Deltares
Enabling Delta Life

Design principles for successful nature based solutions

for healthy, climate resilient cities

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6 April 2017 Green Infrastructure, NBS for sustainable and resilient cities Orvieto

Requirements for successful design of NBS

Aims and ambitions

- Healthy Urban Living
- Climate adaptation

Required for design

- Insight in effectiveness of measures
- Design principles
- Interactive design support tools
- Insight in local critical parameters

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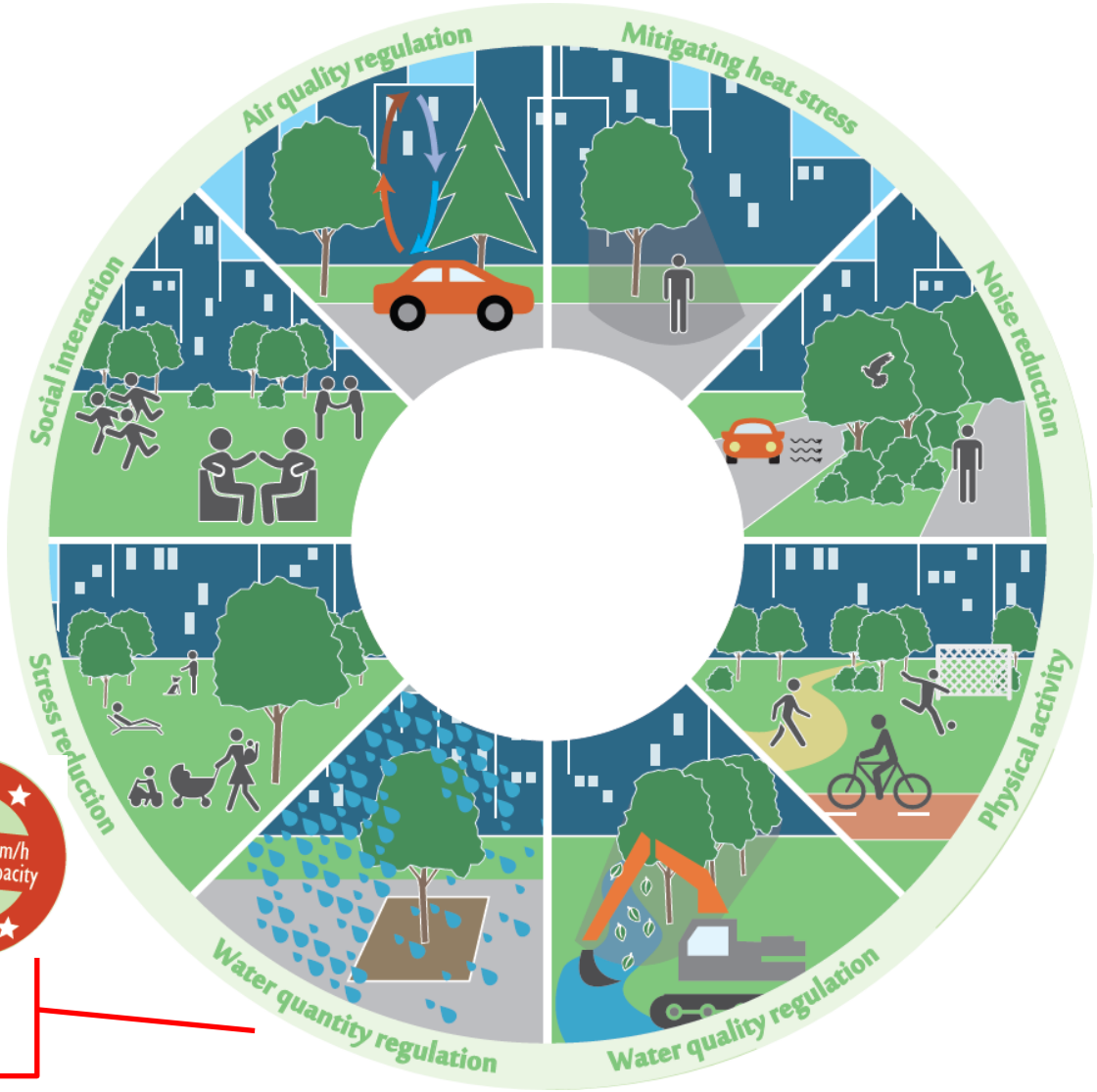
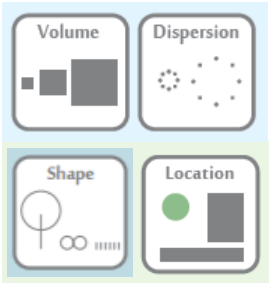
Insight in effectiveness of green measures & design principles



Design principles



Mechanisms Effectiveness

- Interceptior
- Infiltration
- (root uptake and transpiration)

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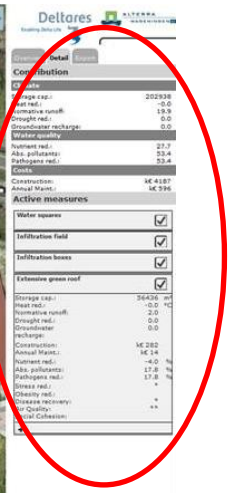
Interactive design support tools

Adaptation Support Tool



2. Effect calculated for water storage and temperature

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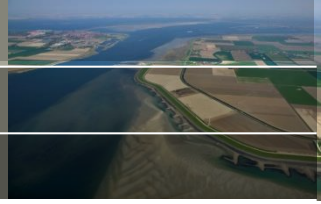
Critical parameters: Water dependence



Stepwise assessment framework

1) Inventory of relevant ecosystem services of GI

Table.

2) Assessment of the dependence on water quality and quantity for ecosystem service delivery

Table & literature

3) Assessing water a

Water balance model

Ecosystem services / Effectiveness limited by	Quantity	Quality	Timing	Remarks
Green spaces (groundwater and soil moisture attributes)				
Temperature regulation (cooling) through: - shadow - evapotranspiration - heat exchange	 - no - yes - yes	 - no - no - no	Water needed for evapotranspiration in summer, in particular during hot & dry spells	Shadow function only affected when tree loses leaves due to severe drought or raising groundwater*. Drought limits evapotranspiration; especially grass susceptible to drought.
Storm water runoff mitigation through: - interception - infiltration - surface storage in green spaces with low surface level	 -no - yes;	 - no - no - yes, indirect	Slowdown of discharge desirable during heavy rain (intensity and duration) to prevent sewer overflow and flooding	Interception only affected when tree loses leaves due to severe drought or raising groundwater*. In dry situation (summer): hydrophobic soil hampers infiltration Under very wet conditions (high groundwater table) : limited or no storage capacity Quality of the storm water could make direct infiltration undesirable although treatment by soil filtration is generally sufficient
Air quality regulation through - influence on air circulation - filtering air pollutants	 - no - yes	 - no - no	Services by deciduous vegetation altered by season (presence of leaves)	Influence on air circulation (either positive or negative) and particulate matter capture altered when tree loses leaves due to severe drought or raising groundwater*. Drought or very wet conditions may reduce the vegetation's effectiveness for absorption of gasses through the stomata of vegetation (they close).
Noise reduction through - noise reduction - reduced perception when noise source visually camouflaged	- no - no	- no - no	Services by deciduous vegetation only delivered during spring and summer	Noise reduction only affected when tree loses leaves due to severe drought or raising groundwater*.

Water dependence of ecosystem services of GI

Case study Utrecht Fair and Central train station area

Most critical:

- Impact of drought on temperature regulation (cooling) via evapotranspiration
- Impact of very wet conditions, when ponding occurs, on recreation potential of green spaces.
- High groundwater tables limit the role of green spaces in stormwater runoff mitigation due to the reduced capacity of the soil to drain and store water.

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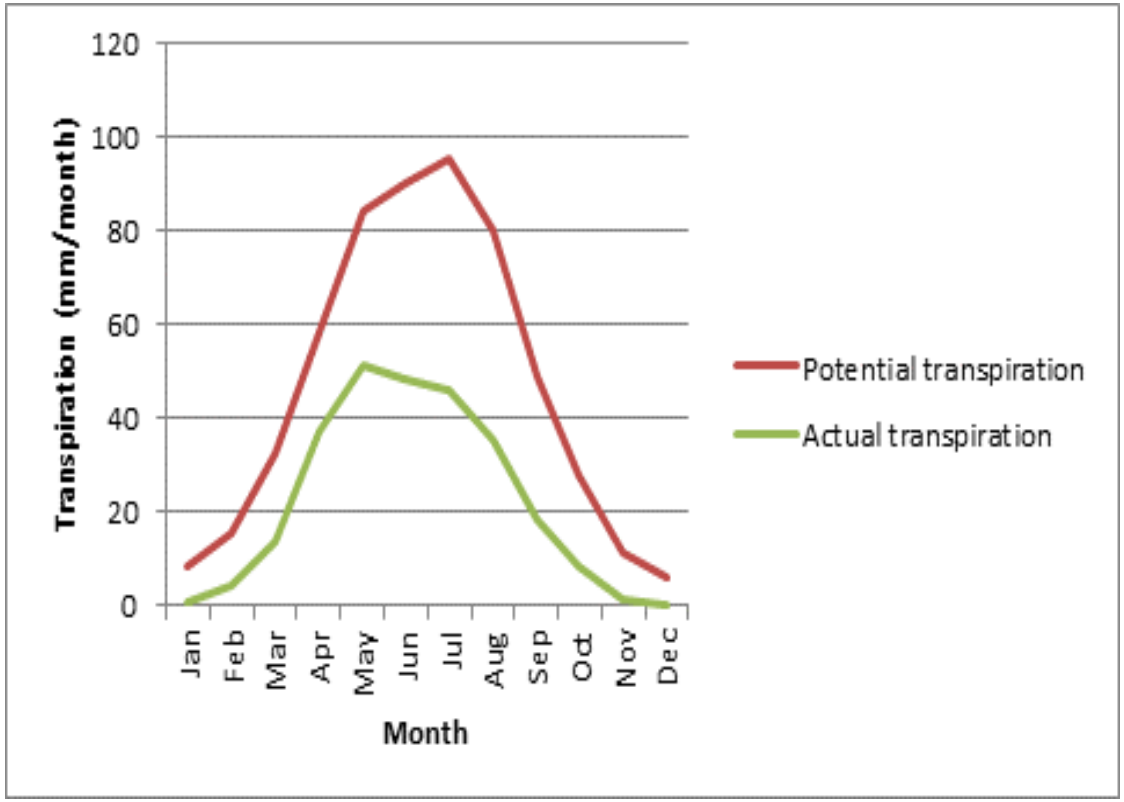
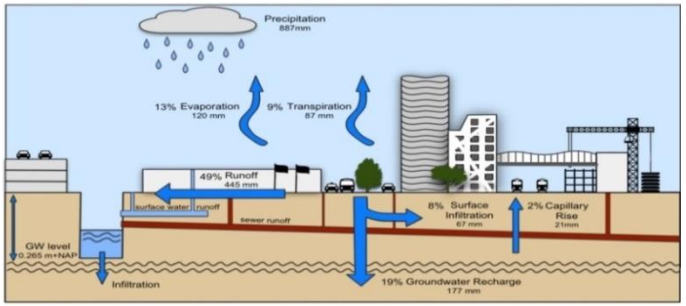
Exploring drougth in Utrecht

Impact of drought on cooling





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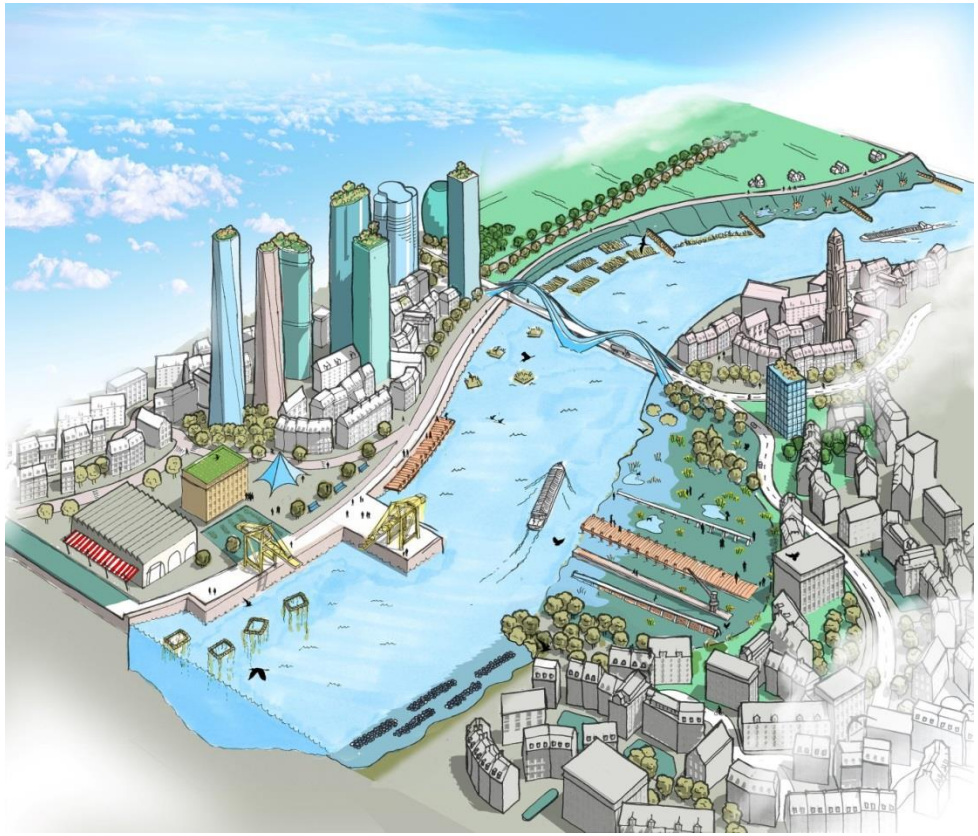
Publications and tools:
www.adaptivecirculararcities.com/downloads



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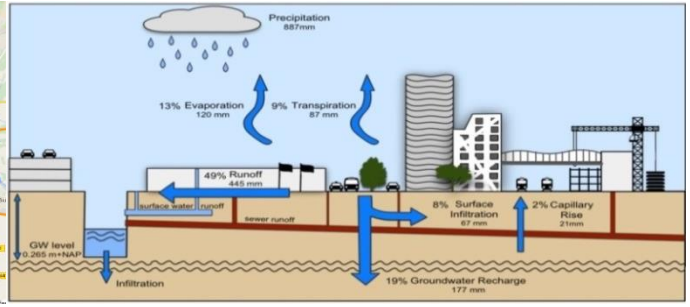
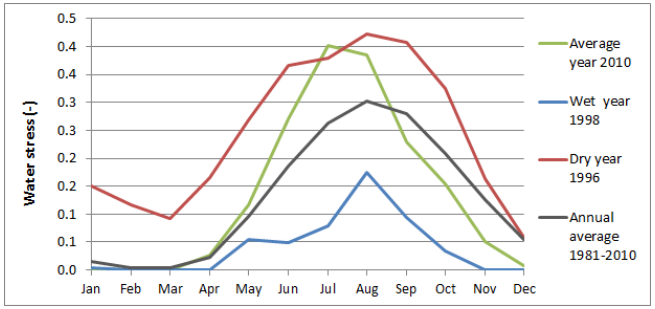
Exploring drougth in Utrecht

Visual observations water stress

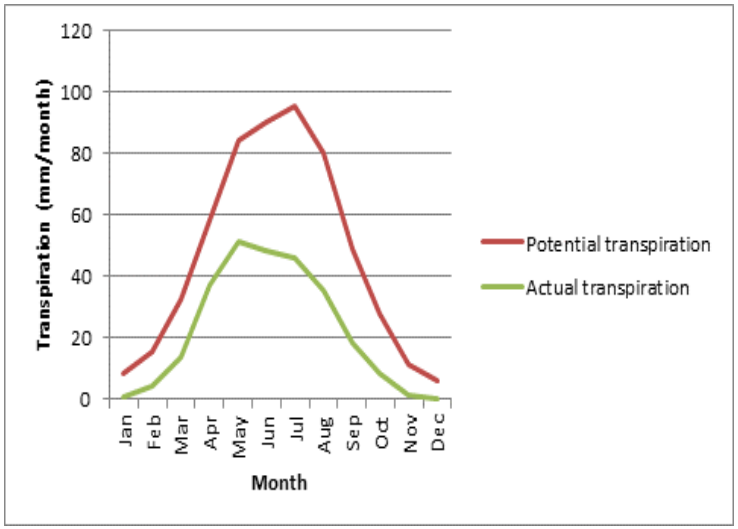
Water balance of the city



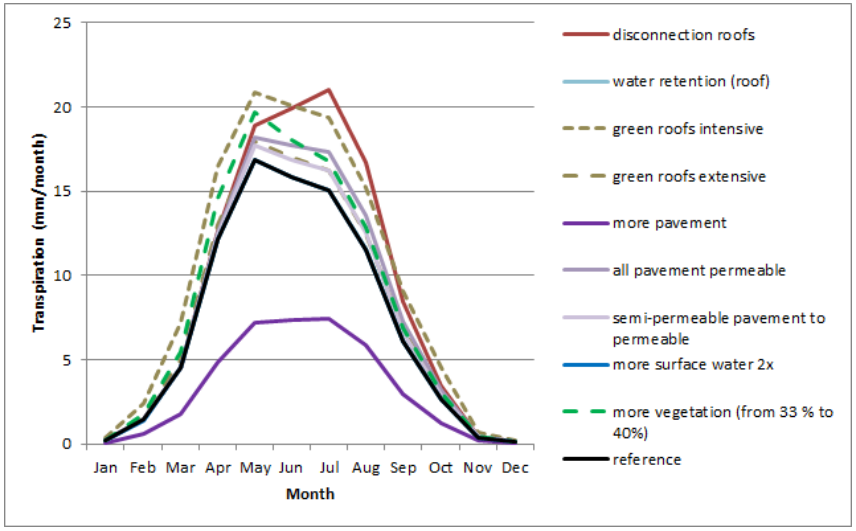
Calculated water stress



Impact of drought on cooling



Effectiveness measures to reduce water stress



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