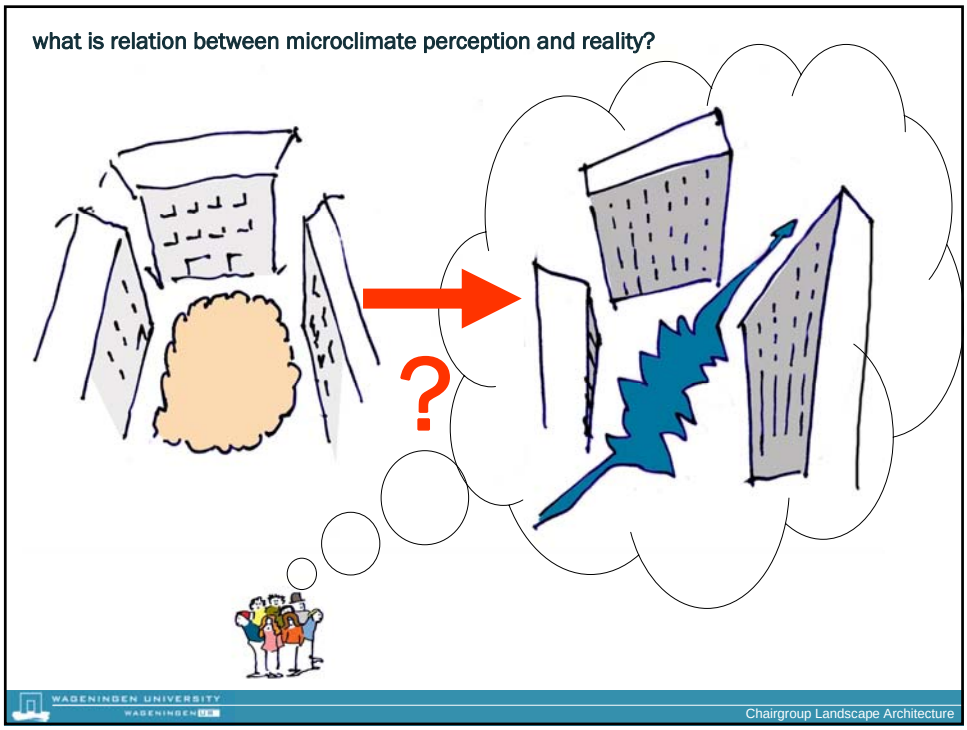
… a quest for knowledge:

designing with urban climate

Summary

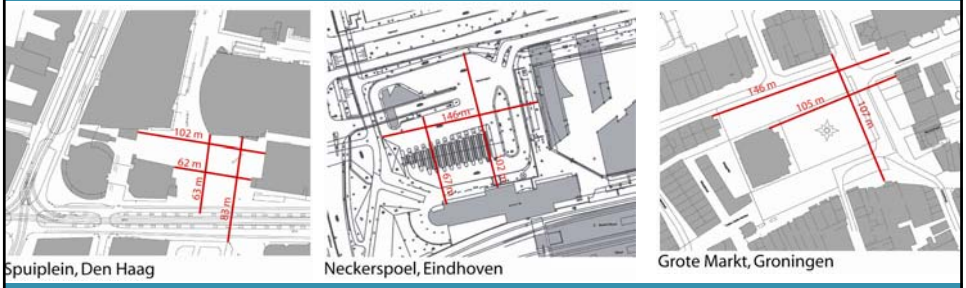
1. Research for design, PhD project
2. Research by design, PhD project
3. Design research urban climate, Arnhem


Thermal comfort experience in urban public space
Research and design
studies on Dutch urban squares
Research project within WIMEK research school, WUR and Uni Kassel
WAGENINGEN UNIVERSITY
Chairgroup Landscape Architecture


what is relation between microclimate perception and reality?
?
WAGENINGEN UNIVERSITY
Chairgroup Landscape Architecture

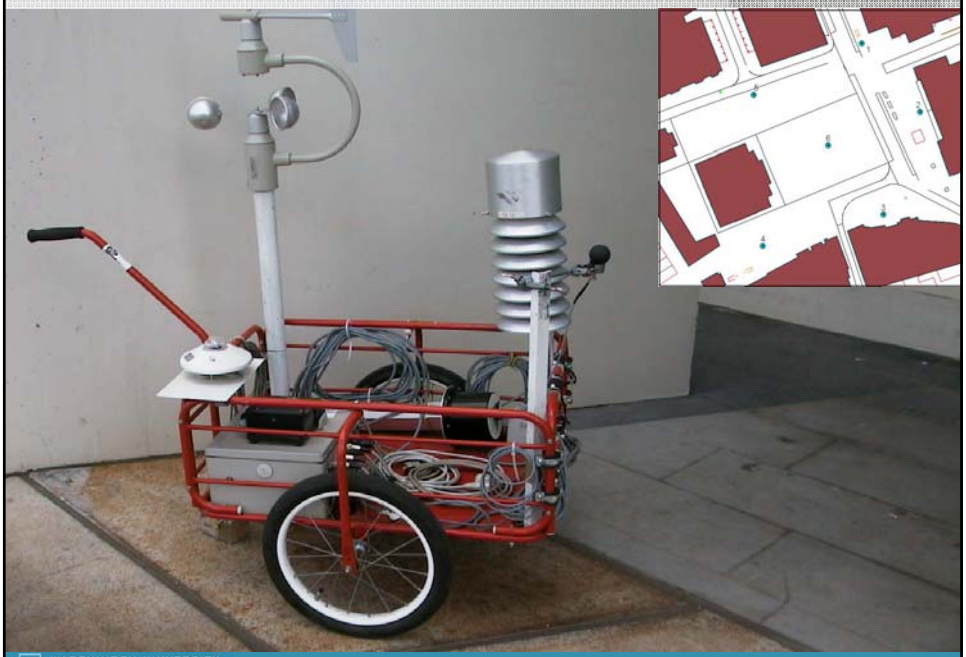
Research for design

generating knowledge and design tools that are usable in design



Spuiplein, Den Haag | Neckerspoel, Eindhoven | Grote Markt, Groningen

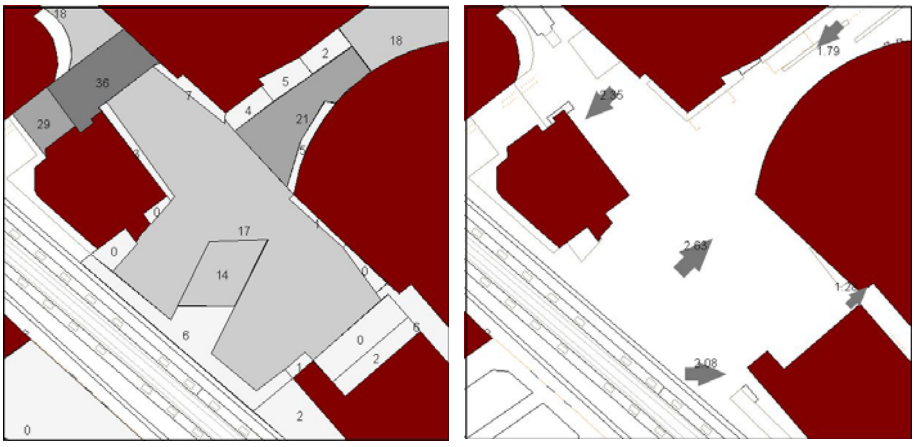
measurements with the mobile mini- weatherstation



Research question 1 “experience schemata”

What is the relation of human thermal experience “schemata” about a public space in comparison with its factual microclimate?

map- comparisons experience and measured data



example: experience “too windy”

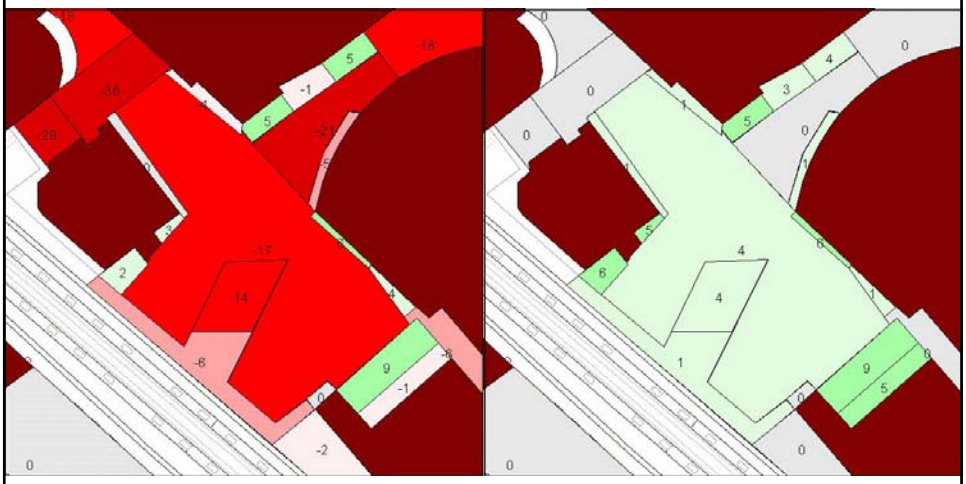
Results thermal comfort “experience schemata”

1. the extreme wind measurement data explain long- term experience mechanisms better than averages, suggesting that more extreme microclimate events have a stronger impact on the schemata people develop about a place
2. these microclimate schemata, because they are based on extremes are generally more negative than positive

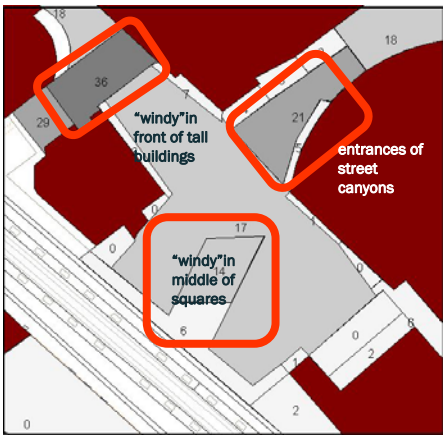
Research question 2 “microclimate and experience of spatial patterns”

Are there spatial typologies that are preferred or avoided with respect to microclimate experience?

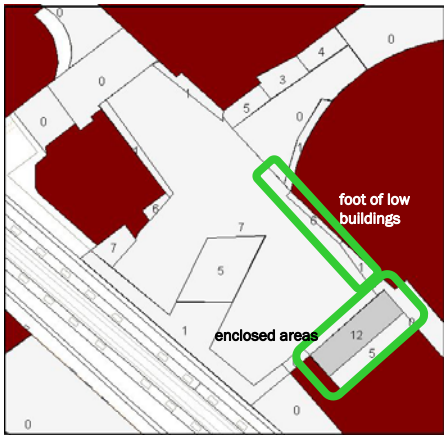
analysis spatial patterns



analysis spatial patterns



experience "wind discomfort"



experience " sun comfort"

Results thermal comfort “microclimate and experience of spatial patterns”

1. mental maps seem to include “spatial cues” for microclimate: spatial configurations that are connected with certain microclimate properties
2. in comparison to factual microclimate (also see research part on schemata) these “mental maps” to a great extent do and a smaller extent do not match with scientific knowledge on microclimate

Research question 3 “proportion, openness and materials”

Are there specific spatial and materialization types that influence thermal experience?

1 main hypothesis

"thermal discomfort is perceived because of configuration and materialization of an urban place"

3 subhypotheses:

a. thermal discomfort can be influenced by too wide proportions of a square

b. thermal discomfort can be influenced by a too open "void" space in a square

c. thermal discomfort can be influenced by the use of materials with a "cold" appearance

statistical analyses

testing subhypothesis a: "thermal discomfort can be influenced by too wide proportions of a square"

dependent variable thermal dis/comfort correlated with the independent variable: proportions of the square

Tests of Between-Subjects Effects

Dependent Variable: diffcomf

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	134.024	8	16.753	1.698	0.095
Intercept	246.111	1	246.111	24.945	0.000
width	79.446	2	39.723	4.026	0.018
plein	9.013	2	4.507	0.457	0.634
width * plein	21.715	4	5.429	0.550	0.699
Error	6,768.111	686	9.866		
Total	7,527.000	695			
Corrected Total	6,902.135	694			

a. R Squared = .019 (Adjusted R Squared = .008)

subhypothesis a proven: "thermal discomfort is influenced by too wide proportions of a square"

statistical analyses

testing subhypothesis b: “thermal discomfort can be influenced by a too open “void” space in a square”

dependent variable thermal dis/comfort correlated with the independent variable: openness of the square

Tests of Between-Subjects Effects

Dependent Variable: diffcomf

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	439.294	5	87.859	10.061	0.000
Intercept	397.563	1	397.563	45.526	0.000
open	370.249	1	370.249	42.399	0.000
plein	5.724	2	2.862	0.328	0.721
open * plein	46.166	2	23.083	2.643	0.072
Error	5,134.760	588	8.733		
Total	6,102.000	594			
Corrected Total	5,574.054	593			

a. R Squared = .079 (Adjusted R Squared = .071)

subhypothesis b proven: “thermal discomfort is influenced by a too open “void” space in a square”

statistical analyses

proposals of interviewees against the “opnenness”

place	flowers	trees	monuments/ art	fountains/water	seats	pavillions	wind/rainscreens	others
DenHaag	18%	23%	4%	2%	22%	2%	2%	13%
Eindhoven	8%	12%	0%	0%	17%	1%	17%	2%
Groningen	7%	29%	0%	8%	23%	2%	4%	10%
average	11%	21%	1%	3%	21%	2%	8%	8%

interesting: most proposals also have a significant impact on microclimate!

statistical analyses

testing subhypothesis c: “thermal discomfort can be influenced by the use of materials with a “cold” appearance”

dependent variable thermal dis/comfort correlated with the independent variable: materials cold/ warm

Tests of Between-Subjects Effects

Dependent Variable: diffcomf

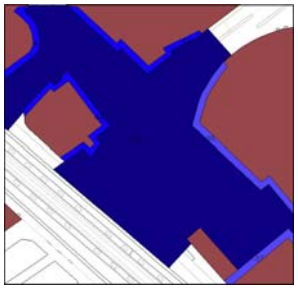
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	74.853	5	14.971	1.749	0.123
Intercept	259.473	1	259.473	30.322	0.000
matcw	66.795	1	66.795	7.806	0.006
plein	4.268	2	2.134	0.249	0.779
matcw * plein	6.625	2	3.313	0.387	0.679
Error	2,815.344	329	8.557		
Total	3,375.000	335			
Corrected Total	2,890.197	334			

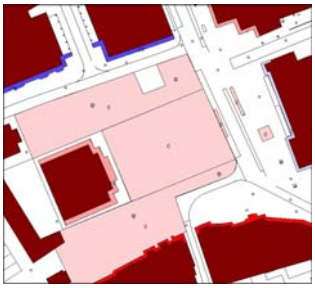
a. R Squared = .026 (Adjusted R Squared = .011)

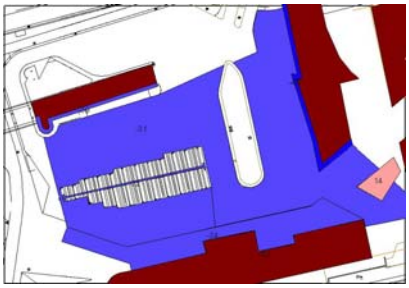
subhypothesis c proven: “thermal discomfort is influenced by the use of materials with a “cold” appearance”

spatial analysis materials and “cold/ warm appearance”

striking differences in perception of materials and their spatial distribution in different squares







First conclusions from research for design

general:

- "people in the street" have quite a high acuity for interpreting the environment with respect to its probable physical microclimate ???? why do designers have less knowledge????

practically speaking this means:

- avoid too square proportions of 0.20 and lower- better offer smaller subplaces or wind protection
- avoid too open squares- better offer sufficient vegetation and other elements that also improve or diversify microclimate
- in Dutch context avoid use of "cold" materials: cool colours, smooth texture, high reflectivity, high heat conductivity, rather use materials with warm appearance, colour and physical properties

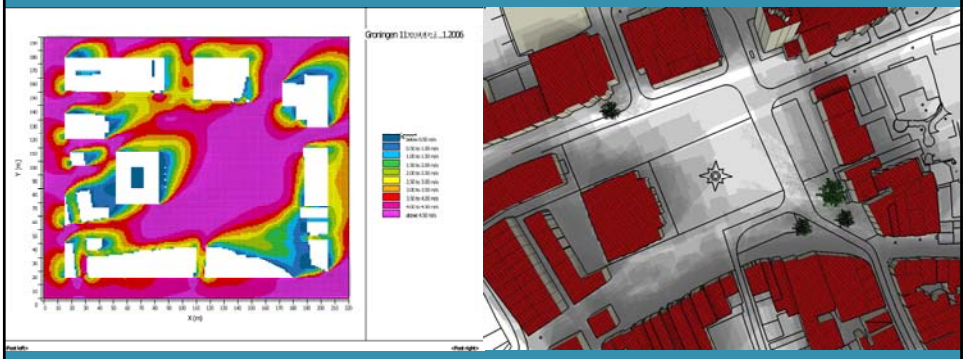
Research by design

design for a climate responsive "opti-model"
of Dutch squares

Physical approach, example Grote Markt

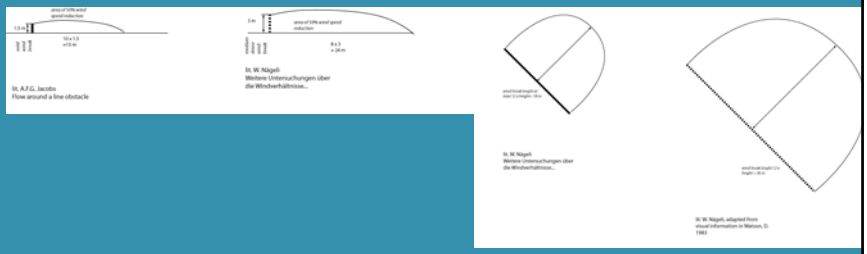
Conclusion simulations:

- southwesterly winds uncomfortable, mostly at southwest entrance and square centre
- shadow study shows certain areas that are exposed to high irradiance

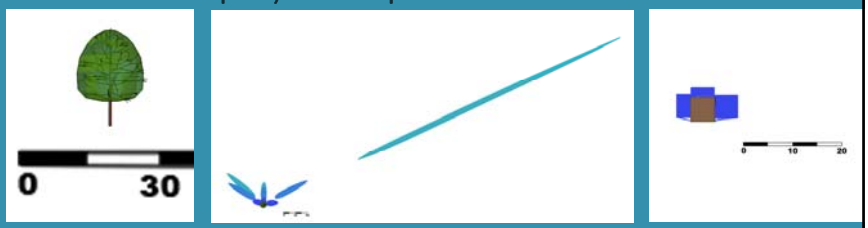


the “elements” of the “opti-model”

- wind protection patterns

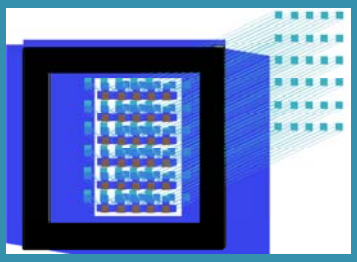


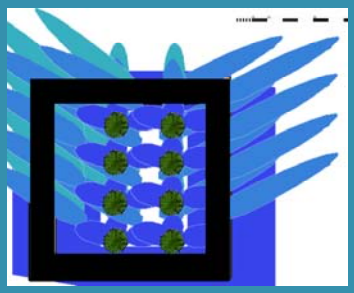
- solar radiation impact:/ shadow patterns



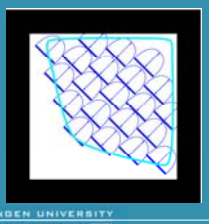
variations “opti-model”

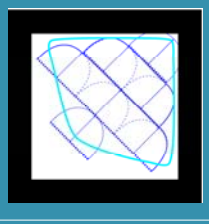
- solar radiation impact:/ shadow patterns





- wind protection patterns

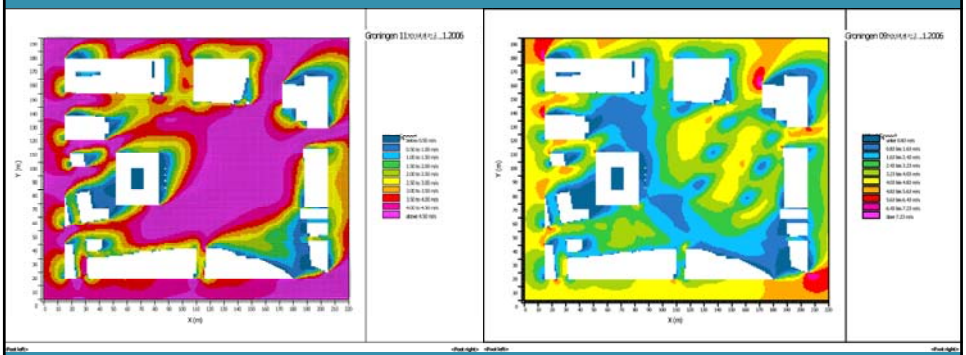




Physical approach, Grote Markt

Conclusion first design alternative:

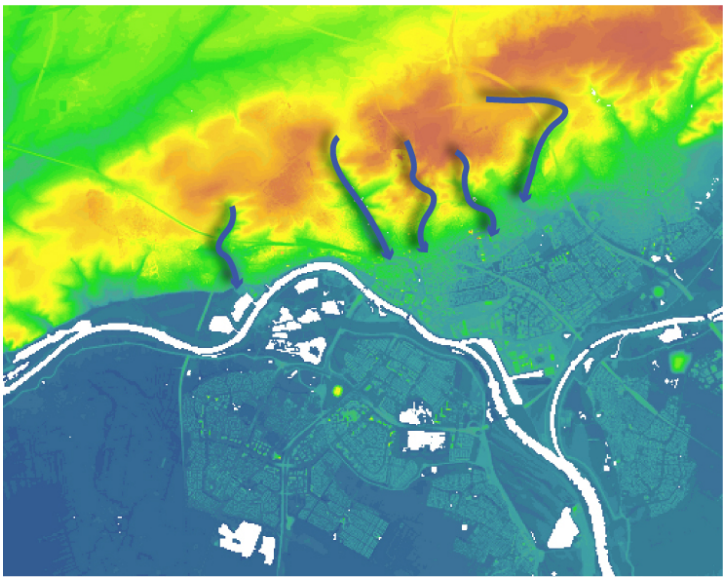
- southwesterly winds not sufficiently buffered
- more protection needed



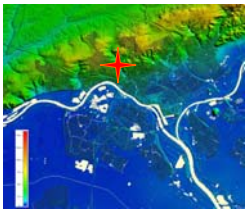
Professional Academy

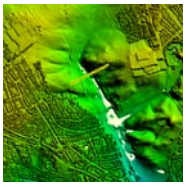
making Arnhem climate- proof: focus atmospheric climate

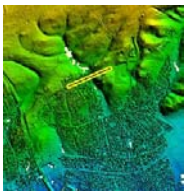
cold air flows (based on the relief) come in the city of Arnhem

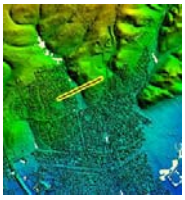


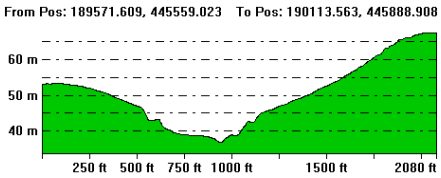
slope analysis valleys

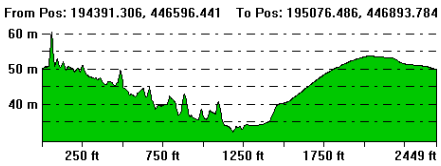


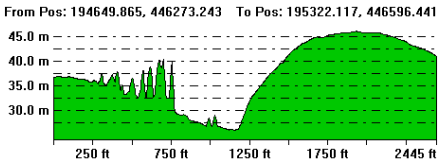




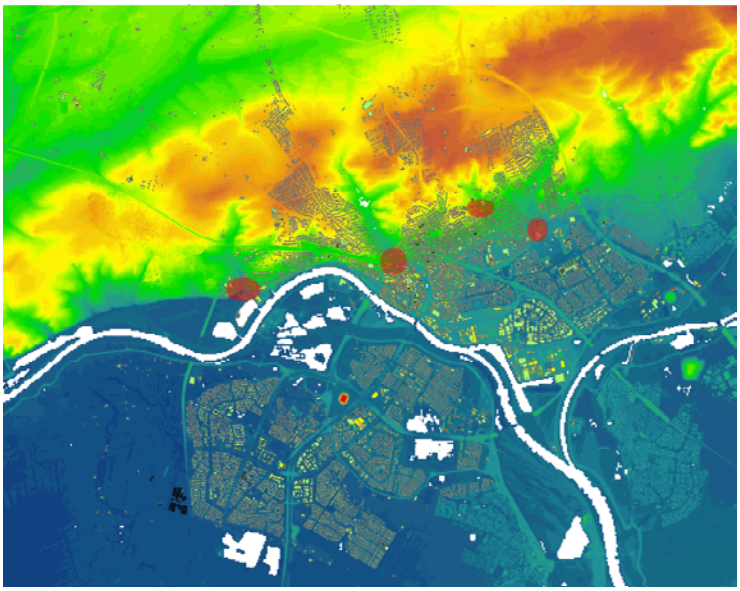




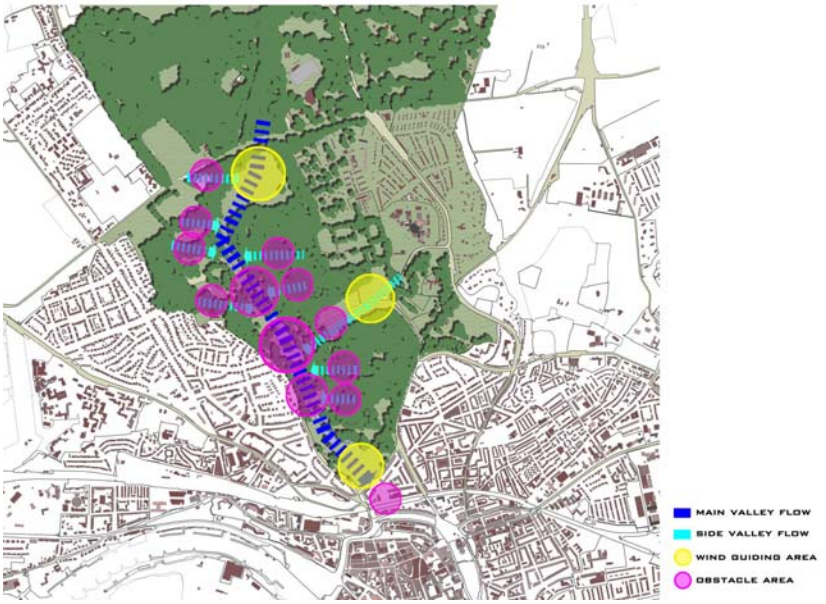




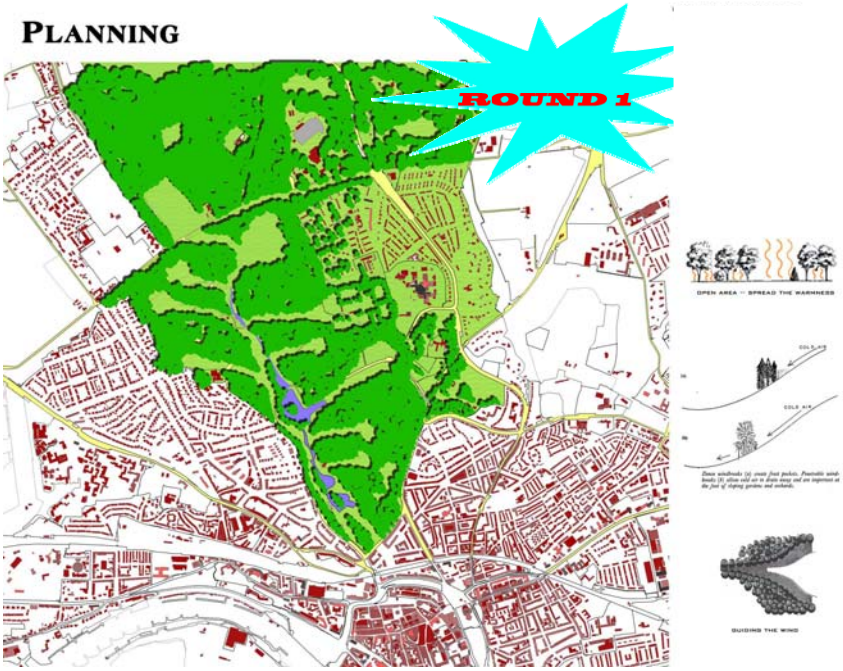
Obstacles: Buildings and elevated road/railways



SPACIAL PROBLEM ANALYSIS



PLANNING



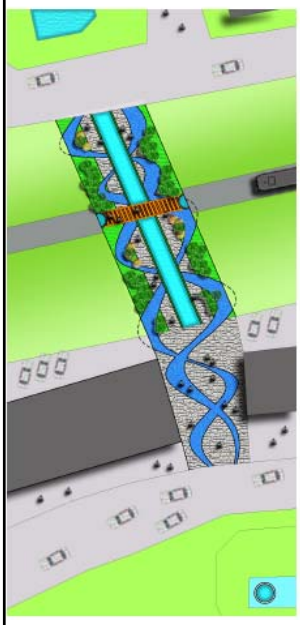
Integrating the concept with design area

-Green System
completeness, participation, accessibility, continuity

-Water System
continuity, expression form, narration, climate benefits

-Cooling
cooling effect, blocking, pros and cons

-People's Activity
walking experience (entering route)

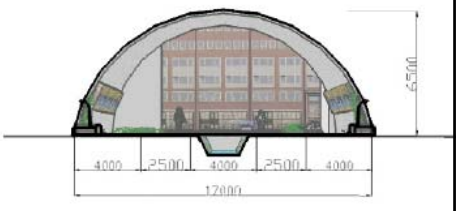


A. Design ideas

• open a water channel in the middle, roughly following the water trail which is mentioned before, also it fits the idea of the "water machine"
• keep the main design line straight to divise the space, for the passing function and walking experience
• reappear the trail of the railway, as a connection of main design lines
• the sand river represents the cold air flow from the sonsbeek valley, which also is an curve element breaking the strong straight lines, but still following the same orientation
• the hanging cultural walls, telling the story of the park, or the climate benefits of Sonsbeek, etc.

B. Scale

- H = 6.5 m
- W =17 m
- L = 50 m



5. Climatopes

Legend

Climatopes

Industry Climatope
- Waste
- Industry

Railroad Climatope
- Railroad

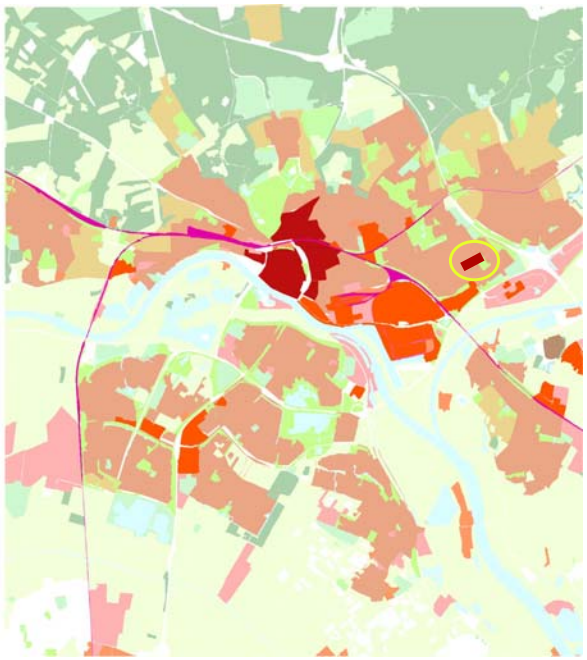
Greenbelt Climatope
- Vacation areas; daily reacreation; sport facilities
- Allotment gardens
- Parks

Forest Climatope
- Forest

Water Climatope
- Water bodies

City Climatope
- Construction Areas/Old Ship Yard
- City center
- Pheriphery
- Villa districts

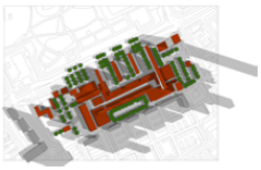
Open Land Climatope
- Agriculture; excavation areas
- Cemetery



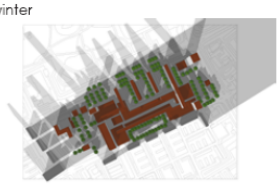
CLIMATE ANALYSIS

PRESIKHAAF IN GENERAL
_problems expected in shopping centre

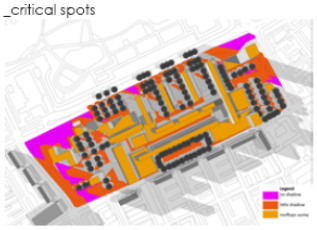
SHADOW-STUDY
_summer



_winter



_critical spots



WINDCOMFORT
_Southwesterly winds

_Easterly winds

1. Use vegetation to block and filter the sun at critical spots

- deciduous trees

(Robinette, 1983)
(Brown and Gillespie, 1995)

3. Make use of green roofs to lower temperature for residents

- in combination with easterly winds
- option for indoor climate of the shopping center

(Robinette, 1983)
(Brown and Gillespie, 1995)

2. Use vegetation to block and filter the sun at south walls

- deciduous trees
- green walls

(Robinette, 1983)
(Brown and Gillespie, 1995)

4. Make use of 'cool' materials for pavement at critical spots

- colour
- surface roughness
- sizing

(Doulos and Santamouris, 2004)

CLIMATE STRATEGIES_WIND COMFORT

1. Catch downwinds with large-canopy trees

- focus at southwesterly winds
- especially around high rise buildings

(Boutet, 1987)
(Robinette, 1983)

3. Change building structure to provide a more comfortable situatio at pedestrian level

- towers not directly situated at corners
- organic shaped towers

(Boutet, 1987)
(Bottema, 1993)

2. Catch wind flows with increased velocity around building corners

- vegetation should be closed untill groundlevel

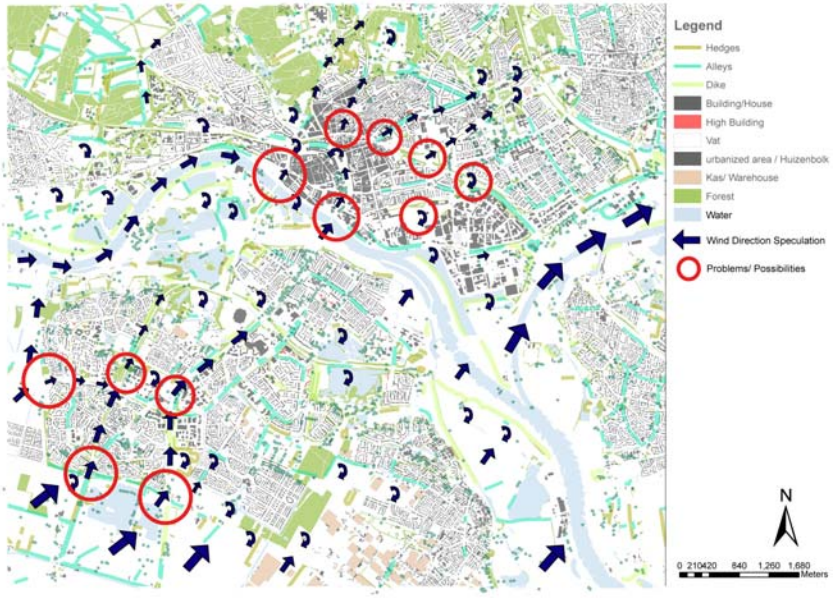
(Boutet, 1987)
(Robinette, 1983)

4. Provide wind screens in front of southwesterly directed openings

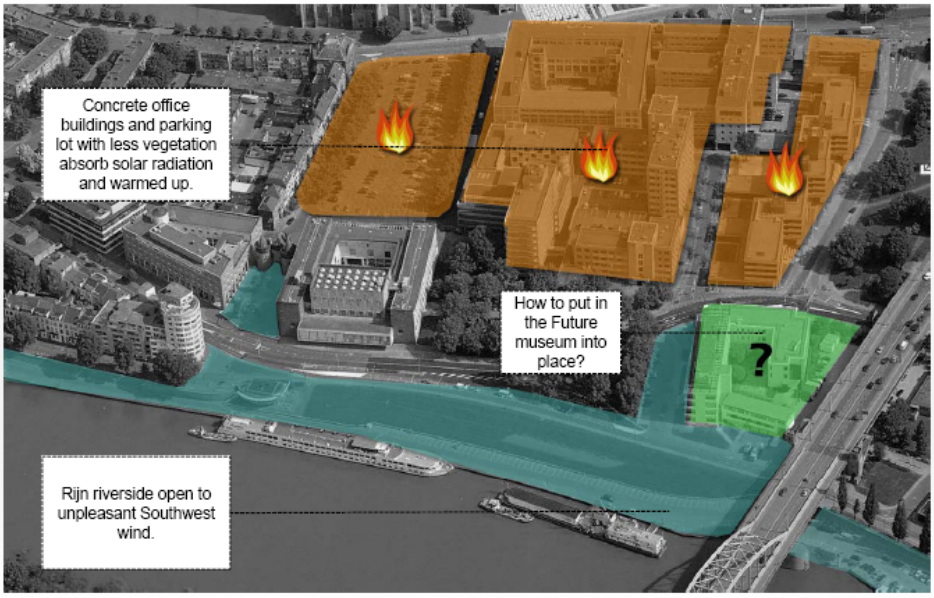
- provide a certain distance between the opening and the wind screen

(Brown and Gillespie, 1995)
(Robinette, 1983)

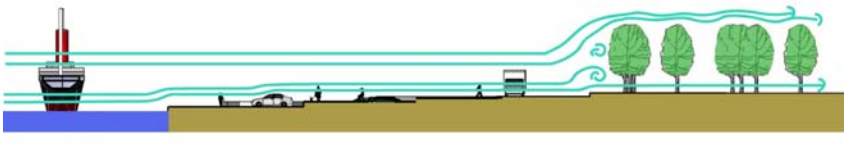
Southwesterly winds



Problems Identification

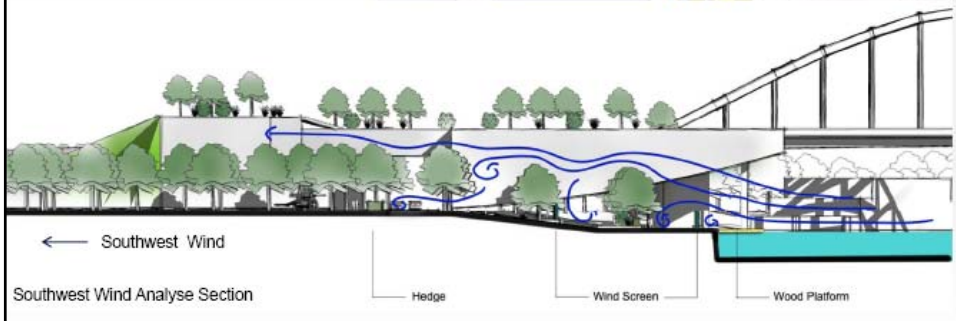


Streamside Current Section

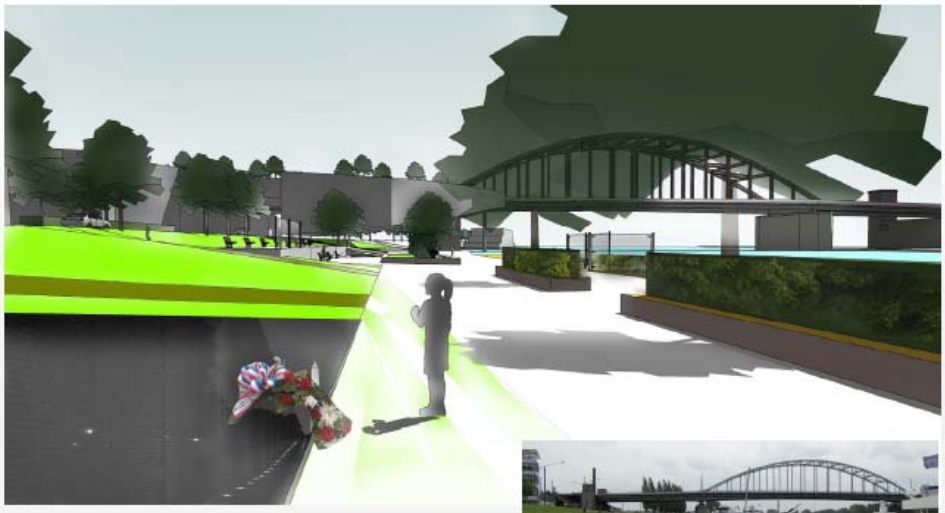


Node3 Current Section

Riverfront Area Plan



Southwest Wind Analyse Section



Riverfront After
&
Before

main questions:

what can be multifunctional green and water-structures in the city that also improve (micro-) climate?

what shapes should these structures have?

what sizes/ dimensions should these structure have?

required:

true transdisciplinary research

application- oriented research for designers/ planners

where landscape architects/ urban designers identify knowledge gaps from the practical field and try to fill these together climate specialists