association of owners (ARQIM) • CNR (Canadian National Railway) • STM (Société de Transport)(Besner 1997)	• USJ (Urban Underground Space center of Japan) • JTA(Japan Tunneling Association) • Investigation Committee for Deep Underground Space use • (MITI) Ministry of International Trade and Industry(Tetsuya 1990) • Urban Development Department • National Land Policy Institute	• Helsinki City Real Estate Department • Geotechnical division • Ministry of Environment • Land use department • Ministry of Agriculture and Forestry (3D cadaster)	• Underground Space Committee (AFTES) • Regional Economic and Social Council • Ministry of Ecology, Energy and Sustainable Development • IREX (Institut de la Recherche appliquée et l'Expérimentation en genie civil)
Methodological application and instruments	• Layered land planning and area mapping • Multi-criteria decision making process • Economic valuation for resources	• Public-private partnership(Boisvert 2007) • Land use rights and incentives (Besner 2007) • Layered planning and inventory (Boivin 1989; Boivin 1990)	• Legalization of deep space • Planning method for zoning(Barles and Jardel 2005) • Numbers of building investigations and social surveys (Nishi, Kamo et al. 1990; Nishida and Uchiyama 1993; Nishida, Fabillah et al. 2007; Okuyama 2007)	• Detail mapping of existing & planned facilities and potential geo-space(Chow, Paul et al. 2002; Paul, Chow et al. 2002) • Public acquisition of land • Legalization of underground (rock) space utilization	• Economic valuation for subsurface use right(Barles 2000) • Integration with existing planning instruments(Barles 1999) • Sustainability indicators(M. Deffayet and d'Aloia-Schwartzentruber 2011)

Key success factors:

1. Strategic level in city planning
2. Advanced databank building
3. Co-development of ug.infrastructure and ug.building
4. Institution for urban subsurface
5. Public-private Collaboration
6. Economic and legal feasibility
7. Social survey to support projects

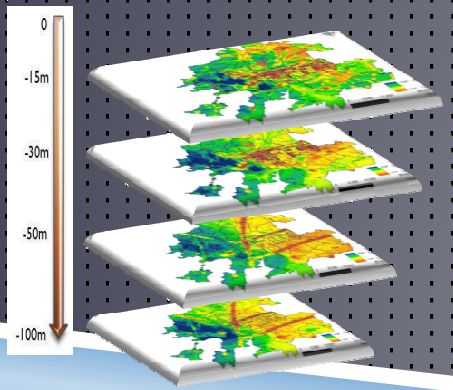
CASE STUDIES

3. THE METHODOLOGY: INTEGRATED MANAGEMENT FRAMEWORK STEP 2 DATA

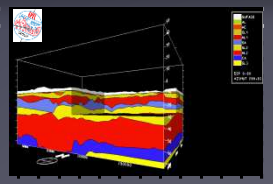


10 determinants for supply capacity

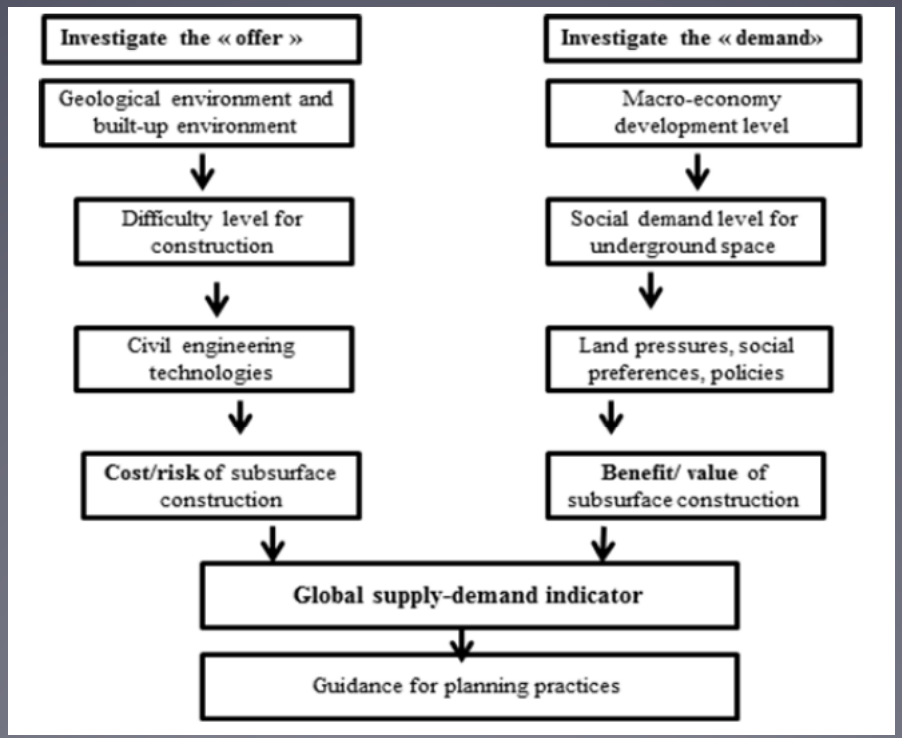
Geomorphology, hydrogeology, sensitive soil, engineering difficulty, subsidence, hazard, heritage zone, ecological zone, existing foundation, existing utility lines

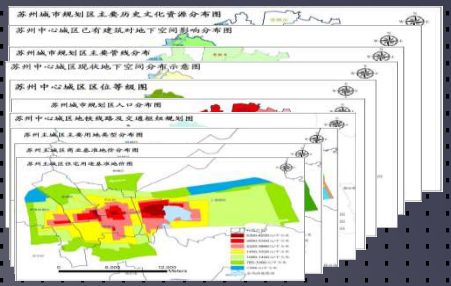


Layered mapping for supply potential



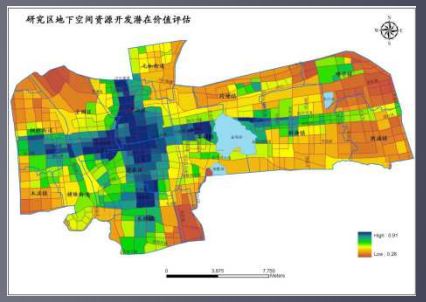
Pilot city





10 determinants for demand forecast

Population density, transit lines, commercial and residential land price, land use type, priority zone, civil shelter zone, historic zone, etc



Mapping for demand potential

Operation for databank building:

Time for data collection: 2 years
Time for data analysis with GIS: 1 year
Special working group for survey and multi-criteria analysis
Several governmental reporting meetings
Output: a webGis platform for information sharing

CASE STUDIES

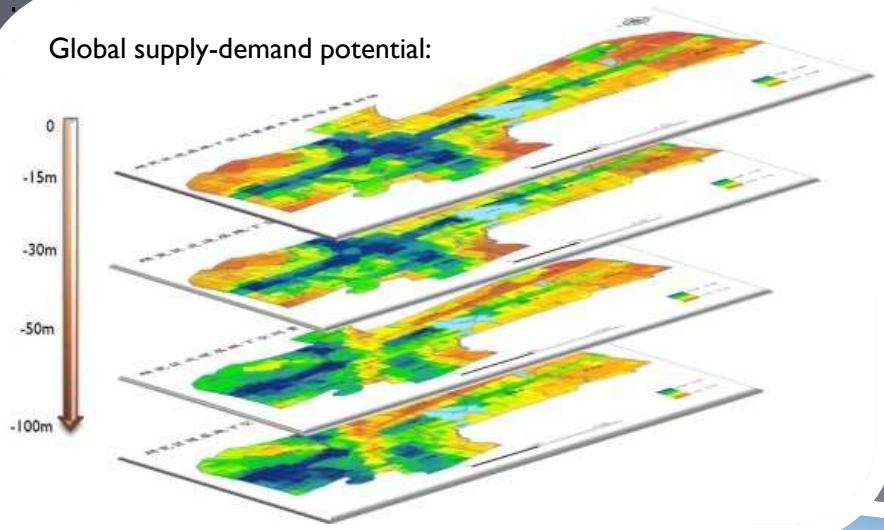
integrated supply-demand indicator	0-15m	use coefficient	15-30m	use coefficient	total volume by level	useful ratio by level
very high potential area	3.11	0.6	2.50	0.4	5.61	8.03%
high potential area	3.54	0.4	2.78	0.2	6.32	9.04%
moderate potential area	2.30	0.2	1.89	0.1	4.19	6.00%
low potential area	0.24	0.1	0.15	0.05	0.39	0.55%
useful volume_100mio m3	9.20		7.31			
total volume_100mio m3	27.95		41.92		69.87	
useful ratio by depth layer	32.90%		17.43%		50.33%	
equivalent floor area_km2	230.00		183.75		413.75	*(if floor height = 4m)*

* Supply forecast:
(based on current technology)
→ 413 km2 floor area for shallow subsurface (0-30m)

Floor Area Ratio	1.00	2.00	3.00	4.00	5.00	6.00
total urban area (km2)	279.50	279.50	279.50	279.50	279.50	279.50
construction land use (50%)	139.75	139.75	139.75	139.75	139.75	139.75
floor space demand (km2)	139.75	279.50	419.25	559.00	698.75	838.50
"undergroundisation" rate	0.02	0.10	0.20	0.29	0.38	0.47
underground floor space (km2)	2.80	27.95	83.85	160.25	263.20	391.30

* Demand forecast:
Compact city trend with underground densification rate to support growth
→ 400 km2 floor area with 50% underground space share

Global supply-demand potential:



City-scale zoning for subsurface construction:
(to be legalized in land use planning)

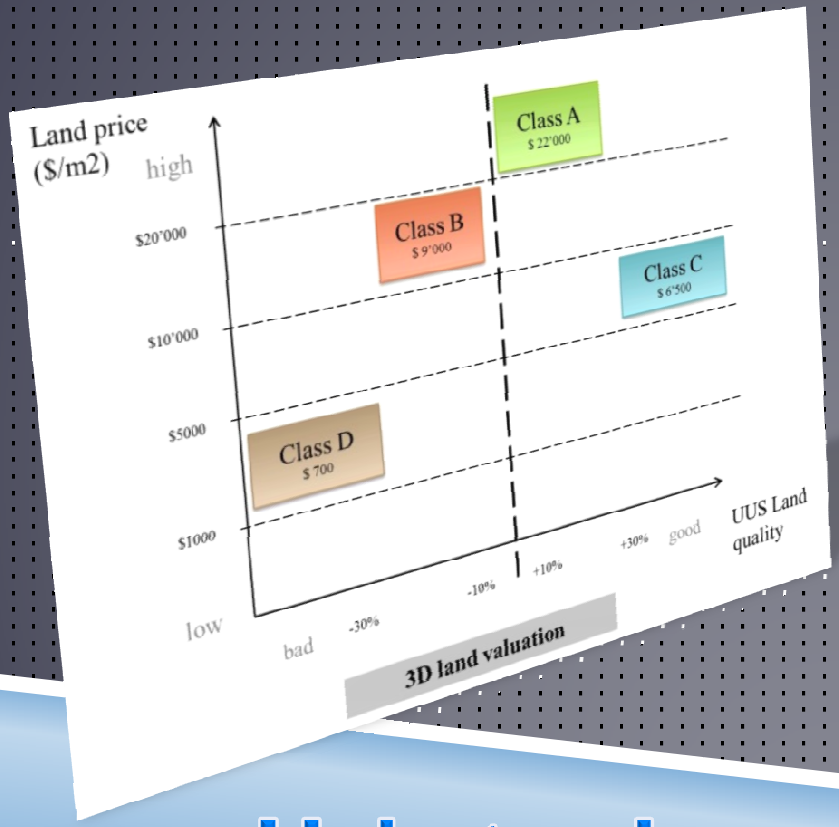
- Very high potential zone
- High potential zone
- Moderate potential zone
- Low potential zone

CASE STUDIES

How to reveal investment interests on underground building project?

New indicator: 3D Land value with "underground premium"

→ Choosing a high potential land parcel for real estate project, construction cost is lower, demand level is higher, leading to a higher integrated land value.

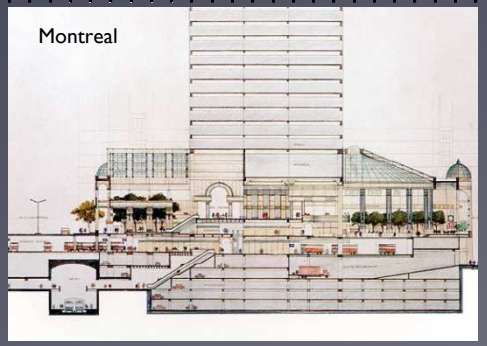


3D land value ($/m2)		UUS land quality coefficient			
Class	land price	-30%	-10%	10%	30%
A	20000	14000	18000	22000	26000
B	10000	7000	9000	11000	13000
C	5000	3500	4500	5500	6500
D	1000	700	900	1100	1300

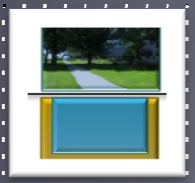
Help to choose the land parcel…

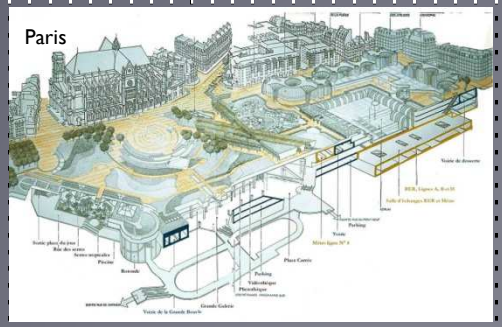
CASE STUDIES

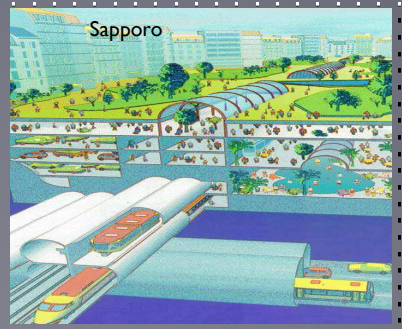
Densification



Revitalisation





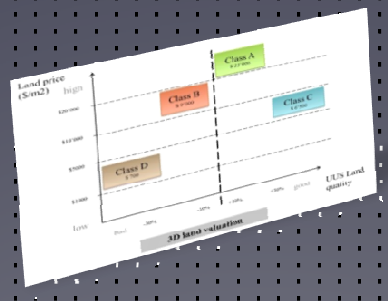


CASE STUDIES

Help to choose the project type…

Criteria for project investment:

Main criteria	Sub-criteria
Cost	construction cost
	energy consumption
	compensation payment
Benefit	business revenue
	improve life quality
	environmental renewal
Opportunity	geothermal system
	material recycling
Risk	groundwater quality
	subsidence



Land development return levels:

Land class	A	B	C	D
Cost	<<	0	<	>>
Benefit	>>	>>	>	0
Opportunity	>	0	>>	0
Risk	0	<	0	<<
score	1	1	2	0

Underground building Scenarios:

	Density type	Revital type
Class A	Scenario 1	Scenario 2
Class B	Scenario 3	Scenario 4
Class C	Scenario 5	Scenario 6
Class D	Scenario 7	Scenario 8

Project performance and the importance to sustainability criteria:

Land class	**A**		**B**		**C**		**D**	
Example	historic center		business district		new development area		mixed area	
Scenarios	1	2	3	4	5	6	7	8
Economic growth	>>	>	>>	>	>>	>	>>	>
Social welfare	0	>>	>	>>	>>	>	<	>>
Environment	>	>>	>	>>	>	>>	<	>
Authority	>	>>	>>	>	>>	>>	0	>>
Performance index	5	8	7	7	8	7	0	7

Historic center: "revitalisation" type

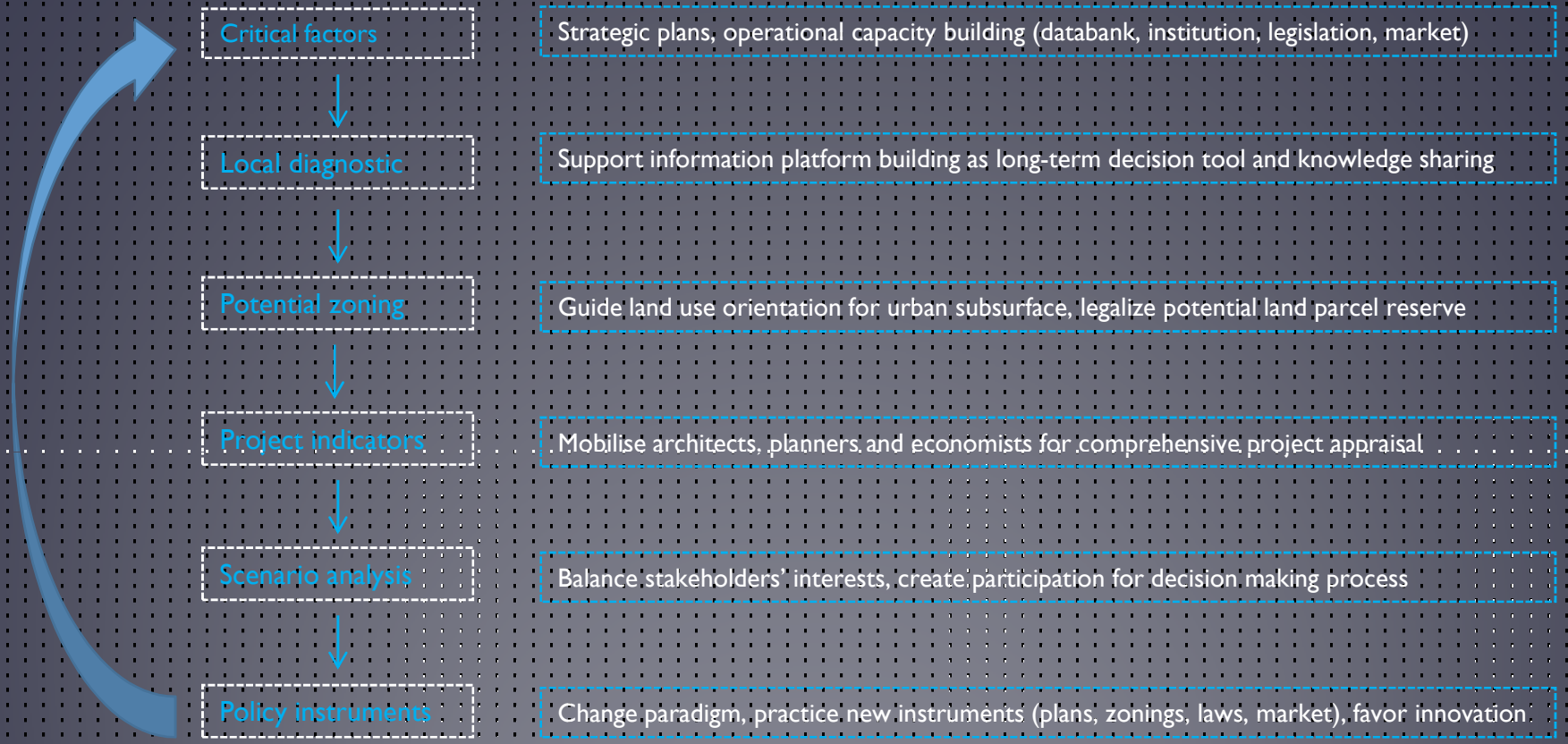
Business center: both types can contribute

New dev. area: "densification" type

Mixed area: Density may not be a good option

key:		score:	
<	diminished weight of the criteria	<	-1
<<	stronlgly diminished weight of the criteria	<<	-2
0	unchanged weight of the criteria	0	0
>	increased weight of the criteria	>	1
>>	strongly increased weight of the criteria	>>	2

3. THE METHODOLOGY: INTEGRATED MANAGEMENT FRAMEWORK STEP 6 POLICY



THANKS FOR YOUR ATTENTION