GREEN WALKING NETWORKS FOR CLIMATE CHANGE ADAPTATION

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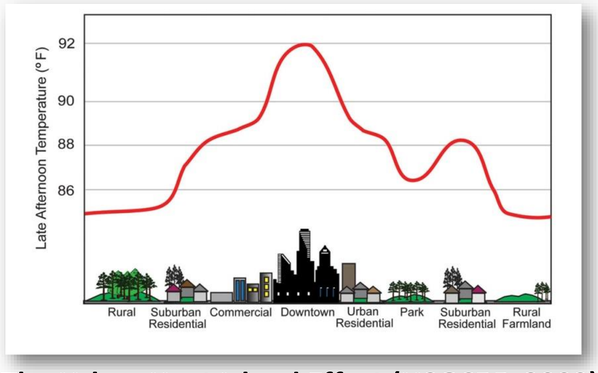
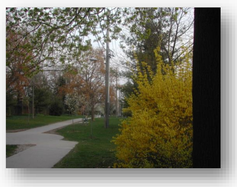
Transport and Climate Change (CC)

In 2011 **transport** used **1/3** of all **energy** and **70%** of all **oil** in EU (EC, 2013)
Urban areas produce **25%** of all **GHG transport related emissions** (EEA, 2013) causing the so called 'Urban Heat Island' (UHI) effect



The Urban Heat Island Effect (USGCRP, 2009)

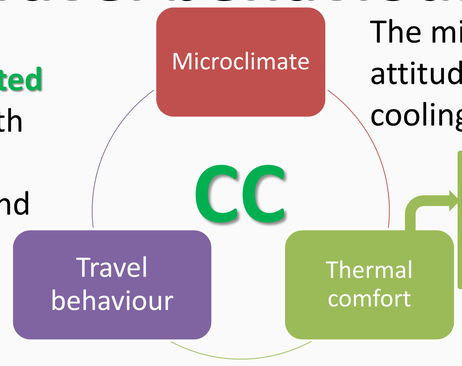


Walking in green spaces as win-win solution for CC

- Encouraging **pedestrian mobility** as a strategy for **CC Mitigation**
- Supporting the presence of **green urban spaces** for **CC Adaptation**
- **Promoting walking in green spaces as win-win solution for CC**

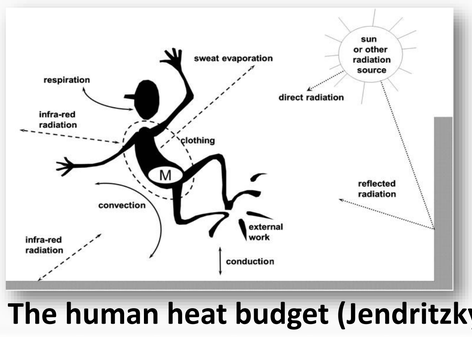
Microclimate, human thermal comfort and travel behaviour

Need to link **climate-related variables** with **travel behaviour** and **modal shift**



The microclimate of a street influences the walking attitude. **Street trees** have a great potential for cooling

'That condition of mind which expresses satisfaction with the thermal environment' (ASHRAE, 1966)



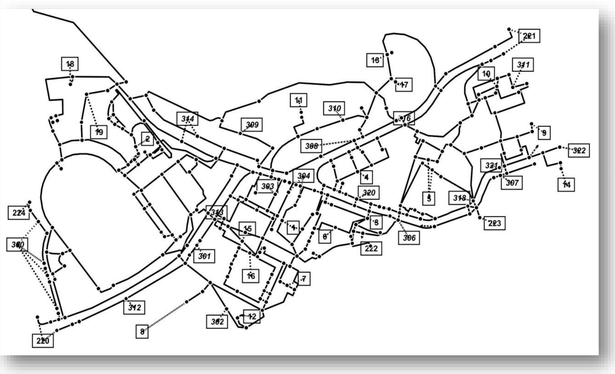
The human heat budget (Jendritzky et al., 2012)

Difference between **indoor** and **outdoor** thermal comfort: solar radiation and wind chill
The '**Universal Thermal Climate Index**' (**UTCI**) is a universally applicable index which takes into consideration solar radiation through the **mean radiant temperature**

The methodology in 4 steps

1 Network model

Building the walking network model



1. Links
2. Nodes
3. Zones

2 Equivalent cost function

Calculating the equivalent cost function for walking

Based on the original formulation of Wibowo and Olszeski (2005):

equivalent distance | ascending slope | number of road crossing

$$ED(i)=(1+\alpha\cdot s(i))\cdot L(i)+\beta_1\cdot X(i)+\beta_2\cdot A(i)+\beta_3\cdot C(i)$$

number of ascending steps | number of traffic conflicts

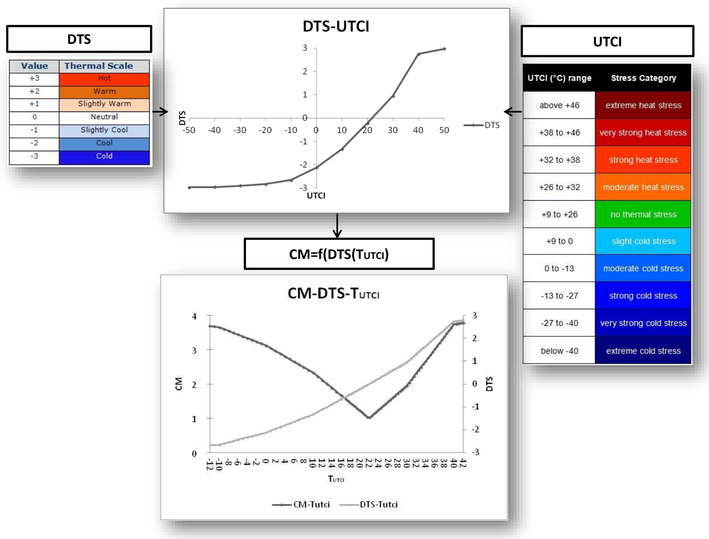
$\alpha, \beta_1, \beta_2, \beta_3$: coefficients

$$ED(i)=(1+0.156\cdot s(i))L(i)+55.4\cdot X(i)+2.81\cdot A(i)+36.31\cdot C(i)$$

1 m = 1 ASCENDING STEP = 2.81 m
1 TRAFFIC CONFLICT = 36.31 m
1 ROAD CROSSING = 55.4 m

3 Climatic Multiplier

Assessing the thermal comfort



$$CED(i)=CM_i\cdot[(1+0.156\cdot s(i))L(i)+2.81\cdot A(i)]+55.4\cdot X(i)+36.31\cdot C(i)$$

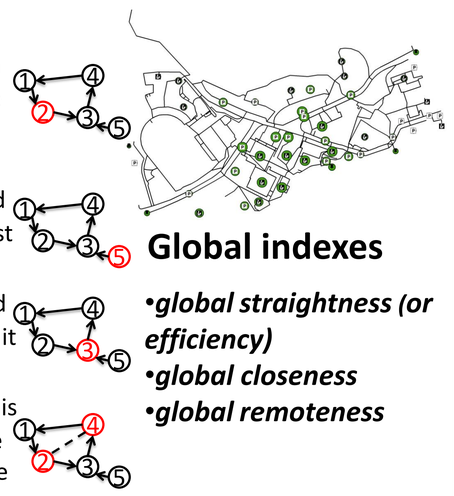
4 Centrality indexes

Evaluating the performance through centrality indexes

Based on Multiple Centrality Assessment (Porta et al., 2008)

Local indexes

- ***closeness centrality***, which is a measure of the proximity of a node to the other nodes through the shortest paths
- ***remoteness centrality***, defined as the mean distance of the shortest paths to a given node
- ***betweenness centrality***, based on the idea that a node is central if it lies between many other nodes
- ***straightness centrality***, which is a measure of how 'winding' are the shortest paths with reference to the Euclidean distance



Global indexes

- ***global straightness (or efficiency)***
- ***global closeness***
- ***global remoteness***

Case study

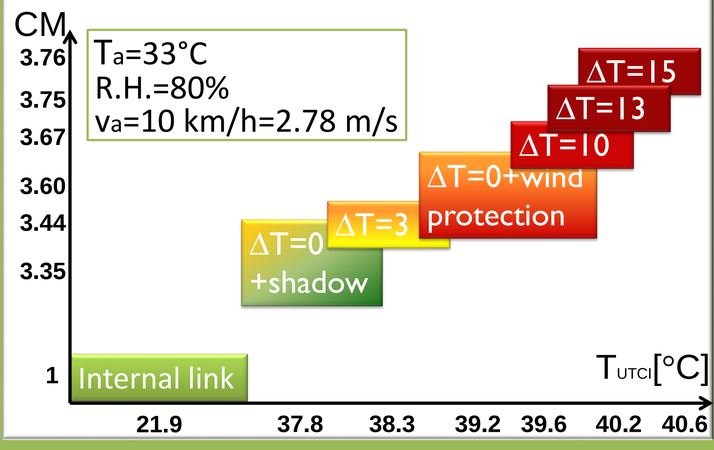
Campus of the University of Catania:
-70 hectares area in Catania: medium-sized city located in the eastern part of Sicily (Italy)
-about 7000 daily people among students, teaching staff and employees
- **Network model**: 342 nodes, 862 links, 20 activities, 5 accesses, 23 parking spaces



Link categories
Type A: sidewalk
Type B: paved
Type C: unpaved

Surroundings:
- Buildings
- Green spaces
- Buildings and green spaces

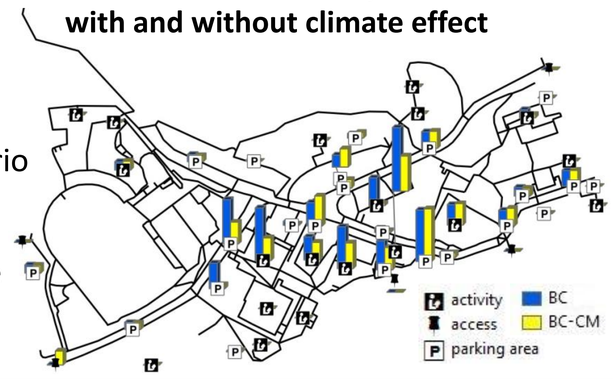
- **Climatic multiplier:**



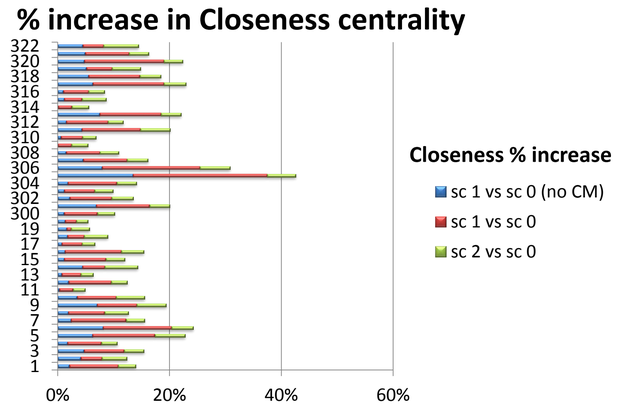
Results

Scenarios
✓**scenario 0**: reference scenario
✓**scenario 1**: activities can be '**crossed**'
✓**scenario 2**: '**greening**' of the network

Betweenness centrality in scenario 1 with and without climate effect



% increase in Closeness centrality



Global index	Scenario 0	Scenario 1	Var% (Scen. 1 VS 0)	Scenario 2	Var% (Scen. 2 VS 0)	Scenario 0 (NO CM)	Scenario ½ (NO CM)	Var% (Scen. 1 VS 0) (NO CM)
Global Straightness (internal trips)	0.1846	0.1977	**+7%**	0.2051	**+11%**	0.5103	0.5236	**+3%**
Global Straightness (ingoing trips)	0.1529	0.1711	**+12%**	0.1774	**+16%**	0.4398	0.4590	**+4%**
Global Straightness (outgoing trips)	0.1802	0.1982	**+10%**	0.2053	**+14%**	0.5133	0.5270	**+3%**
Global Remoteness (internal trips)	1.9596	1.8151	**-7%**	1.7536	**-11%**	0.6914	0.6687	**-3%**
Global Remoteness (ingoing trips)	2.2666	2.0467	**-10%**	1.9810	**-13%**	0.8015	0.7699	**-4%**
Global Remoteness (outgoing trips)	1.8518	1.7022	**-8%**	1.6473	**-11%**	0.6824	0.6666	**-2%**
Global Closeness (internal trips)	0.5103	0.5509	**+8%**	0.5703	**+12%**	1.4463	1.4954	**+3%**

Main references

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