*RUEG2016, Huddersfield, Feb.3-5 2016*

# SUSTAINABILITY:
# 10 REASONS TO REVISIT THE SMALL SCALE, LOW-DENSE CITY

## Urban planning, climate and energy policy

**Chris Butters, Ali Cheshmehzangi**

c.p.butters@warwick.ac.uk

*EPSRC funded 3 year research program, Energy and Low Income Tropical Housing. Partners in China, Thailand, Uganda, Tanzania*

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# 10 REASONS TO REVISIT THE SMALL SCALE, LOW-DENSE CITY

1. Inhabitant Density / Land Use
2. Microclimate and Green Space
3. Infrastructures and transport
4. Renewable Energy Supply
5. Buildings Typology
6. Operational Energy/Carbon
7. Embodied Energy/Carbon
8. Recurrent EE/EC
9. Post-Use Impacts
10. Resilience

*Also: «new» conversations in the area of social sustainability:*

*-- participation (Agenda 21)*
*-- governance / transparency*
*-- closeness/trust (Nordic model)*

*The issue of «small-ish scale» raises relevant questions at all levels, from single building to neighbourhood to town.*

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# 1. Population density / land use

| Urban Typology | SC | FAR | Average height |
|---|---|---|---|
| 1.Ningbo low-dense traditional | 0.50 | 1.4 | 2.4 |
| 2.Ningbo 6 storey block | 0.23 | 1.2 | 5.0 |
| 3.Ningbo high-rise block | 0.17 | 2.6 | 15.5 |
| 4.Jinan low-dense traditional | 0.54 | 1.2 | 2.2 |
| 5.Jinan grid 1920s | 0.31 | 1.7 | 5.8 |
| 6.Jinan enclave 1980s | 0.34 | 1.8 | 5.3 |
| 7.Jinan superblock 1990s | 0.22 | 2.0 | 10.1 |
| 8.Europe, detached housing | 0.10-0.30 | 0.2-0.7 | 1.5-2.5 |
| 9.Europe, row/terrace housing | 0.15-0.35 | 0.5-1.0 | 2.0-3.0 |
| 10.Europe compact city block | 0.35-0.55 | 1.5-4.0 | 4.0-6.0 |
| 11.Europe slab housing | 0.15-0.40 | 0.6-2.0 | 3.5-6.5 |
| 12.Europe modernist high-rise | 0.10-0.25 | 1.0-2.5 | 8.0-14.0 |

## Urban Density Comparisons

Sources: Ningbo [7], Jinan [8] Europe [6].

Densities (dph) are **HIGHER** in traditional European cities such as Berlin, Istanbul or Paris than in the high-rise model

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# 1. Population density / land use

Courcelles, Paris: SC 57, FAR 4.88
S/V 0.11 SC 57. Source: LSE/Eifer

***Very high FAR in typical European city blocks.***

***Requires large public spaces fairly nearby***

***"Big, compact city" has no particular advantage for dph***

Zafer, Istanbul: SC 55; FAR 3.14
Source: LSE/Eifer

# 2. Microclimate and Green Space

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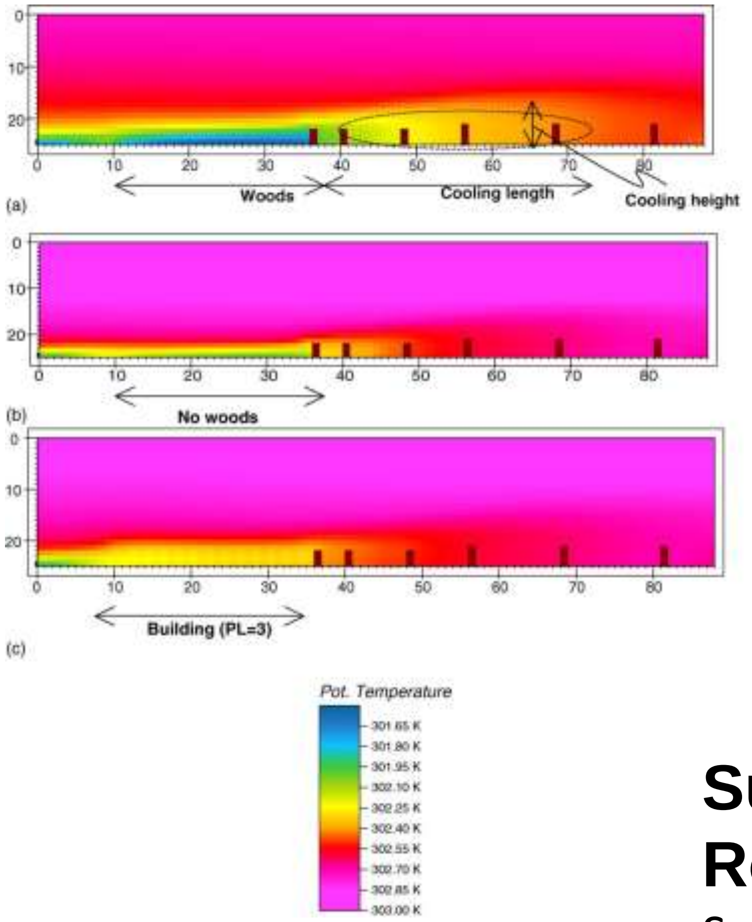
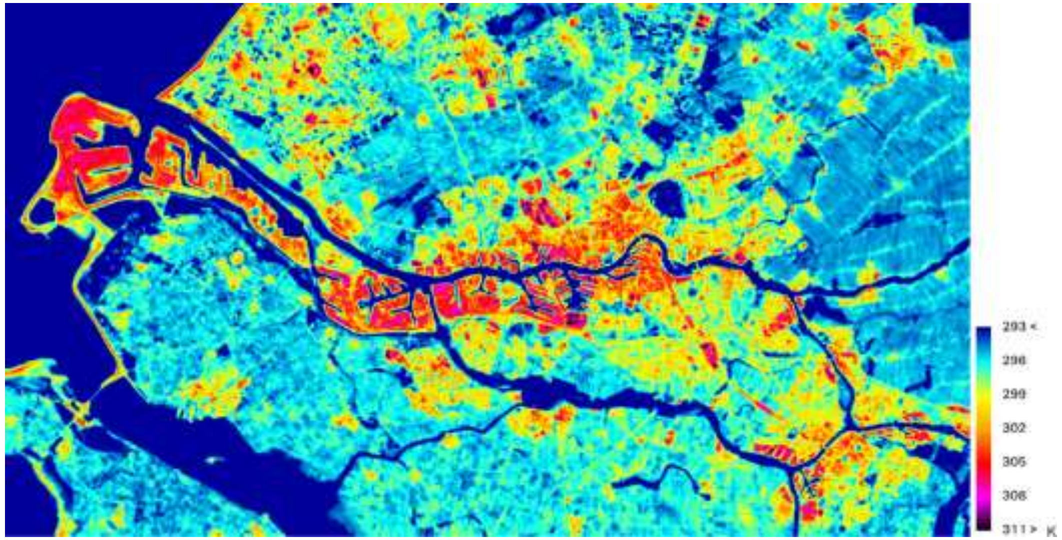



## Urban Heat Island Effect and Green Spaces:

Comparison of section views of scenarios with woods (top), without woods (middle), and with buildings replacing woods (bottom) at 00:00 h.
Source: Chen Yu, Wong Nyuk Hien, *Thermal benefits of city parks*, Energy and Buildings 38 (2006) 105–120).

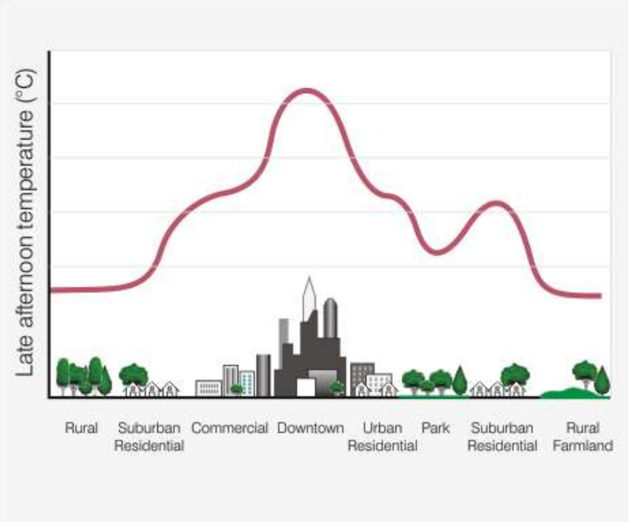
## Surface temperatures, Rotterdam

Source: Resources, Conservation and Recycling 64 (2012) 23– 29



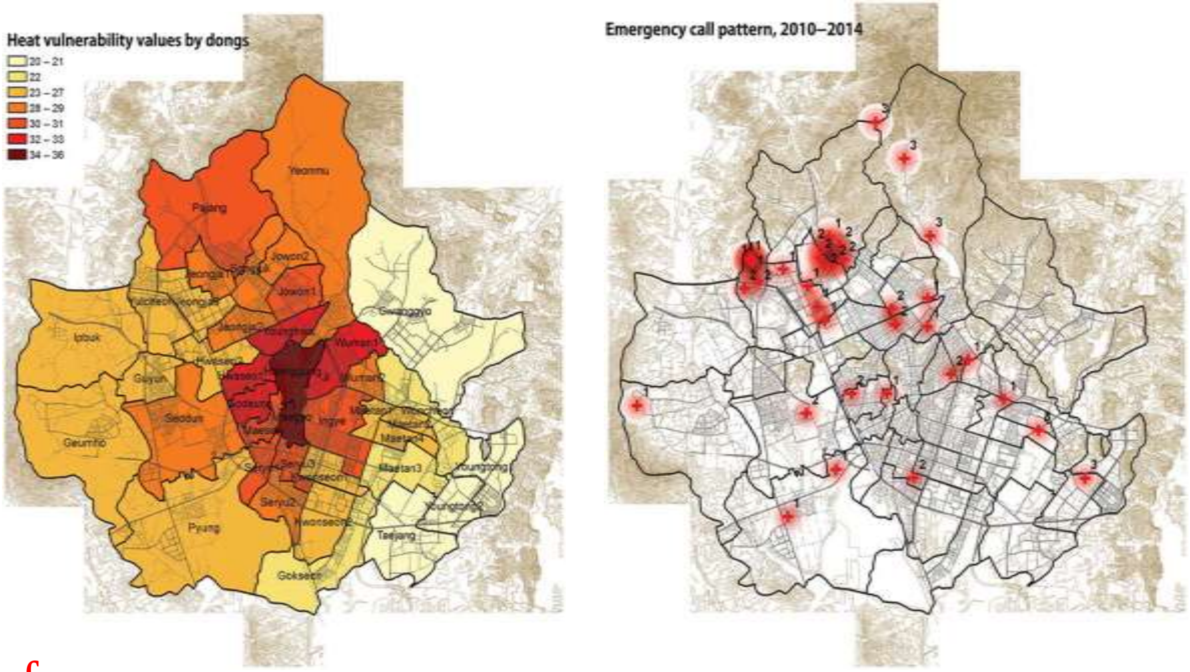
# 2. Microclimate and Green Space

Dense compact cities generally create an unfavourable urban microclimate including rising energy use and pollution as well as increasing heat island effect, heat stress and mortality



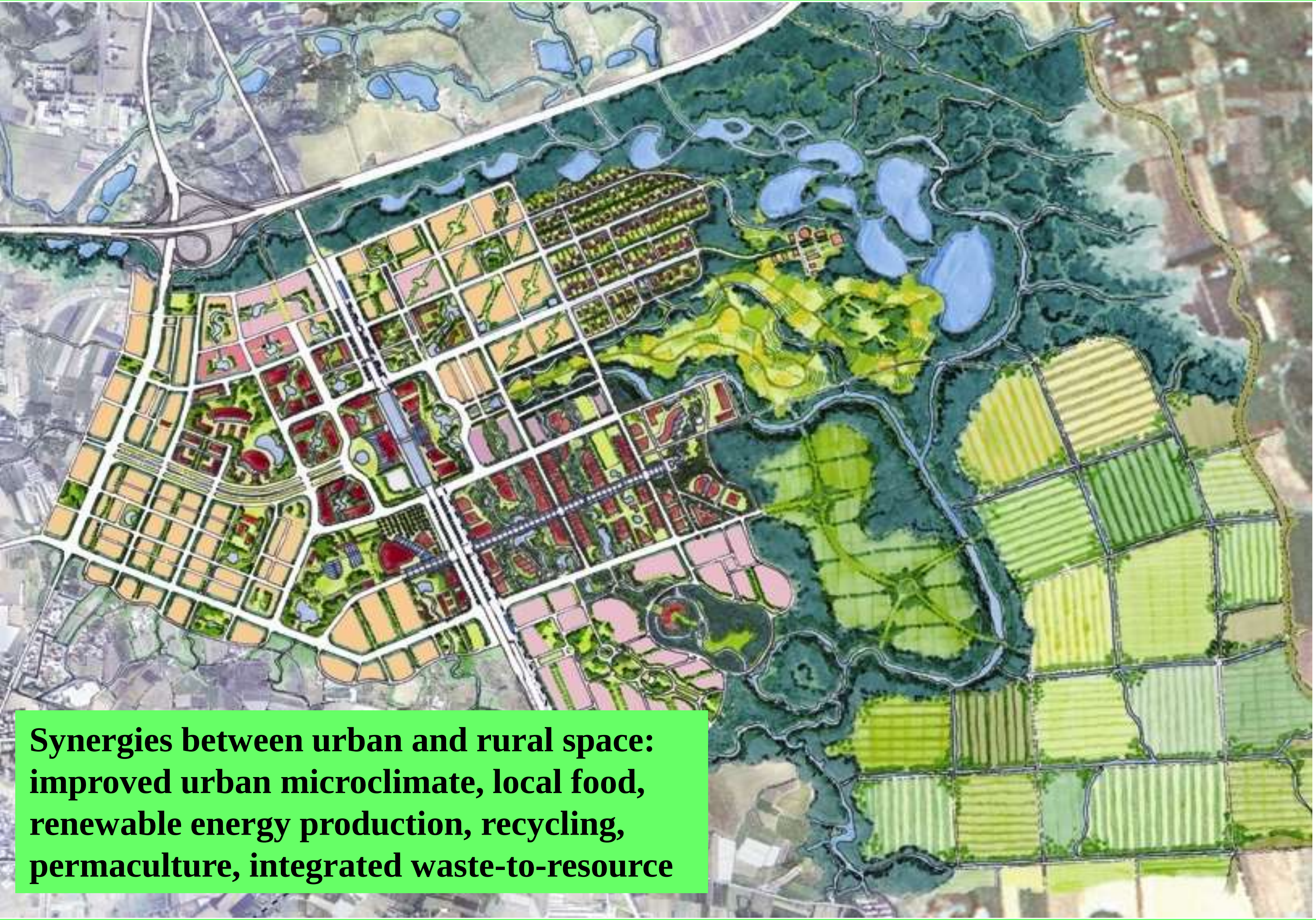

**Type I: high-rise building complexes with large in-between open space**

"type I sites were a hotspot of multiple emergency calls"




## *Heat vulnerability – Suwon, South Korea*

Saehoon Kim & Youngryel Ryu, *Describing the spatial patterns of heat vulnerability from urban design perspectives*. International Journal of Sustainable Development & World Ecology, Vol. 22:3, 2015



Synergies between urban and rural space: improved urban microclimate, local food, renewable energy production, recycling, permaculture, integrated waste-to-resource

*Master design by:*
*Archilife / EDS /*
*GAIA International.*
*Eble/Bokalders/Butters*

**台灣**
**生態城市**

**永續城鄉模型**

- **ecology**
- **economy**
- **community**

# 3. Infrastructures and transport

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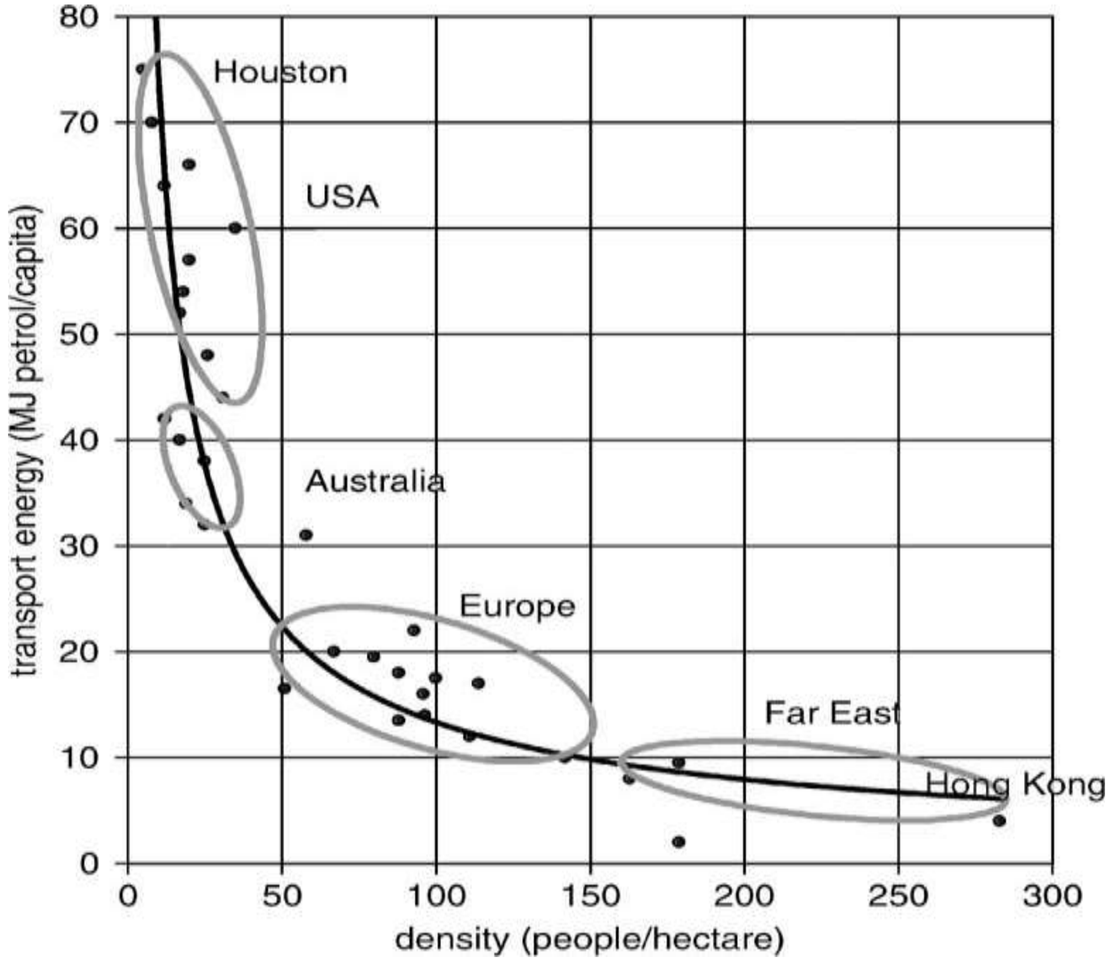


**Transport energy vs. urban density for 32 cities – where is the best balance between the extremes of sprawl and congestion ?**

**from: (17), originally Newman & Kenworthy 1989.**

*Alternative solution: French style parking !*

# 3. Infrastructures – carbon footprint

| | t | $CO_2e$/kg | t $CO_2e$ | kg $CO_2e/m^2$ |
|---|---|---|---|---|
| The buildings: | | | | |
| Total floor area 180,000 $m^2$ | | | 144,000 | 800 |
| | | | | |
| The site infrastructures: | | | | per $m^2$ building |
| RC approx. 42,000 $m^3$ 63000 | 100,800 | 0.2 | 20,160 | 112 |
| All other site works +7% of 1,000 | | | | 70 |
| Total (per $m^2$ of floor area) | | | | 182 |

**Infrastructures as % of total Embodied carbon:**

**182/(800+182): 18,5%**

**If low carbon buildings, this could become well over 30**

Paper: ***Embodied carbon of the infrastructures and site works in a high-rise residential urban block, Ningbo, China.***

Butters & Cheshmehzangi (2015)

**= 20-30% of total EE/EC**

**Infrastructures (esp. underground parking): low embodied carbon solutions are near impossible in dense inner cities**

# 3. Infrastructures – carbon footprint

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***High-rise residential urban block, Ningbo***
***FAR: 2,6        SC: 18%***
*(older 6-storey housing) >>>*

# 4. Renewable Energy Supply

***<< Plus-energy housing, Freiburg – since 2004***
***[www.rolfdisch.de](http://www.rolfdisch.de)***

***Solar Amersfoort, NL >>***
*«solar access for all buildings is possible up to about FAR 1,6-1,8»*

***In low-dense settlements, 100% of energy needs can often be covered with on-site renewable energy sources***
***- - - - but NOT in compact cities***

*but not urban windmills !*

# 5. Buildings typology and design

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*climatically very inefficient (unintelligent!) design*

**Dense city typologies narrow the choices for good building design, eliminating recognised, climatically favourable solutions. Examples:**

**---in inner cities one cannot choose climatically favourable sites or building orientation**
**---one cannot use courtyards, sunscoops and similar vernacular solutions to create improved microclimate**
**---local materials will be less applicable**
**---building services and shafts, for ventilation, lifts, stairs, etc, take up excessive amounts of costly space in high-rise buildings**
**---lightweight materials, favourable in hot-humid climates, are not feasible in high-rise dense cities**
**---in low-income contexts, complex urban buildings are expensive and also render self-build or user-led maintenance impossible.**

# 5. Buildings typology and design

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**Most of the megacities are in hot climate, developing countries**

Sukhumvit, Bangkok / Butters

**High quality dense city may be fine, but LOW COST "compact city" may be little better than vertical slums**

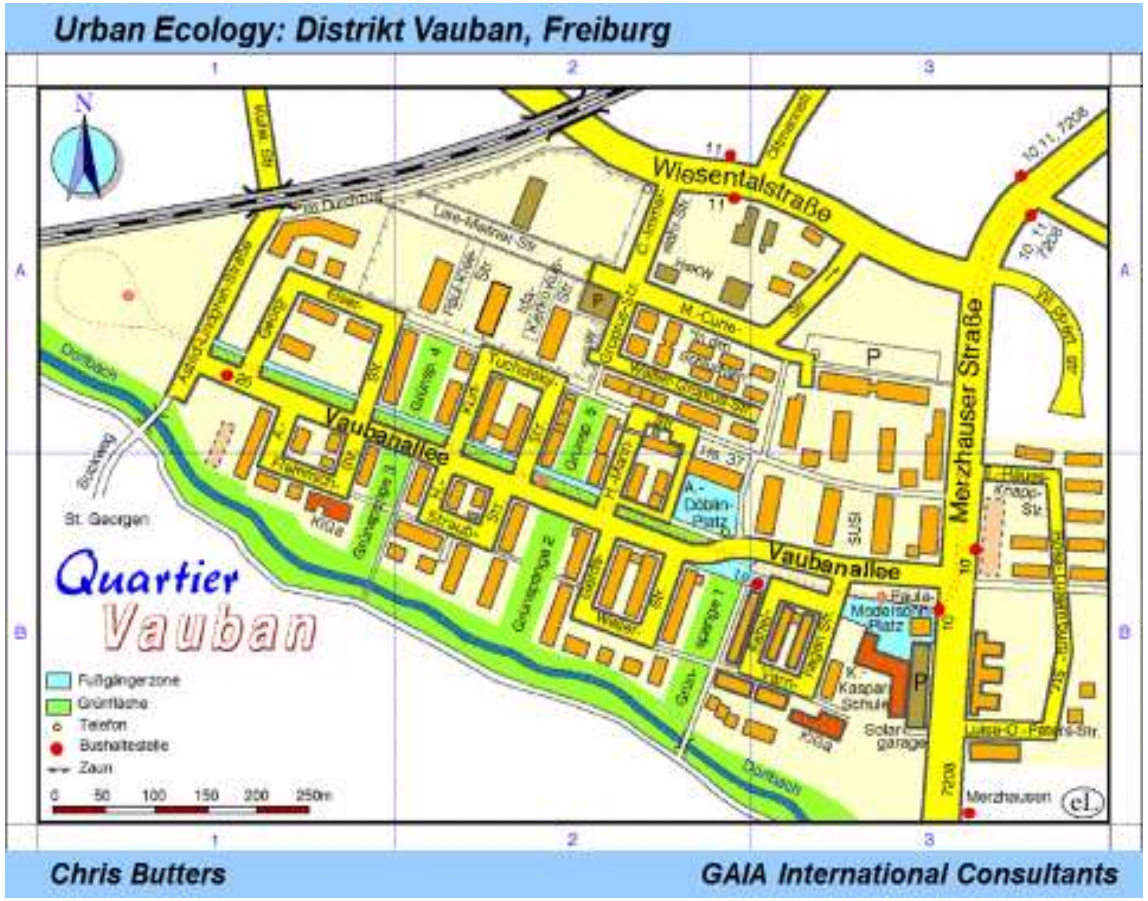
Sham Shui Po Kowloon, Aaron.Tam/AFP/Getty Images

# 6. Operational energy

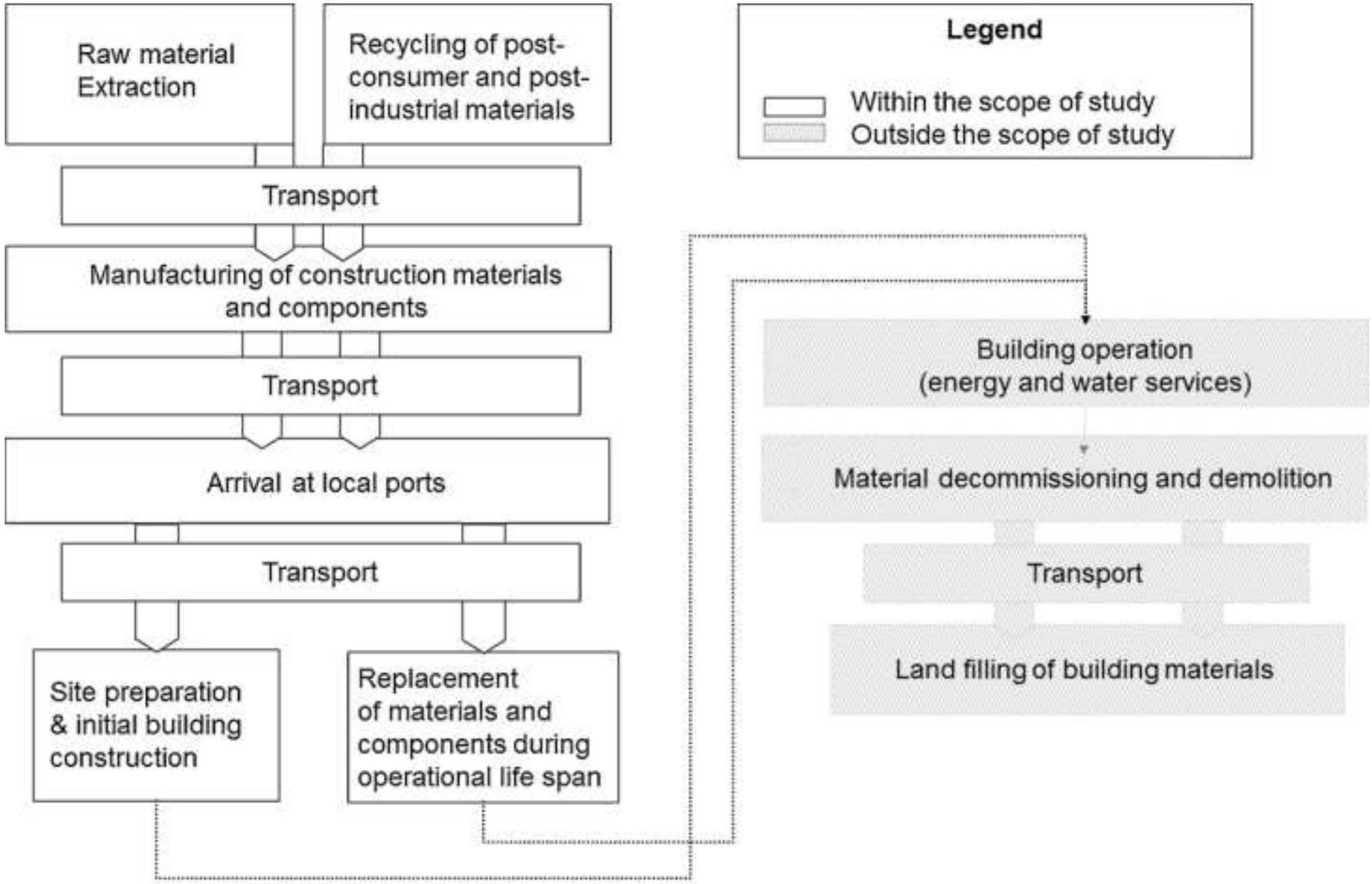
***Ecocities: Distrikt Vauban, Freiburg***
[www.vauban.de](http://www.vauban.de)

***Low-dense form offers very high thermal energy efficiency***

***All 3 SD areas of ecology, economy and community***



# 7. Initial embodied energy/carbon




Note: Carbonation has also been accounted for over the life time of the concrete products but has been omitted from the figure for clarity.

***Embodied energy/carbon:***
***-initial***
***-operational***
***-recurrent***
***-post-use***

C.K.Chau, W.K.Hui et al., *Assessment of CO2 emissions reduction in high-rise concrete office buildings using different material use options*. Resources, Conservation and Recycling 61, 2012

***«Inner city» type buildings tend to have far higher embodied energy/carbon***

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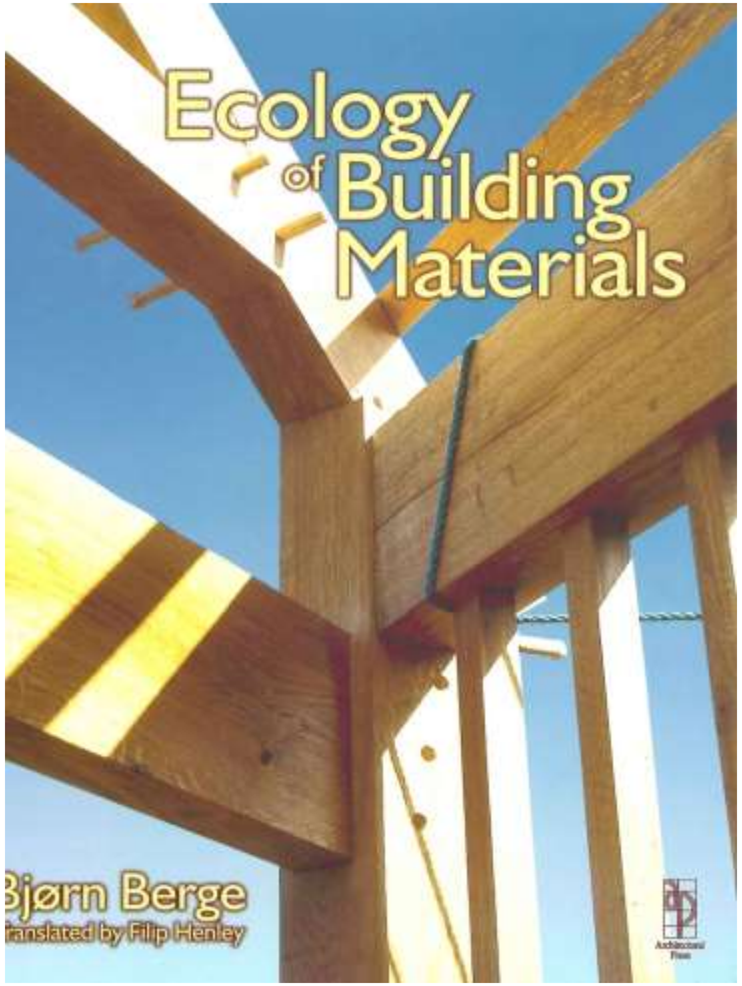
# 7. Initial embodied energy/carbon

## EMBODIED CARBON: MATERIALS

**In many buildings, RC and steel comprise by far the major part of the total carbon footprint**

| Concretes + steel: | | source: |
|---|---|---|
| Sweden, 4-storey office | 81% | (29) |
| Italy, 6-storey apartmentS | 76% | (30) |
| China, high-rise office | >70% | (31) |

29. Wallhagen W, Glaumann M, Malmqvist T. ***Basic building life cycle calculations to decrease contribution to climate change - Case study on an office building in Sweden***. Building and Environment 46, 2011.
30. Blenghini G. ***Life cycle of buildings, demolition and recycling potential: A case study in Turin, Italy.*** Building and Environment 44:319–330, 2009.
31. Xiaocun Zhang, Fenglai Wang. ***Life-cycle assessment and control measures for carbon emissions of typical buildings in China***. Building and Environment 86:89-97, 2015




*Bjørn Berge, GAIA Norway*
*Bygningsmaterialenes Økologi*

# 7. Initial embodied energy/carbon

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**EMBODIED ENERGY: TRANSPORT AND ON-SITE CONSTRUCTION**

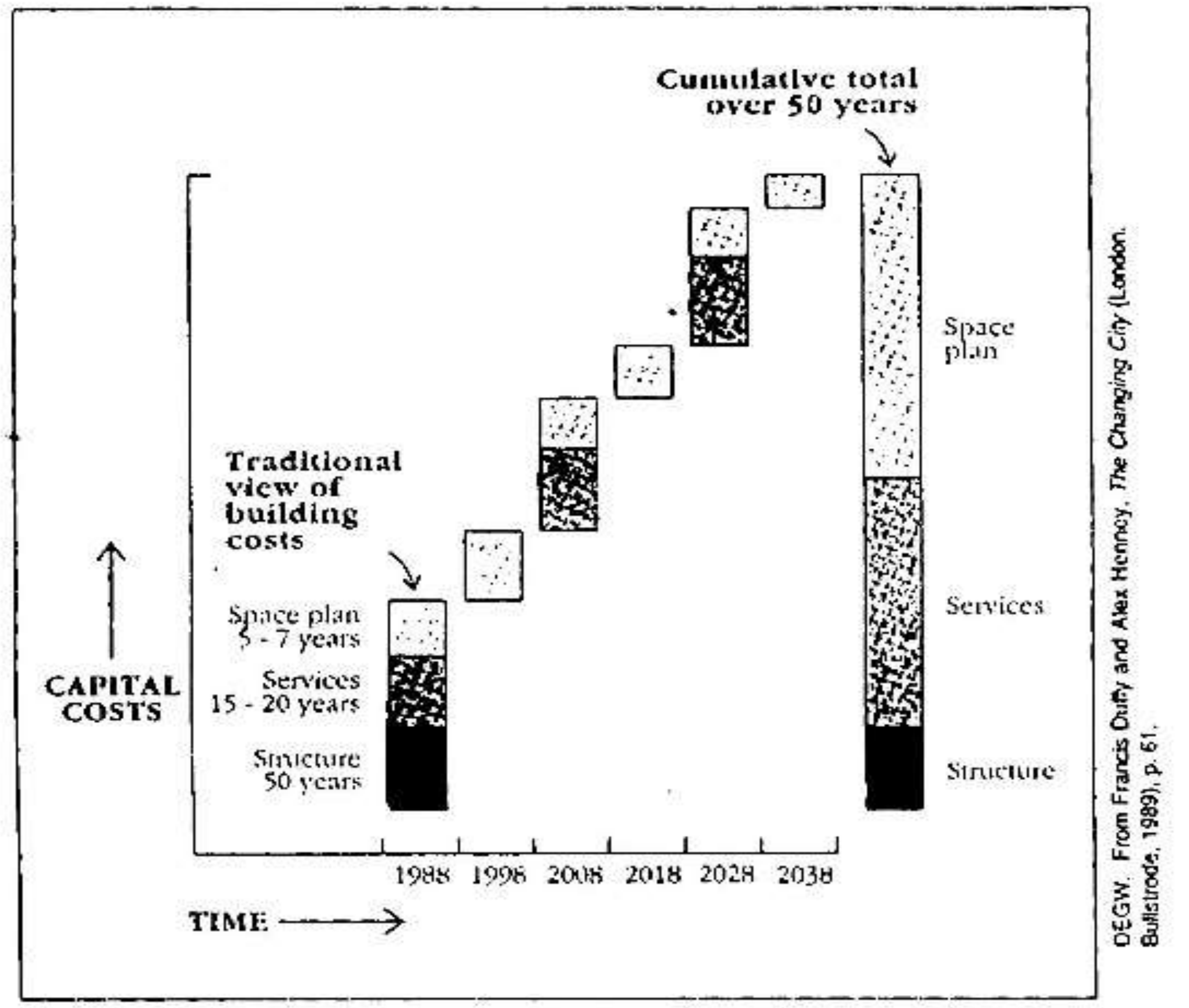
**These parts are fairly minor - but they will INCREASE in future as operational energy decreases**

**"Embodied energy is dominated by building material manufacturing, representing 90%, and the share of transportation and construction is 4% and 6% respectively, see Fig. 2. This proportion is very close to the average value of 18 case studies in Sweden and Denmark examined by Nässén et al: 91% for material manufacturing, 3% for transportation and 6% for construction." (32)**

(32) Yuan Chang, Robert J. Ries, Shuhua Lei, ***The embodied energy and emissions of a high-rise education building: A quantification using process-based hybrid life cycle inventory model***, Energy and Buildings 55: 790–798, 2012.

***text***

# 8. Recurrent embodied energy/carbon



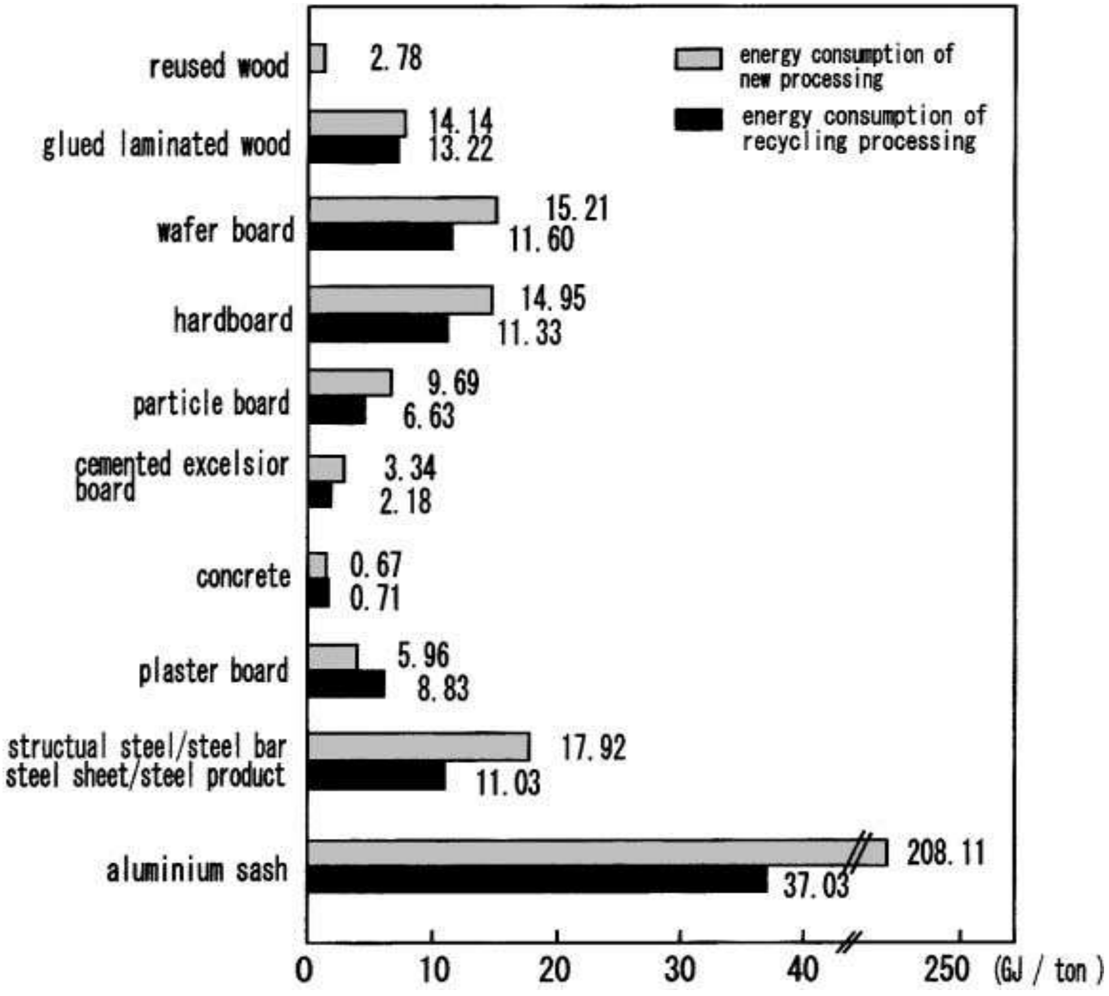

***Energy/carbon LCA:***

***Over a building lifetime, the total RECURRENT inputs for maintenance, replacement and modifications may be as large as the initial embodied inputs***

***- similar to this picture of LCC***

*source: Duffy & Henney, The Changting City, London 1989***)**

# 9. Post-use energy/carbon and other impacts




## Energy Impacts of Recycling Materials:

**In some cases recycling takes MORE energy than using virgin materials; examples are concrete (-5%), plasterboard (-48%)**

Source: Weijun Gao, Takahiro Ariyama, Toshio Ojima, Alan Meier, ***Energy Impacts of Recycling Disassembly Material in Residential Buildings***, Energy and Buildings 33:553-562, 2001.

**plus the post-use costs+impacts of toxic materials**

# 10. Resilience, adaptability

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***Resilience:***

***<<Older types of buildings – here refurbished up to zero energy standard. Karl Viriden, Zurich***

***>>Refurbished, low energy, Distrikt Vauban, Freiburg***

***Simple, low-dense building types often offer high resilience over time (see: Stewart Brand, How Buildings Learn)***

# 11 … and: social / economic sustainability

**Ecocommunities: modern lifestyle, 1/3 of footprint**

**local work, local community, local food …**
**Andelssamfundet Hjortshøj, Denmark**

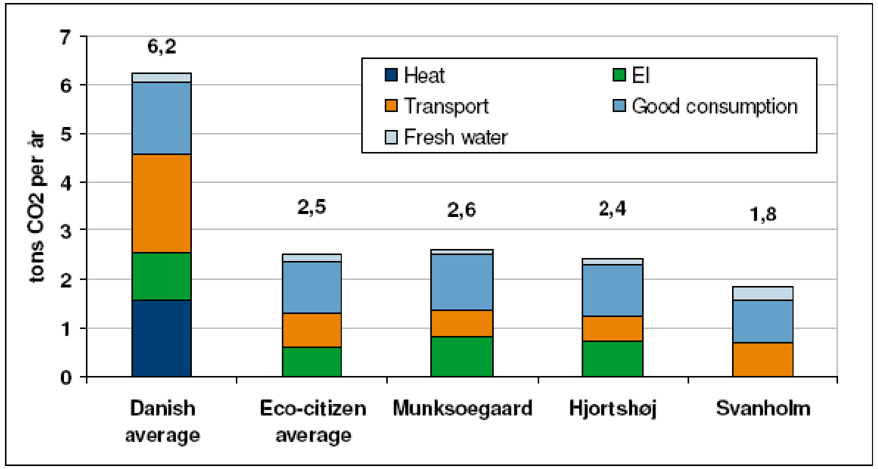


**Figure 2:** Average $CO_2$ emissions for a Danish citizen compared with citizens from the different eco societies

***Source: LØSNET no. 61-62, Dec. 2009 Special international edition, "Creating Oneness": a study by consultants Pöyry AB shows Danish ecovillages have CO2 emissions 60-70% below the national average.***

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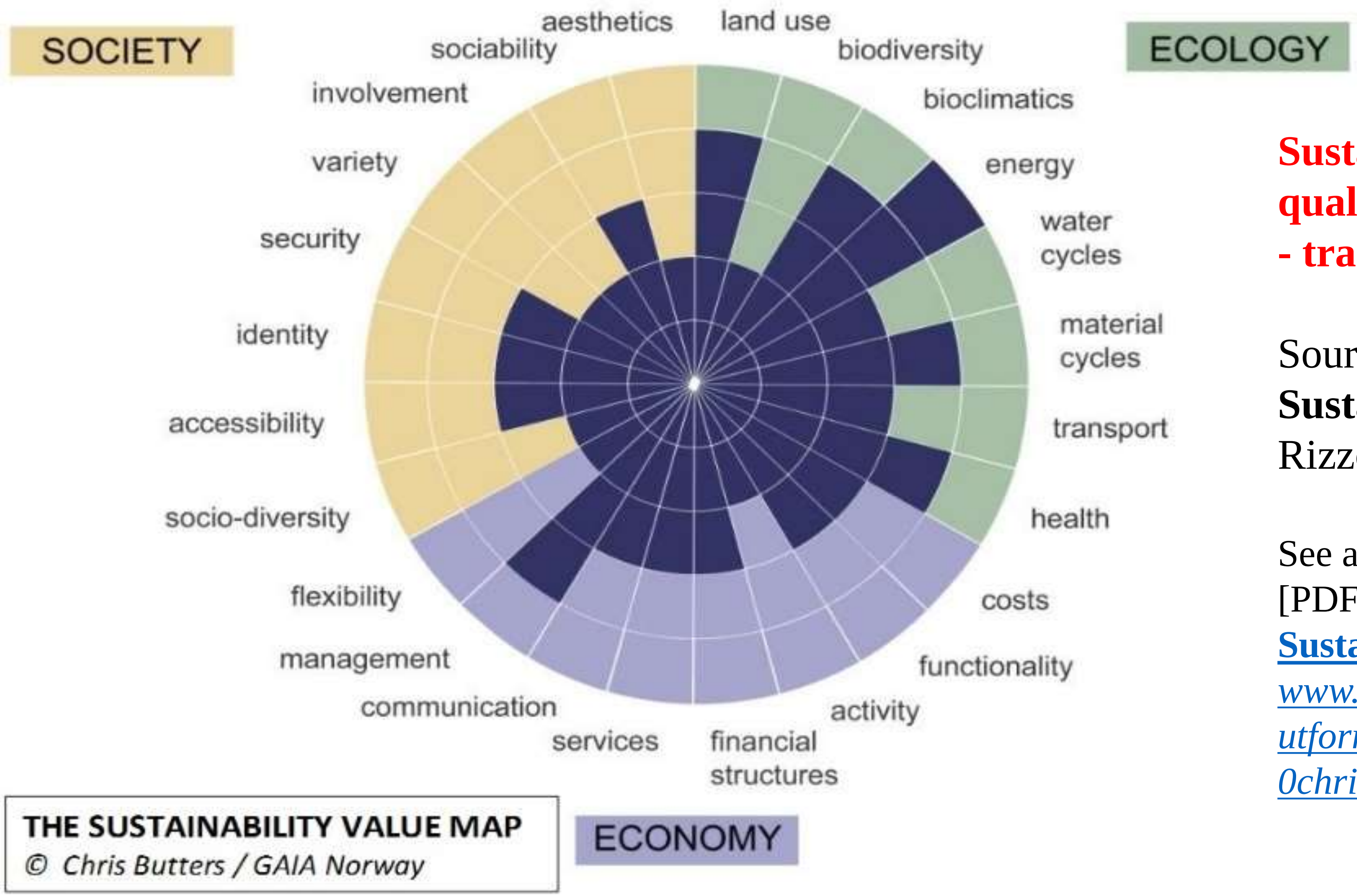


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**Sustainable solutions must have high quality in all three areas.**
**- tradeoffs, synergies, holistic thinking**

Source: C. Butters, in: Tigran Haas (ed.)
**Sustainable Urbanism & Beyond**
Rizzoli, New York 2012

See also articles on Google, i.e
[PDF]**A Holistic Method of Evaluating Sustainability - Universell ...**
*www.universell-utforming.miljo.no/.../idebank%20article%20chris%20b...*

# For and against the ”compact city”

**Seen in terms of sustainability, compactness has some advantages. This is often used by politicians / developers to argue in favor of dense, high rise (and more profitable)**

**Some of the main arguments cited in favor of concentration are:**

**-It allows minimum land use** *(not correct)*
**-High density of activities is dynamic, varied, productive** *(yes, but mega?)*
**-Efficient and fully utilized public transport systems** *(in theory!)*
**-Compact technical infrastructures, including DHS energy** *(but very costly)*
**-Compact therefore energy efficient building volumes** *(not correct)*
**-It facilitates walking distances and ”walkable cities”** *(not if full of cars)*

**But taking sustainability in a holistic way, such as with the Sustainability Value Map, one sees downsides in compactness:**
**-Urban heat island effect**
**-Higher concentrations of negatives such as traffic, air pollution, noise**
**-Specialized urban space requires more in/out flows, imports and transports**
**-Land prices become very high**
**-Far more complicated technical solutions are needed**
**-Unfavorable environment for children (high rise living, stress, little nature)**

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## SUSTAINABILITY: ADVANTAGES OF LOW-DENSE, SUMMARY:

| Environmental Impact Area: | Low-dense opportunities: |
| --- | --- |
| | |
| 1. Inhabitant Density / Land Use | equal / some advantages |
| 2. Microclimate and Green Space | advantages |
| 3.Infrastructures and transport | both sides; some advantages |
| 4. Energy Supply | both sides; advantages for RES |
| 5. Buildings Typology | equal |
| 6. Operational Energy | equal |
| 7. Embodied Energy | advantages |
| 8. Recurrent EE/EC | advantages |
| 9. Post Use | advantages |
| 10.Resilience | advantages |

*NB with obvious simplifications*

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