The role of green roofs in sustainable development of urban cities

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• Urban cities
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Urban cities

• World urbanization
  • Will increase from 50% in 2009 to 69% in 2050
  • By 2050, urban dwellers will account for 86% of the population in the more developed regions and for 66% of that in the less developed regions

• Problems of urban cities
  • Urban heat island (UHI)
  • Lack of greenery space
  • Large ecological footprint
Urban cities

- Examples:
  - Hong Kong
  - London
  - New York
  - Shanghai
  - Taipei
  - Tokyo
Hong Kong
Satellite image from Dr. Gabor Remetey-Fülöpp, Hungarian Association for Geo-information (HUNAGI)
Areas in Hong Kong with high population density
Potential of promoting green roofs in urban areas

Kwun Tong

(Source: http://hk.centamap.com)
SUSTAINABLE DEVELOPMENT
The Brundtland Report defines “Sustainable Development” (S.D.)

Full text of the report:
http://www.un-documents.net/wced-ocf.htm
Sustainable development

• The Brundtland Report (*Our Common Future*)
  - S.D. is development which meets the needs of the present without compromising the ability of future generation to meet their own needs.” – World Commission on Environment and Development.

• Two important concepts
  - **Needs** – maintain an acceptable life standard
  - **Limits** – within the carrying capacity of supporting ecosystems and resource base

“Most important is the future generation” - Confucius
Human needs and development

Supply

Waste

Supporting ecosystems and resource base

Ecological footprint (hectares/person) *
- world average = 2.3
- USA = 10.3
- Hong Kong = 6.0
- China = 1.2

[* Source: Friends of the Earth (HK)]

Carrying capacity and ecological footprint
Environmental Sustainability
- Ecosystem integrity
- Carrying capacity
- Biodiversity

Economic Sustainability
- Growth
- Development
- Productivity
- Trickle-down

Social Sustainability
- Cultural Identity
- Empowerment
- Accessibility
- Stability
- Equity

Three dimensions of sustainability

Human Well Being

Balance scale
Green roof systems

- **Green Roofs**: roofs bearing vegetation – FLL
  - “Living vegetation installed on the roofs”
  - “Vegetated roof”
- **Green Roof System** – Definition
  - “A roof area of plantings/landscape installed above a waterproofed substrate at any building level that is separated from the ground beneath it by a man-made structure.” – *NRCA Green Roof System Manual 2007*
- Other terms: Eco-roof, Living roof
Examples of green roofs in Hong Kong

Ocean Park Hong Kong

EMSD Headquarters

Parklane, Tsimshatsui

A school in San Po Kwong

(Photos taken by Dr Sam C M Hui)
Green roof systems from Germany (left) and Japan (right)
Typical structure of extensive green roof

- Vegetation
- Substrate/Growing medium
- Filter sheet
- Drainage/storage layer
- Moisture mat
- Root resistant membrane/barrier
- Thermal insulation
- Waterproof membrane
- Roof structure
<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Extensive</th>
<th>Semi-intensive</th>
<th>Intensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth of material</td>
<td>150 mm or less</td>
<td>Above and below 150 mm</td>
<td>More than 150 mm</td>
</tr>
<tr>
<td>Accessibility</td>
<td>Often inaccessible</td>
<td>May be partially accessible</td>
<td>Usually accessible</td>
</tr>
<tr>
<td>Fully saturated weight</td>
<td>Low (70-170 kg/m²)</td>
<td>Varies (170-290 kg/m²)</td>
<td>High (290-970 kg/m²)</td>
</tr>
<tr>
<td>Plant diversity</td>
<td>Low</td>
<td>Greater</td>
<td>Greatest</td>
</tr>
<tr>
<td>Plant communities</td>
<td>Moss-sedum-herbs and grasses</td>
<td>Grass-herbs and shrubs</td>
<td>Lawn or perennials, shrubs and trees</td>
</tr>
<tr>
<td>Use</td>
<td>Ecological protection layer</td>
<td>Designed green roof</td>
<td>Park like garden</td>
</tr>
<tr>
<td>Cost</td>
<td>Low</td>
<td>Varies</td>
<td>Highest</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Minimal</td>
<td>Varies</td>
<td>Highest</td>
</tr>
</tbody>
</table>
Table 2. Public and private benefits of green roof systems

<table>
<thead>
<tr>
<th>Public benefits:</th>
<th>Private benefits:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Aesthetic value</td>
<td>- Increase roof life span</td>
</tr>
<tr>
<td>- Mitigate urban heat island</td>
<td>- Reduce cooling loads</td>
</tr>
<tr>
<td>- Stormwater retention</td>
<td>- Contribute to green building rating credit points</td>
</tr>
<tr>
<td>- Create natural habitat</td>
<td>- Better use of space</td>
</tr>
<tr>
<td>- Functional open space</td>
<td>- Reduce noise levels</td>
</tr>
<tr>
<td>- Agricultural space</td>
<td>- Reduce risk of glare for surrounding buildings</td>
</tr>
<tr>
<td>- Filter dust and pollutants</td>
<td></td>
</tr>
<tr>
<td>- Filter rainwater</td>
<td></td>
</tr>
</tbody>
</table>
Sustainable rooftops

• Environmental sustainability
  • Mitigate urban heat island, manage stormwater, enhance biodiversity, reduce air pollution

• Economic sustainability
  • Extend roof life, reduce costs (energy and maintenance), enhance property value

• Social sustainability
  • Useful roof space, civil education, local job creation, food production
Examples of green roof and solar PV integration

Shading by PV panels

Cooling by vegetation

(Source: (Peck and van der Linde, 2010); www.livingroofs.org; www.igra-world.com)
Sustainable rooftop farming

- Wind energy
- Greenhouse
- Composting
- Solar energy
- Rainwater harvesting

(Source: www.skyvegetables.com)
A green roof project with integrated systems

- Micro-wind turbines
- Rainwater recycling
- Modular system
- Built-in system
- Space for green roof research and urban farming
Urban farming on green roofs

Farming on the roof

Vegetables and herbal plants

Water melon

Green beans

(Photos taken by Dr Sam C M Hui; Acknowledgement: St. Bonaventure Catholic Primary School)
Rooftop urban farming in the world

Bangkok, Thailand (fruits, rice)

Tokyo, Japan (greenhouse)

London, UK (with bee keeping)

San Francisco, USA (kitchen)

(Source: www.time.com)
Eagle Street Rooftop Farm in NYC
(Source: http://blog.anandaharvest.org)
Rice paddy and vegetable plot at Roppongi Hills in Tokyo, Japan

(Source: www.greenroofs.com)
Modern green roofs in Osaka, Japan (Namba Parks) (2003)

(Source: www.treehugger.com & www.toho-leo.co.jp)
Container garden in Taiwan

(Source: http://yiu.com.tw/green.htm)
Conclusions

• Green roofs are important for sustainability and for achieving green performance development in urban cities

• New buildings
  • Green roofs can be accommodated easily

• Existing buildings
  • Through retrofit projects
  • Age & condition of the roof will affect feasibility
  • May use light-weight green roof systems
THANK YOU 謝謝 !!

Green roofs help cool cities, manage storm water, clean the air, and build habitat.

(More information: www.hku.hk/bse/greenroof/)