A METHODOLOGICAL APPROACH to the ENVIRONMENTAL QUANTITATIVE ASSESSESSMENT of URBAN PARKS






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Background: URBAN NUISANCES

Rapid urban development and intensive human activity have increased environmental nuisances in cities worldwide.

- Micro-climatic changes - wind regime, air and radiation temperature, lack of ventilation.
- Drastic increase in emissions.
- Increase in noise levels.
- Drainage and hydrological problems.

The Outcome:

- Thermal discomfort, air pollution and noise stress
- A negative impact on the quality of life in urban areas

Urban Vegetation and Environmental Quality

The use of urban vegetation (parks, green courtyards, street trees) is considered an effective tool to improve urban environmental quality, by:

- Moderating micro-climate conditions (Ta, T_{mrt} , wind gusts)
- Improving air quality (trapping particulate matters, absorbing CO_2 and creating O_2)
- Decreasing sound levels (by filtering noise)

Green open spaces are a valuable land use in the urban tissue.

A literature review of studies regarding the effect of urban green open spaces on environmental nuisances showed a lack of:

- **Multi-seasonal studies:**
  Few studies have investigated changes in the various nuisances throughout the year (hot/cold; high/low pollutant concentrations) were limited to daylight hours.

- **Comparative studies:**
  Only a few studies have investigated simultaneously two or more types of nuisances at various urban sites.

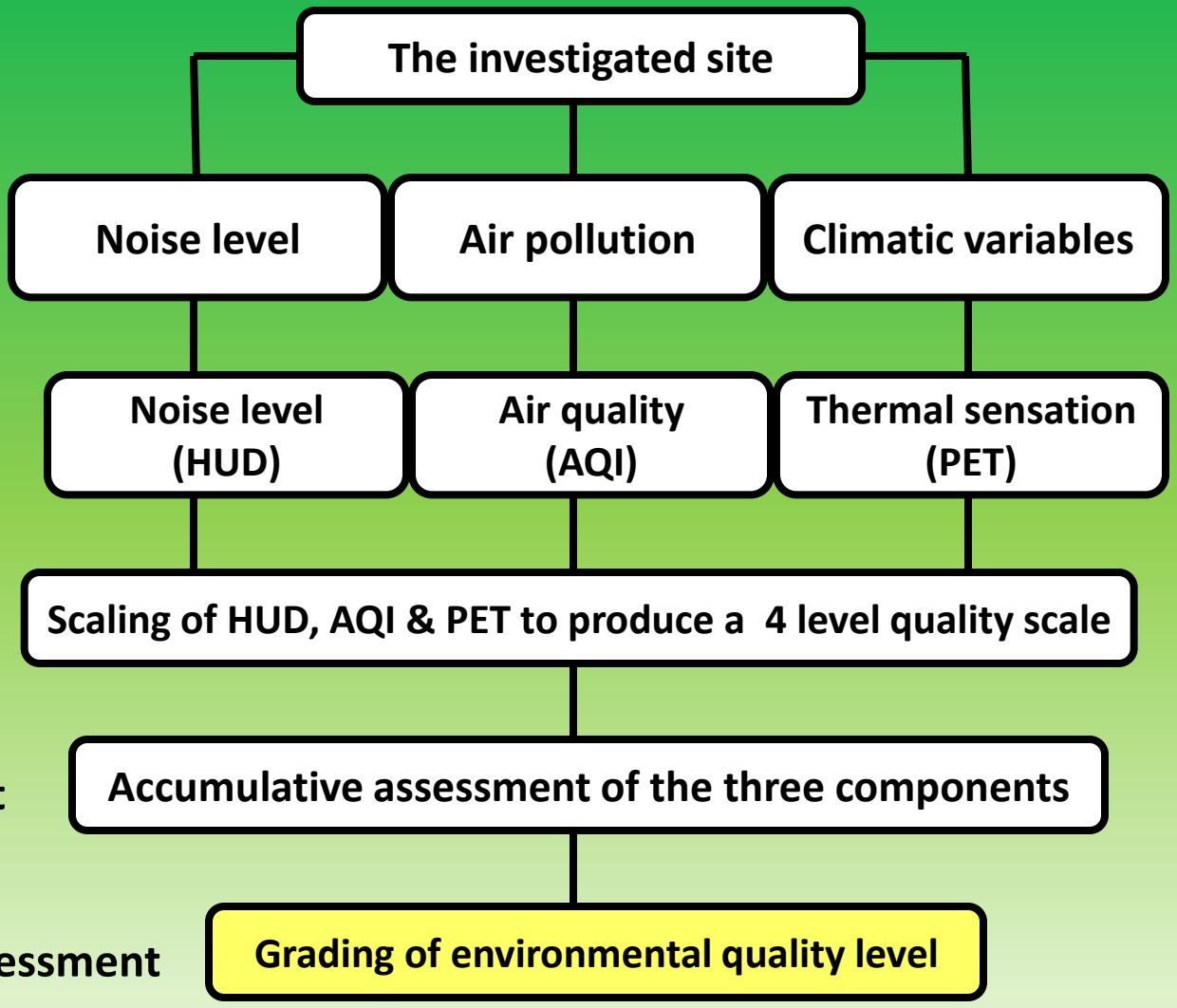
- **Holistic and quantitative studies:**
  There is a dearth of studies that have investigated the overall impact of urban parks on microclimate, air pollution and noise at one specific site, or at various sites, and their accumulative effect on parks' users' comfort.

Objective

To develop a quantitative methodology for the environmental assessment of urban parks.

- The methodology concentrates on 3 environmental nuisances (thermal discomfort, air pollution and noise) which have the greatest impact on human health.
- Data collection relates to diurnal and seasonal variables.
- Data analysis and data indexing based on verified indices.
- The methodology offers an integrated examination of the overall impact of these nuisances.

Methodological Approach



A Case Study: Tel Aviv, Israel

Examining the methodology in different sites by repeating data collection, 2007-2011

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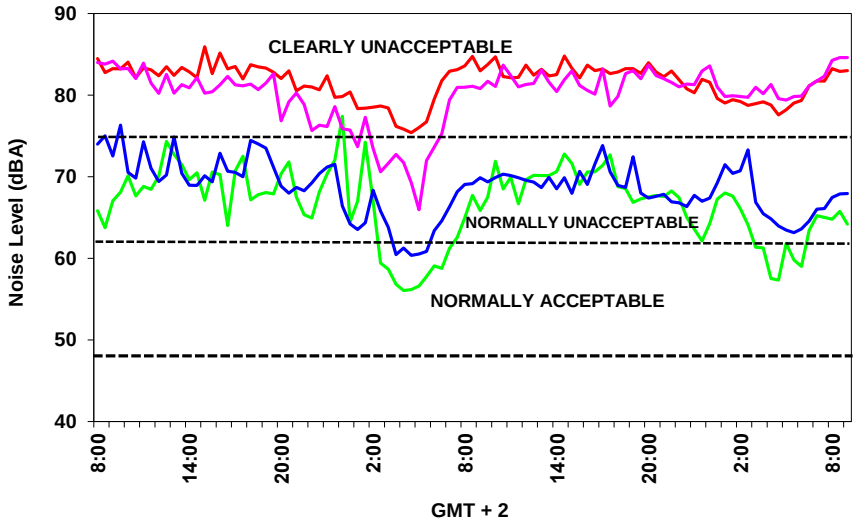
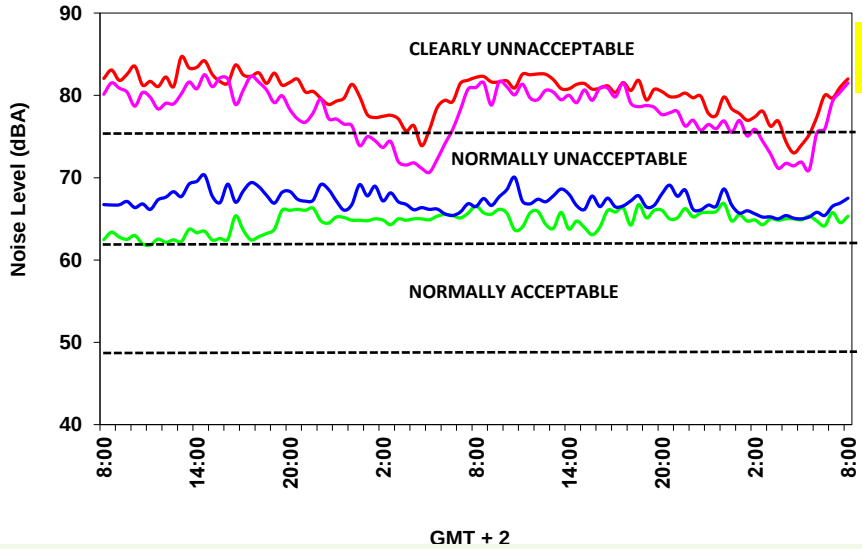
Stage 1 - In-situ Measurements

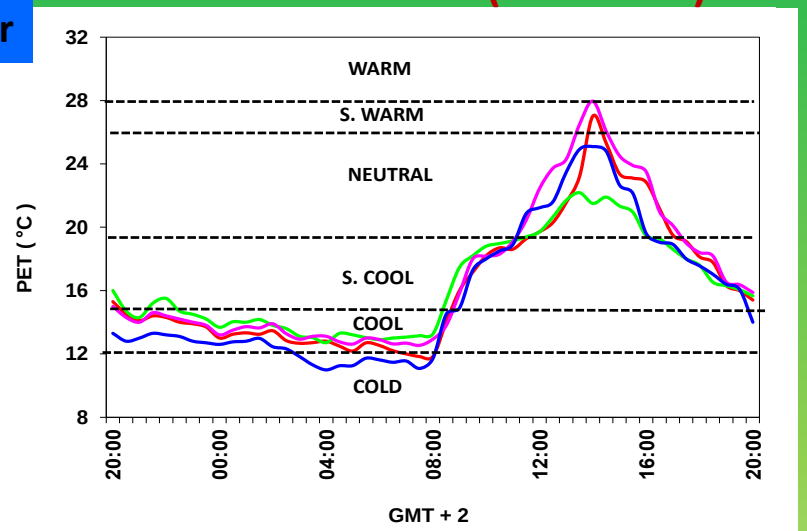
Noise level and PET values at the investigated sites (Source: Cohen et al., 2014[a])

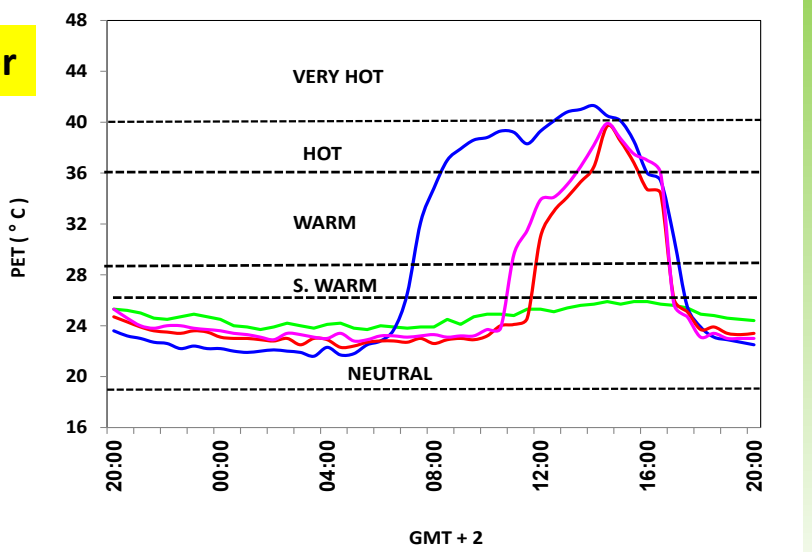
Noise level





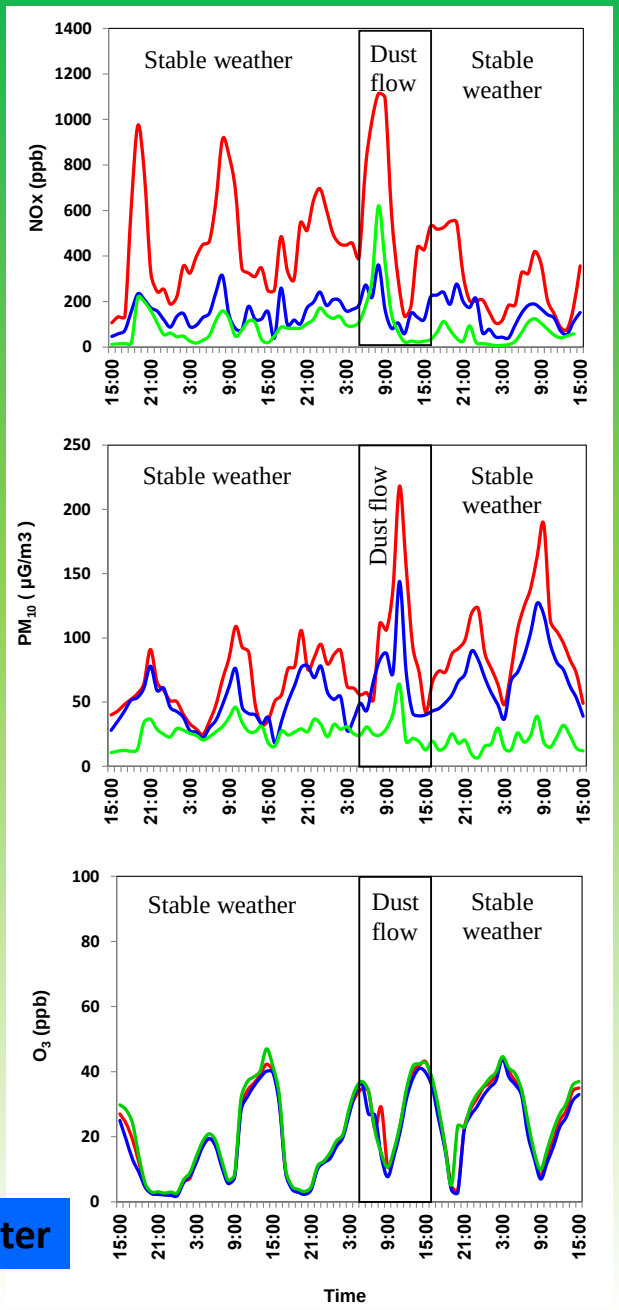
Thermal sensation (PET index)

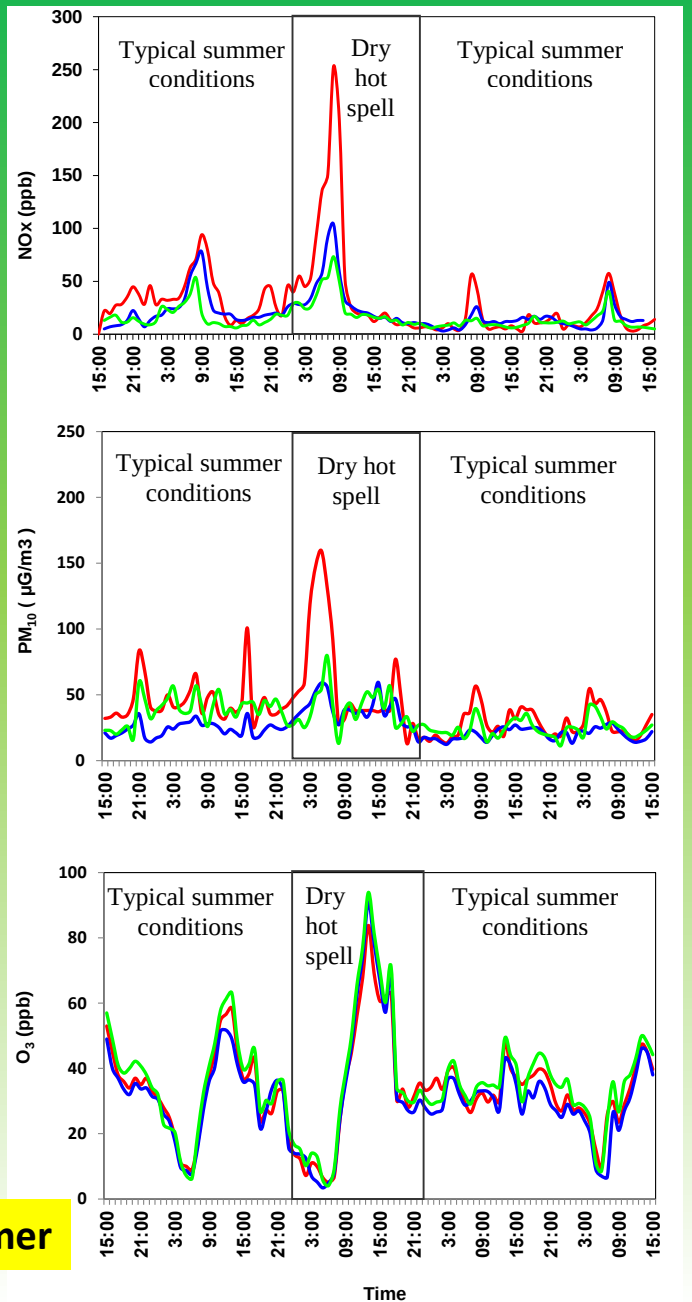




Urban park — Street 1 — Urban square — Street 2

Stage 1 (continued) - Air pollution: NOx, PM_{10} , O_3 values





Street canyon
Urban square
Uraban park

Source: Cohen et al., 2014[b]

Winter

Summer

Stage 2 - Thermal Sensation Indexing

- The Physiological Equivalent Temperature Index (PET) a 9 level scale was adopted.
- The PET index was calibrated for the Coastal Mediterranean climate (*).
- PET Index was converted into a 4 level discomfort scale.

Thermal sensation classification	Mediterranean climate (°PET) *
Very cold	8 ≤ X
Cold	8.1 < X ≤ 12
Cool	12.1 < X ≤ 15
Slightly cool	15.1 < X ≤ 19
Neutral	19.1 < X ≤ 26
Slightly warm	26.1 < X ≤ 28
Warm	28.1 < X ≤ 34
Hot	34.1 < X ≤ 40
Very hot	40.1 < X

Thermal sensation	Discomfort level	Environmental thermal sensation grade
Very cold	Very high	1
Cold	Very high	1
Cool	High	2
S. cool	Medium	3
Neutral	None	4
S. warm	Medium	3
Warm	High	2
Hot	Very high	1
Very hot	Very high	1

(*) **Cohen et al., 2013**

- "neutral" thermal sensation = **the best** thermal environmental quality (4).
- "very cold" & "cold" / "very hot" & "hot" thermal sensation = very high thermal discomfort, **the worst** thermal environmental quality (1).

Stage 2 - Air pollution indexing

- Based on the Pollutants Standard index (PSI) used by the EPA.
- Examines 4 pollutants that are most harmful for humans.
- The calculation of PSI for each pollutant is based on specific breakdown values, using the formula: ***PSI =(Ihi - Ilow)/(BPhi – Bplow)*(Cp – BPlow)+ Ilow***

NOx (ppb) 30 min. avg.	**PM_{10} (µg/m ^{3})** running 24 h. avg	**O_3 (ppb)** 30 min. avg.	**CO (ppm)** 30 min. avg.	**PSI** Breakdown values	**AQI values**
0 - 249	**0 - 59**	**0 - 58**	**0 – 4.7**	**0 - 49**	**51 to 100**
250 - 499	**60 - 149**	**59 - 116**	**4.8 - 9.5**	**50 - 99**	**1 to 50**
500 - 600	**150 - 349**	**117 - 203**	**9.6 - 14.7**	**100 - 199**	**0 to (-) 199**
601 - 1200	**350 - 419**	**204 - 407**	**14.8 - 29.6**	**200 - 299**	**(-) 200 to (-) 400**

- The **worst case** of the PSI among the monitored pollutants defines the AQI value.
- Air Quality Index is categorized into 4 levels.

Air Quality Index (AQI) value	Level of health concern	Environmental quality grade
51 to 100	Low	4
1 to 50	Medium	3
0 to (-) 199	High	2
(-) 200 to (-) 400	Very high	1

Stage 2 - Noise level indexing

Data was indexed according the U.S. Department of Housing and Urban Development (HUD) classification, which has 4 categories for noise level in residential neighborhoods.

Noise level values (dBA)	Noise level classification	Level of health concern	Environmental noise quality grade
$L_{Aeq} > 49$ dB(A)	Clearly acceptable	Low	4
49 dBA < $L_{Aeq} \leq 62$dB(A)	Normally acceptable	Medium	3
62 dBA < $L_{Aeq} \leq 76$ dB(A)	Normally unacceptable	High	2
$L_{Aeq} > 76$ dB(A)	Clearly unacceptable	Very high	1

When noise level is lower than 49dB(A), level of health concern is low.
When noise level is 76dB(A) and up, level of health concern is very high.

Time	Air Quality (AQI)		Thermal Sensation (PET)		Noise		Accumulative Value
	Value	Grade	Value	Grade	Value	Grade	
0:00	-100.3	2	13.0	2	79.83	1	5
1:00	1.2	3	13.3	2	78.36	1	6
2:00	9.7	3	13.5	2	78.51	1	6
3:00	11	3	12.7	2	78.42	1	6
4:00	9.5	3	12.8	2	76.03	1	6
5:00	21	3	12.2	2	76.20	1	6
6:00	-131.1	2	12.5	2	79.51	1	5
7:00	-161.1	2	12.0	1	82.92	1	4
8:00	-178.5	2	11.8	1	83.57	1	4
9:00	-138.5	2	16.5	3	82.98	1	6
10:00	-86.1	2	18.2	3	84.70	1	6
11:00	39.4	3	18.6	3	82.12	1	7
12:00	38.7	3	19.7	4	79.83	1	8
13:00	36.5	3	21.6	4	83.16	1	8
14:00	12.8	3	27.0	4	82.52	1	8
15:00	15.2	3	23.4	4	83.30	1	8
16:00	-30.7	2	22.8	4	83.67	1	7
17:00	-47.4	2	19.5	4	83.20	1	7
18:00	-51.5	2	18.1	3	82.82	1	6
19:00	-48.5	2	16.3	3	83.25	1	6
20:00	22.7	3	15.0	2	83.97	1	6
21:00	34.8	3	14.9	2	82.25	1	6
22:00	34.8	3	14.5	2	81.28	1	6
23:00	34.8	3	13.9	2	80.28	1	6

WINTER,
STREET
CANYON

STREET

AQI
+ PET
+ NOISE

Stage 3 – scaling the nuisances at each of the sites to a 4 level quality scale.

Time	Air Quality (AQI)		Thermal Sensation (PET)		Noise		Accumulative Value
	Value	Grade	Value	Grade	Value	Grade	
0:00	80.1	4	13.6	2	75.40	2	7
1:00	75.2	4	14.0	2	66.98	2	8
2:00	73.2	4	14.2	2	67.02	2	8
3:00	69.5	4	13.6	2	58.66	3	9
4:00	74.8	4	13.0	2	56.04	3	9
5:00	77.6	4	13.3	2	56.60	3	9
6:00	64.5	4	13.0	2	59.07	3	9
7:00	41.2	3	13.0	2	61.23	3	8
8:00	-22.9	2	13.2	2	64.96	2	6
9:00	65.0	4	15.4	3	65.86	2	9
10:00	71.7	4	18.2	3	71.89	2	9
11:00	78.0	4	19.1	4	69.92	2	10
12:00	76.7	4	19.4	4	69.62	2	10
13:00	76.7	4	20.6	4	70.43	2	10
14:00	76.7	4	22.2	4	71.27	2	10
15:00	76.7	4	21.9	4	72.61	2	10
16:00	76.6	4	21.0	4	70.57	2	10
17:00	76.9	4	19.3	4	71.39	2	10
18:00	77.3	4	18.0	3	68.77	2	10
19:00	77.6	4	16.5	3	66.84	2	9
20:00	77.8	4	16.1	3	69.52	2	9
21:00	78.2	4	15.7	3	67.56	2	8
22:00	78.3	4	15.3	3	72.74	2	8
23:00	78.6	4	14.9	2	63.58	2	8

WINTER,
URBAN
PARK

PARK

AQI
+ PET
+ NOISE

Stage 4 –

the quality grades of all the components were summed, assuming they have an equal impact on human environmental sense of discomfort.

Stage 5 - Grading of environmental quality level

The cumulative assessment values were categorized into 4 levels of environmental quality, from Good (A) to Very poor (D).

Winter

Time	Environmental Quality Level		
	Street canyon	Urban square	Urban park
0:00	C	B	B
1:00	C	B	B
2:00	C	B	B
3:00	C	B	B
4:00	C	B	B
5:00	C	B	B
6:00	C	B	B
7:00	C	C	B
8:00	C	C	C
9:00	C	B	B
10:00	C	B	B
11:00	B	B	A
12:00	B	A	A
13:00	B	A	A
14:00	B	A	A
15:00	B	A	A
16:00	B	A	A
17:00	B	B	A
18:00	C	B	B
19:00	C	B	B
20:00	C	B	B
21:00	C	B	B
22:00	C	B	B
23:00	C	B	B

Accumulative assessment value	Environmental Quality	
	Level	Grade
10 to 12	Good	A
7 to 9	Moderate	B
4 to 6	Poor	C
3	Very Poor	D

Summer

Time	Environmental Quality Level		
	Street canyon	Urban square	Urban park
0:00	B	A	A
1:00	B	A	A
2:00	B	A	A
3:00	B	A	A
4:00	B	A	A
5:00	B	A	A
6:00	B	A	A
7:00	B	B	A
8:00	B	B	A
9:00	B	C	A
10:00	B	C	A
11:00	B	C	B
12:00	B	C	B
13:00	C	C	B
14:00	C	C	B
15:00	C	C	B
16:00	C	C	B
17:00	B	B	B
18:00	B	B	A
19:00	B	B	A
20:00	B	B	A
21:00	B	B	A
22:00	B	B	A
23:00	B	B	A

Results

- **The case study points to the higher environmental quality of the urban park in comparison to the urban square and the streets.**
- **Summer -** The environmental quality of the park is pronounced mainly by the mitigation of thermal discomfort.

- At 12:00-17:00 - “Moderate” level in the park
  “Poor” level in the square and the street.
- At the rest of the daylight hours - “Good” level in the park
  “Moderate” level in the street.

- **Winter -** The environmental quality of the park is pronounced mainly by decreasing of air pollutants.

- At 12:00-17:00 - “Good” level in the park & square
  “Moderate” level in the street.
- For the rest of the daylight hours - “Moderate” level in both park & square
  “Poor” level in the street.

The findings emphasize the importance of treed parks in the urban tissue and justify an investment in them in terms of sustainable development.

Summary

The **METHODOLOGY** for the
ENVIRONMENTAL QUANTITATIVE ASSESSESSMENT of URBAN PARKS

- **Provides an integrative tool for examining environmental nuisances**
- **Is based on empirical data that is usually monitored by researchers or by official agents.**
- **Is analyzed according to verified categorizations, is feasible and is universally applicable.**
- **Enables the grading of different types of parks and open spaces as per their environmental quality level.**
- **Can offer a beneficial tool in the planning process, helping to attain the ultimate environmental benefits from urban open spaces for the wellbeing of the inhabitants.**

Thanks for your kind attention