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RESEARCH AND DESIGN FOR CLIMATE ADAPTATION IN LANDSCAPE ARCHITECTURE EDUCATION

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Adaptation to climate change implies many new challenges for landscape architecture and urban design projects. In order to prepare the new generation of landscape architects to these challenges it is of great importance to include the issue of climate adaptation in design education. In Wageningen University, a first step in this direction was taken: a landscape architecture studio focusing on climate responsive design was set up. The atmospheric climate of a city was the main topic of research, was analyzed and translated into climate responsive design for the case of the city of Arnhem, The Netherlands. The studio had a didactic structure where research and design were connected through three steps: 1. scientific knowledge acquisition, 2. local climate analysis on different scale levels, 3. response to analysis through design. This article reports the learning process and results and draws conclusions for educational methods on research and design for climate adaptation in landscape architecture.

1 INTRODUCTION

The problem of a lack of professional knowledge on climate- responsive urban and landscape architectural design has been brought forward by several authors earlier. That encompasses both a lack of fundamental scientific knowledge and of procedural knowledge: design methods to apply urban climate knowledge (Eliasson, 2000; Katzschner, 2006). Especially due to the urgency that the global climate discussion has on the topic of climate adaptation in cities, it has become inevitable to provide landscape architects and urban designers with more design knowledge in relation to urban climate. This involves the translation of climate knowledge into design directives and designing on various scale levels for climate adaptation.

We think that it is necessary to introduce this topic of urban climate adaptation in our design classes to prepare the students on the challenges awaiting them to practically deal with climate responsive design after graduation. To offer students the possibilities to explore this topic and acquire this highly demanded knowledge we decided to include it in the 3 month "Professional Academy" studio taking place in the first year of our MSc landscape architecture in Wageningen University. The educational level in this studio was based on the prerequisite that the students have a BSc degree in landscape architecture, assuming that they have some general knowledge about scientific methods and design. In this studio we normally have a mixture of international students with backgrounds form very different universities all over the world.

In this "Professional Academy" studio, we normally do not only explore different relevant scientific fields (ecology, hydrology or in this case urban climate), but we also cooperate with real- world partners from the professional field as "stakeholders". The "stakeholders" have a specific design problem which they ask the students to investigate in relation to the field in question. In this case we linked the studio to a "stakeholder" who was interested in introducing climate responsive design, being the municipality of Arnhem. The municipality needed climate responsive plans and design recommendations as an inspiration for

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development of the new master plan ("structuurvisie") for city development. In this "structuurvisie" the municipality wanted to introduce the issue of urban climate in their urban planning. By doing so, they are the first local authority in The Netherlands who tries to actively include these climate issues in urban planning. We provided the municipality of Arnhem with design ideas that could trigger a deeper understanding of urban climate issues in their urban planning and design strategies. These were concrete climate- responsive design proposals on different scale levels for different locations in the city.

We were aware of the problems with respect to climate-responsive design. This mainly concerned the availability of fundamental usable urban climate knowledge and consequently a lack of design guidelines and reference projects of climate responsive design. But we considered the issue of climate adaptation so important that we decided to tackle these problems within the studio work. We tried to generate as much design knowledge as possible ourselves. Here it was of great help that the main tutor of the cours has a specialization climate responsive design. Additionally we asked the help of external experts in urban climate and meteorology (Prof. Dr. L. Katzschner, Dr. W. Beckröge, Dr. B. van Hove). So we gave the students the possibility to acquaint the necessary design knowledge mostly by themselves and translate this into design proposals. This is in line with our general approach in landscape architecture education in Wageningen where a clear focus lies on the integration of scientific research and design. Resulting from the issues and problems mentioned above we formulated three main learning goals for the studio. After completion of the studio we wanted the students to:

- be able to transfer scientific knowledge into design recommendations
- conduct general meso- and microclimate analyses for urban environments
- apply design recommendations on different scale levels

Resulting from this, the main didactic questions derived from the learning goals were:

1. How can the students translate fundamental knowledge into design implications?
2. How can the students learn to analyze the climate of the urban environment?
3. How can climate-responsive design be achieved for different scale- levels?

Unfortunately, to answer this array of questions we could not build on existing didactic knowledge. The literature on landscape architecture design education did not provide any hints on educational approaches to climate responsive design whatsoever. Therefore we had to come up with an experimental setup for the design studio. In the following, I report on this first studio that we taught in 2008/9. I structure this report by first discussing the teaching methods and results that we used related to the main didactic questions and eventually I will try to draw some conclusions from the experiences with this first climate-responsive studio in our MSc landscape architecture in Wageningen UR.

2 METHODS AND RESULTS

We used different teaching methods in the different phases that were related to the main questions mentioned above. The sequence of questions also reflects the sequence of the research and design work in the studio. We started to build a general knowledge basis that got applied in a location analysis and was eventually addressed in design responses.

2.1 How can the students translate fundamental knowledge into design implications?

In this phase the main assignment was to inventorize relevant scientific knowledge by literature research and if necessary, translate it into design recommendations. The students were asked to generate a reliable, comprehensible set of knowledge that can be used as a "knowledge pool" for everybody throughout the subsequent studio work. This phase, taking about 3 weeks, was done in group work and three groups were formed. Each group addressed one of the typical design interventions that can be used within landscape architecture and urban design to influence urban climate: green, water and building configuration.

As a first step, the students were asked to conduct literature research in the university library and especially via the use of scientific literature databases such as Scopus or the ISI database. It occurred that there were some typical problems in this knowledge inventory phase. Firstly, students often seemed unable to differentiate between reliable scientific literature and other non peer-reviewed or "grey" literature or information picked from the Internet. It took considerable efforts to make the students aware of that difference and motivate them to use scientific, reliable knowledge. Also, students often did not research all available sources, so the outcome was not complete. These are both problems related to the previous knowledge the students had acquired in their former schools concerning scientific literature research methods. Since in many landscape architecture schools little attention was and is given to this issue, we faced very different levels in this literature research phase. But we also encountered general problems in the availability of scientific literature on urban climate knowledge. Indeed, much scientific knowledge is very scattered over all kinds of journals and other publications, also in different fields. For instance, very relevant and usable knowledge exists on wind protection elements in agricultural studies, but someone researching within urban contexts would not be very inclined to search in that field. These problems called for intense tutoring. Also, to make sure that this literature research was conducted in a conscientious way and on a sufficient scientific level, a substantial previous knowledge of the literature by the lecturers was needed.

Through this literature research the students became "specialists" on green, water or building configuration in relation to urban climate. They were asked to reproduce this scientific knowledge in a conscientious and understandable way for the rest of the course mates. This also posed typical problems: much of the scientific knowledge- even when it is intended to be used by other non-specialists is incomprehensible. This problem has been identified earlier in the field of climate knowledge and design (Eliasson, 2000). When the scientific knowledge is presented in jargon and complicated formulae it often becomes too much of a challenge for students to make sense of this information. On the other hand, it also stimulated the more daring students to "crack these nuts". To tackle this problem of comprehensibility we included, supplementary to the tutor's knowledge, extra scientific advice from external specialists in the field of urban climate and meteorology.

We expected the outcome of this literature inventory to find design guidelines to be incomplete because we knew that much scientific knowledge needs another translation step to serve as design guidelines. Apart from few comprehensive publications on small scale landscape architectural interventions (Robinette and McClennon, 1983; Brown and Gillespie, 1995) and some on urban design interventions (Littlefair et al., 2000; Ministry of Economy Baden- Württemberg, 2008) not much directly implementable design knowledge was accessible. That lack of design- related knowledge required another step and didactic approach in the studio work- translating scientific knowledge into design recommendations.

To achieve this, the students were invited to deduce precise and valid design guidelines that were easy to use in a design process from their literature research. This knowledge was expected to serve as a "toolbox" that they have at their disposal during the subsequent design work. The typical issues that had to be addressed here were the differentiation of "problem" and "solution" on different scale levels. To address the problems and possible solutions, the students were assigned to generate specific overviews on how green, water and building structures influence the main parameters (temperature, wind, etc.) of urban climate. They differentiated interventions on different scale levels, based on the knowledge that temperature and humidity are mainly influenced by very large scaled interventions and radiation and wind on a smaller scale –level.

To generate an easy- to use "toolbox" for green, water and building structures, we encouraged the students to firstly visualize the fundamental scientific knowledge that they had found as clear as possible in diagrams or overviews where the main information is seen in one glance. In order to understand the very important time- factor of climate processes, they were also encouraged to visualize this in time steps. A typical problem occurring in making a generic "toolbox" was that the design solutions generated for one situation often brought on other new problems for other situations. For instance, when ventilation axes or when shading devices were proposed to cool the city in summer, they could have an averse effect in winter. That required a strategic approach where different situations were studied very conscientiously over time, also taking into account the typical weather situations with their typical regional wind directions. The recommended solutions addressed the most common situations or they were general "no regret" solutions that show positive effects in many circumstances.

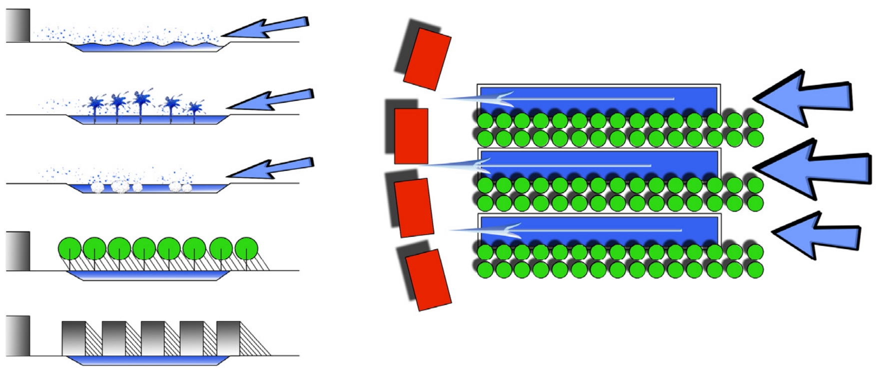


Figure 1 model of the “passive urban aircondition”

Of course, it would go beyond the scope and educational topic of this article, to reproduce all the “tools” that were researched and formulated. But I would like to illustrate some typical results with two examples of how students translated fundamental knowledge into a new design tool. One of the new tools is the “urban air condition”, a system of East- West oriented shaded canals where the Easterly winds that predominate during hot weather are funneled and get cooled with water vapour. This vapour can either be evoked by generating waves in very long canals, by roughening the water surface with stones or by introducing fountains in the waterbodies. This vapour is then carried into built- up areas by the Easterlies to generate a cooling effect during heat- waves (see example Figure 1). The other set of tools serves to filter or displace urban air pollution within street canyons. Here, different “passive cleaning models” were developed of which several proposals can be seen in Figure 2.

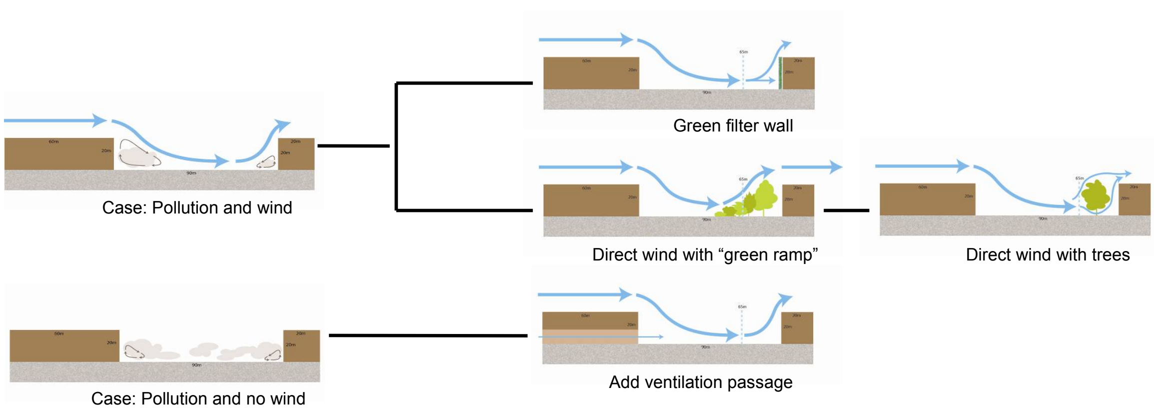


Figure 2 passive systems for air pollution mitigation

The creation of this “toolbox” was not easy for the students due to different reasons. Sometimes there was not sufficient fundamental knowledge available to deduce spatial “tools”. Also, after the study of different hypothetical solutions over time, the students concluded that a reliable prediction of effects of certain design interventions is not possible without knowing the specific site and its surroundings- in other words, that many situations are unique and they require unique solutions. However, in some cases as shown above, it was possible to generate these “tools” and these supplemented the existing design recommendation pool.

Through this phase of literature search and design knowledge deduction the students had acquired sufficient understanding of the effects of climate on the urban environment (which consists to a large extent of built up, vegetated and water areas). Vice versa they had also understood general effects of the urban environment on the urban climate. They were thus ready to take the next step in the learning process, which was a concrete case-related application of their acquired theoretical knowledge.

2.2 How can the students learn to analyze the climate of the urban environment?

To make students acquainted with the analysis of existing urban climate we asked them to come up with first assumptions on the expected meso- and microclimate in our case- area, the municipality of Arnhem. Based on the knowledge they had acquired in the first phase about the urban climate effects of green, materials, urban configurations, etc. they were now able to generate first assumptions about urban climate for the concrete case. Supplementary to their own analysis, we also invited them to study the methodology of practical urban climate analysis projects that were conducted elsewhere. We focused on the well-developed analysis methods that were used in Germany (Stuttgart, Kassel, Freiburg, Ruhrgebiet), specifically the ones documented in the English language by the municipality of Stuttgart (Ministry of Economy Baden- Württemberg, 2008).

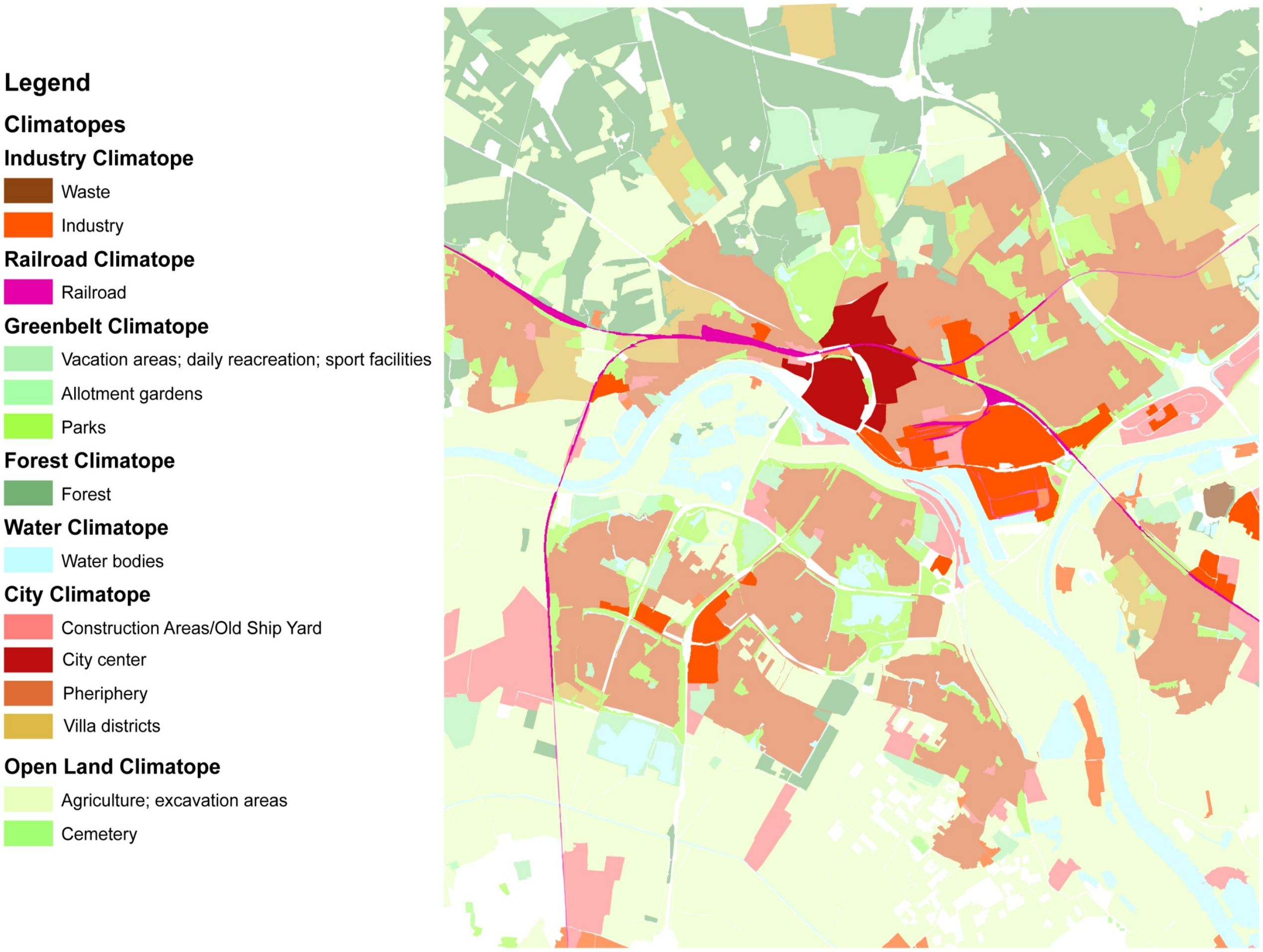


Figure 3 "climatopes" in Arnhem

We did not ask for the students to generate extensive quantitative data because this would have lead astray from the design focus of the studio. Generation of quantitative data would have required lengthy measurements or simulation series that could by no means be fit into a tight studio time frame of three months. Based on the experiences from urban climate experts in Germany (Prof. Dr. L. Katzschner, Dr. W. Beckröge) we considered a qualitative analysis of expected problems and potentials sufficient. According to these experts, for the analysis of heat and wind problems the knowledge of topography, land use and urban density information, can often suffice. So, the students had to rely on their own newly acquired knowledge to make the analysis and the students developed their own qualitative GIS data based analysis methods. For the issue of air pollution, which is more difficult to analyze, fortunately the students could use some existing data provided by the municipality of Arnhem. In this phase the students worked together in teams again, but now each of the teams focused on different atmospheric climate problems or potentials concerning wind, heat and air pollution. This analysis phase took 3 weeks. In the following, I will give an overview of results of this phase showing different problems and potentials concerning atmospheric climate for the case of Arnhem.

Heat problems: the potential urban heat problem areas were analyzed with the “climatope” method (Ministry of Economy Baden- Württemberg, 2008). Climatopes form (similar to biotopes) areas with certain climate characteristics, predominantly due to their density, land use and materiality. Densely built up city areas, commercial or industrial areas, large paved surfaces such as parking lots or railway yards, for instance, are areas that are prone to show distinct heat problems, especially during hot summer nights. The climatope map of the city of Arnhem is shown in Figure 3. Cooling potentials: the cooling potentials of green areas could be derived from the land-use based climatope maps as well. The students also revealed a different type of cooling potentials for the city centre that is caused by nocturnal cold air streams coming downhill to the foot of the Veluwe hills. An analysis of valley geometries (slope expositions and angles) led to the conclusion that several small valleys have the potential to carry cold air into the dense city centre where heat problems are expected (Figure 4).

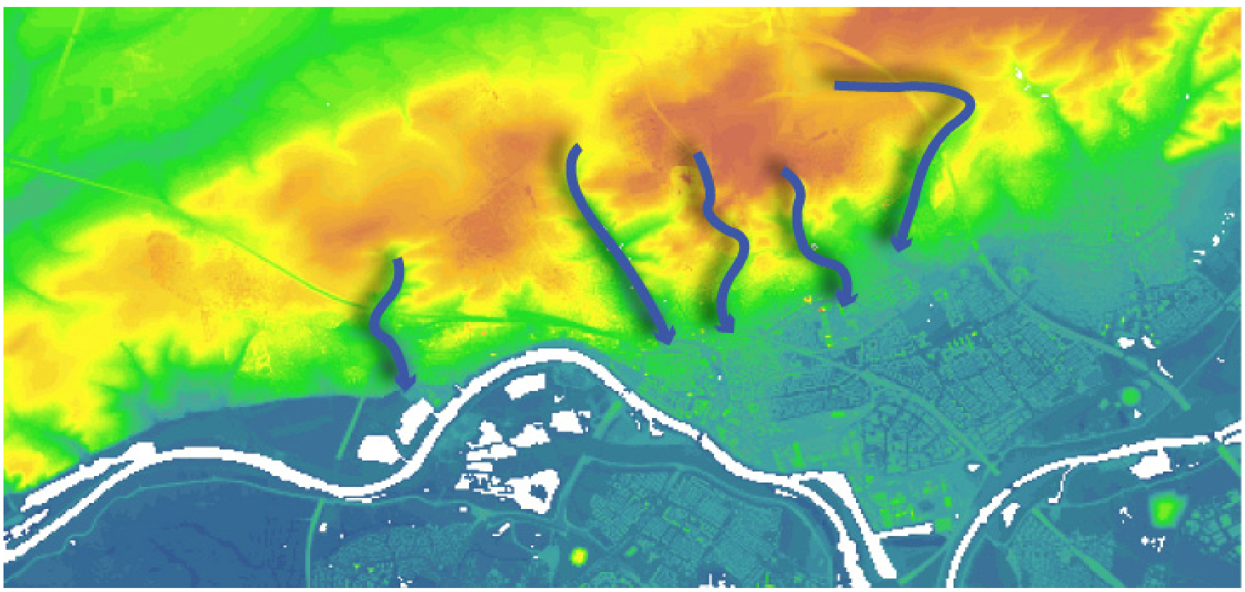


Figure 4 expected cold air streams in the valleys of Arnhem- North

Wind problems: these form a prominent problem in Dutch climate (Lenzholzer, 2008; Lenzholzer, 2009). In the Netherlands especially the Southwesterlies prevail and these are generally stronger than winds from other directions. Based on the analysis of relief, building and vegetation structure, large openings in the urban fabric were identified as possible problem areas that can be affected by the Southwesterlies (Figure 5). Additionally, the students analyzed wind problem areas according to the smaller scaled street patterns in different neighbourhoods and building morphologies. From this analysis they came up with well- founded assumptions on the areas where ventilation problems exist and areas where a higher roughness through tall buildings might bring about more turbulences. Wind potentials: wind is not only a nuisance in The Netherlands because in very hot summers, ventilation can also be a relieving factor. In typical hot, anticyclonic situations, generally the wind direction is East. Hence, the students also analyzed the wind path potentials for these possibly cooling Easterly winds and marked the problematic areas where these winds are blocked, e.g. by buildings, river dikes or forested areas.

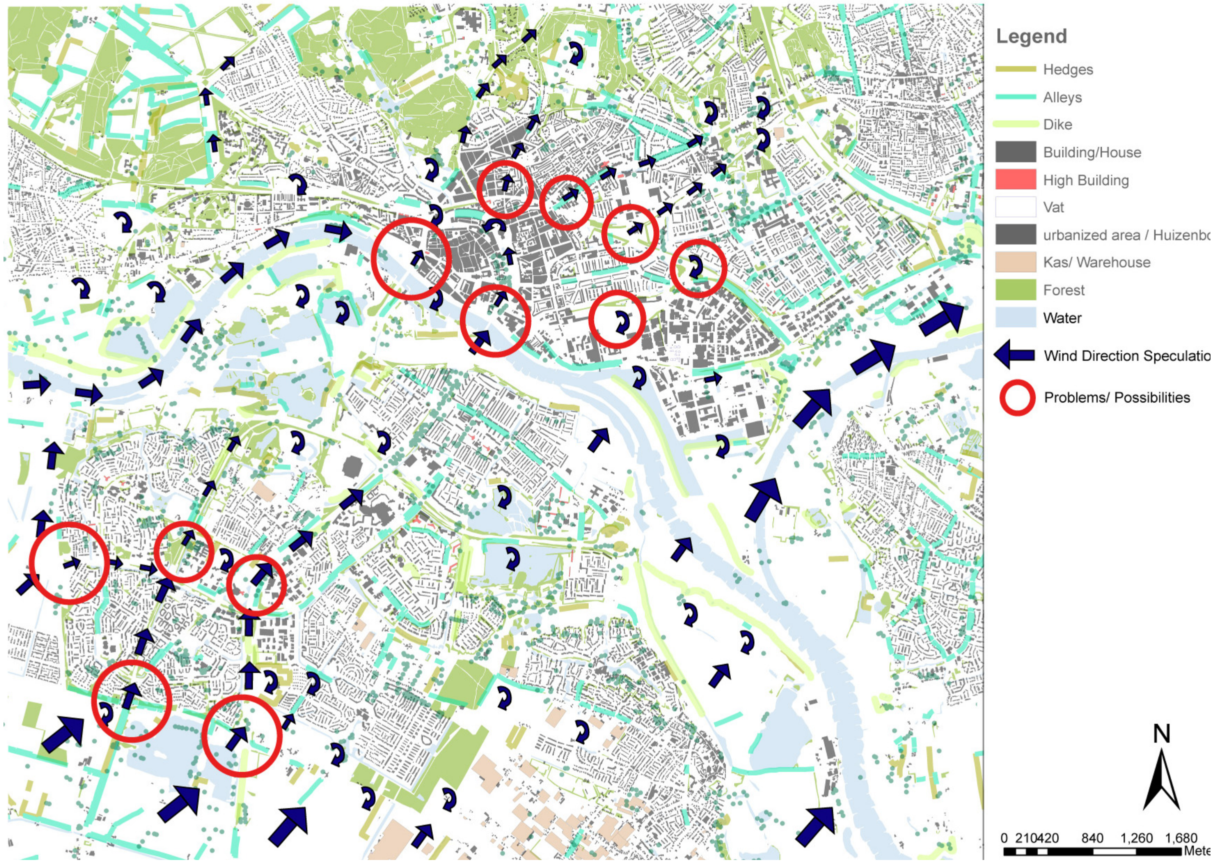


Fig. 5 main corridors Southwesterly winds and problematic places for wind nuisance

Air quality problems: apart from the problems concerning thermal comfort, also air pollution is a problem. Here, the students were able to use the data provided by the municipality of Arnhem. The problematic areas, for the two most relevant types of air pollution (NO2 and fine dust) seemed to be concentrated along the motorways and the major road system (Figure 6).

This local climate analysis phase went unexpectedly unproblematic and the results of this analysis phase showed that students had internalized the scientific climate knowledge and were now able to transfer it to evaluations of existing places. Since they did not have very concrete analysis method examples at their disposal they were very inventive in generating their own analysis tools. They used GIS- data, aerial pictures and site visit data in a creative way to generate their analyses.

The student's urban climate analyses for Arnhem were assessed not only by the tutors but also by German urban climate specialists who considered the analyses a sufficient and useful basis for the next step- the design proposals. Also from these expert's experience, it was often not necessary to use quantitative data as a basis for climate responsive design. They reported from their own experience with climate responsive urban design projects and planning, that for the implementation of climate responsive design interventions, qualitative information, just as the information that the students had generated, is often sufficient.

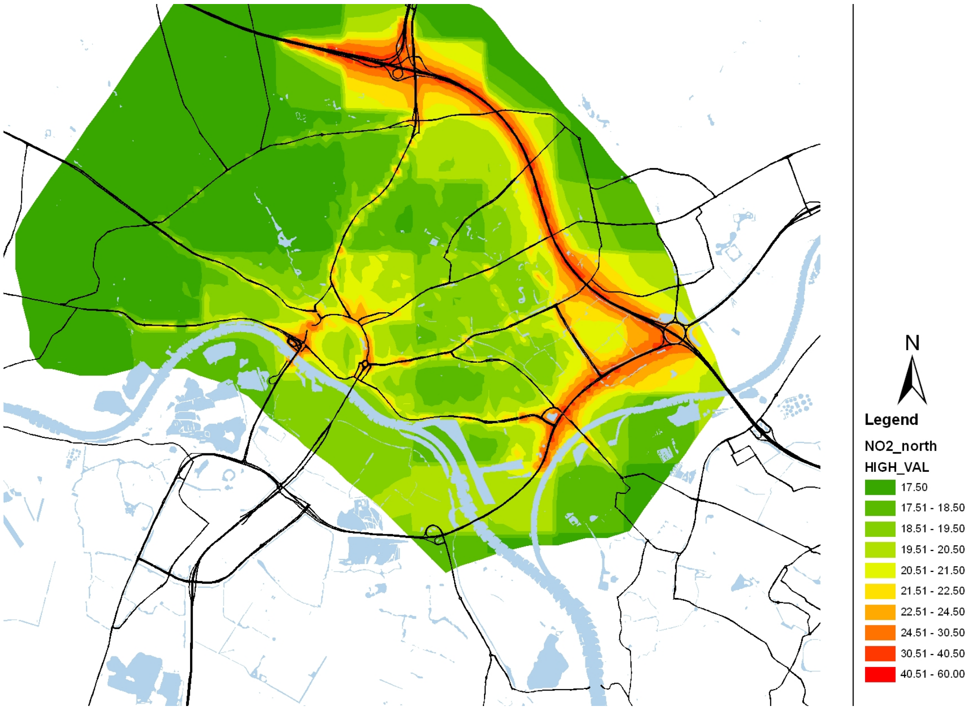


Figure 6 example of map with NO2 values

The stakeholders from Arnhem municipality were surprised about the wealth of knowledge that the students had generated within a few weeks of analysis and were very curious about the implications on design. For the municipality these implications were the most important outcome of the studio because the municipality intended to include design recommendations in their urban design master plans. As a consequence, the stakeholders were very anxious to know more about the outcome of the next phase- climate responsive design.

2.3 How can climate-responsive design be achieved for different scale- levels?

The group concluded from the climate analysis that effective interventions should be taken on various scale levels, but that the large scale interventions were often very generic such as “more green in the city” and that this directive did not offer enough design challenges. Therefore, we decided to select spots that occurred specifically problematic in terms of urban climate and invited the students to create climate-responsive design proposals on a site scale for these places. In this case, the students worked individually on a specific area or site. This phase took about 1,5 months.

In this phase we intended to bring the scientifically oriented method of “research by design” into practice. We consider such a scientific approach as pivotal in our MSc in landscape architecture Wageningen. The term “research by design” was developed by Dutch architecture scholars and they understand it “as the development of knowledge by designing, studying the effects of this design, changing the design itself or its context, and studying the effects of the transformations. The ‘TOTE model’ from systems analysis may be recognized in this : Test→ Operate→ Test→ Exit.” (de Jong and van der Voordt, 2002, p. 455). This requires a rational, scientifically oriented approach to design with clear statements of expected effects of designs (design hypotheses), testing of different alternative design hypotheses and objective evaluation of design hypotheses before a final design can be proposed. This approach demands an analytical, conscientious, rigid way of thinking from the designer. We considered this rational “research by design” an appropriate approach to design problems of a large scope where design proposals need to be reasoned in a very sound manner. Climate responsive design often has this large scope and also requires a good knowledge foundation. Also due to these reasons we considered a “research by design” approach suitable for this studio focusing on climate responsive design.

Consequently, we asked the students to work on their design in such an analytical, conscientious way. We also strongly encouraged this way of working because we knew that many design students tend to be carried away by their imagination and their “nice design ideas” that they want to implement no matter what the context calls for. So we expected the students to first formulate clear problems they presume for the site, then develop different design hypotheses of which they assume that their effects solve the formulated urban climate problems. These hypotheses were then supposed to be continuously tested during the design process, based on the scientific knowledge acquired. In this article, of course, it is not possible to discuss all the design proposals. Hence, I will focus on two projects where the design process was followed in an exemplary manner.

One project (author Aleksandra Mysiorska) focused on the wind problems in the city centre where many people would like to abide outdoors, but the circumstances are often not optimal. The student evaluated the expected wind fields in different spots of the centre, identified problematic areas and suggested remedies through vegetation or changed building configurations. An example of the hypothesis testing is shown in Figure 7 which displays the main areas where higher wind speeds occur due to a new design intervention. The final result consisted of small scale interventions for wind protection (Figure 8)

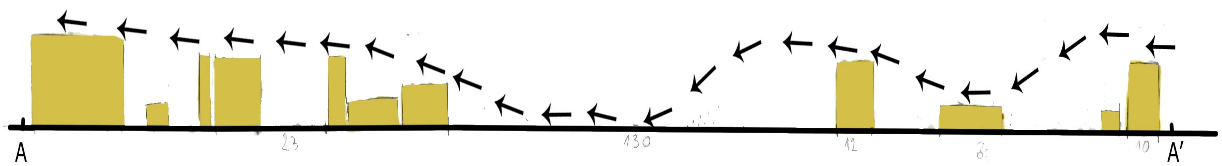


Figure 7 testing wind remedy hypothesis for wind field effects

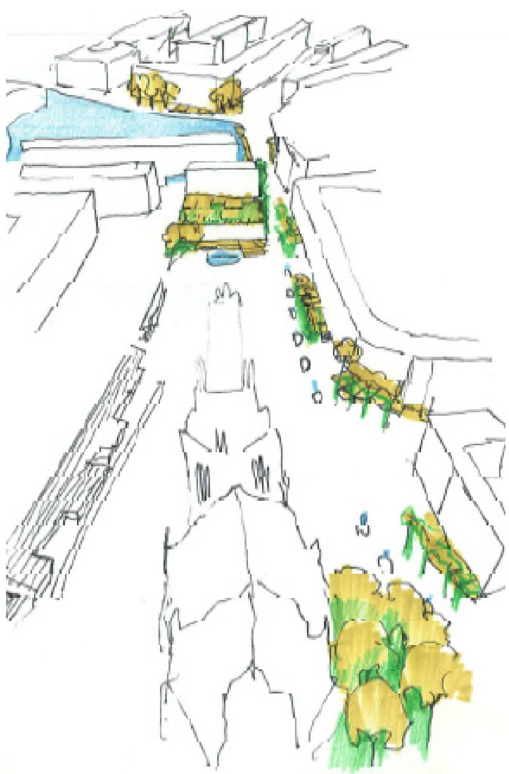
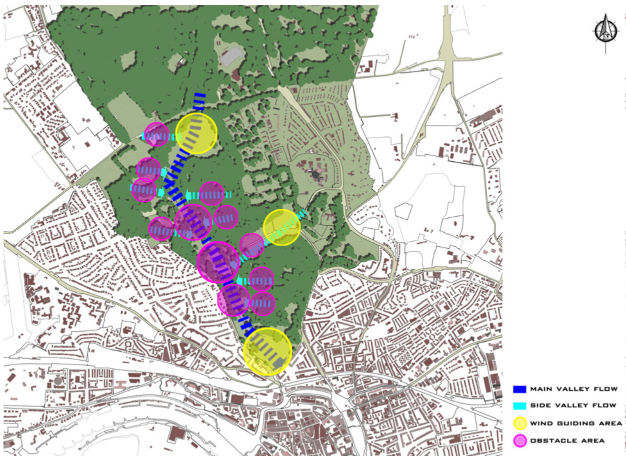


Figure 8 design proposal church square with more vegetation and wind protection elements

The other project that exemplifies this analytical approach is the climate-responsive design study for Arnhem’s famous English landscape style park Sonsbeek. This student project (author: Jiang Wen) shows how this rational, rigid approach can sometimes lead to “out of the box thinking” and surprising results. In this project, the potential cold air generation areas as well as potential cold air stream channels were analyzed for the valley of the Sonsbeek creek. The student concluded that there are great potentials to use these air streams to cool the dense city centre during heat waves. But due to dense planting patterns in this monumental park and a railway dike this cold air system is obstructed from its flow towards the city centre (Figure 9). Therefore, the student introduced a radical redesign of this park where the possible cold air production areas and the cold air stream are opened and channeled towards the centre (Figure 10).



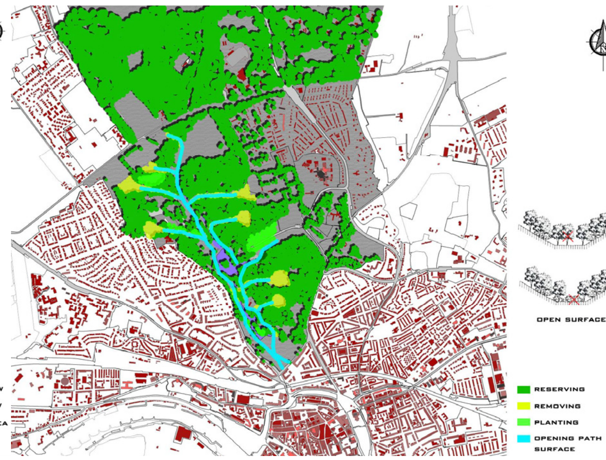


Figure 9 (left) analysis of expected cold air generation and flow paths and obstruction areas and Figure 10 (right) redesign proposal for the whole park for optimal cold air production and passage

Projecting this climate responsive new structure brought about an entirely different planting structure in the park and a new passage through the railway dike that also opened a new recreational connection between the city centre and the park (Figure 11).

Figure 11 a new passage between Sonsbeek park and the city centre for cold air flows, also serving and as a new gateway between park and city

These two design projects reflect the “research by design” approach quite well. Some other students, however, found it difficult to work in such a rational, analytic manner. They were used to work very intuitively and were only partly able to legitimize their work with rational arguments. We think that this problem was mainly caused by the more artistic, intuitive approaches to landscape architecture that some of the international students were used to from their previous educations. For these students, this project was a way of getting to know the analytic, science oriented Wageningen approach to landscape architectural design.

3 CONCLUSIONS

In general, the stakeholders from Arnhem municipality were very enthusiastic about the student’s design proposals. They were inspired by the projects and the way how design and climate can be integrated. For the urbanists and landscape architects of Arnhem’s local authorities this was an eye- opener on the possibilities what climate- responsive design can mean and they were eager to learn more about this topic. Since the results of this project were such a success, we decided to conduct another similar climate design study for the city of Nijmegen this academic year. But not only the stakeholders were enthusiastic- also the students were. They were curious about this topic that was completely new to them and they stayed very motivated throughout the project. The student evaluations showed that the students liked this subject very much and that they felt that they had learnt a lot. This enthusiasm was also fed by the positive remarks from the external experts coming from the fields of applied meteorology and urban climatology. Since these experts showed their appreciation of the student’s work, the students were more confident and motivated to explore the subject deeper. So, for the students it was a great learning experience and they claimed that from now on they will always take urban climate into consideration in their designs.

But also from our educational experiment on climate responsive landscape architecture and urban design we can draw some first conclusions. They relate to the different methodological questions and methods and I address them separately.

1. How can the students translate fundamental knowledge into design implications? We saw that this is possible by thorough literature research. It requires an academic, sharp thinking attitude by the students to understand the scientific knowledge, but also creative thinking from the students to translate this fundamental knowledge into design implications. Apart from that it calls for intensive tutoring by persons who are knowledgeable in the field of urban climate. So, teaching such a literature research either needs constant presence of tutors from the field of applied meteorology and urban climatology or a designer with a lot of experience in this field or urban climate.

2. How can the students learn to analyze the climate of the urban environment? It seemed that after students had understood the basic information on how climate relates to spatial configurations and circumstances, they were able to use this for their analyses. Probably this was not difficult for the landscape architecture students because they were used to analyzing other natural phenomena (hydrological, ecological, etc.) and all kinds of information provided in GIS. I think that also the fact that as landscape architecture students they are already used to thinking in processes and dynamics over time helped to make this a rather easy exercise. But also here it was of great help that the tutors had experience in urban climate issues.

3. How can climate-responsive design be achieved for different scale- levels? The design of the students showed that they were now able to work with climate after having acquired the necessary knowledge. Students were often able to conduct analytic and rigid “research by design” on the climate issue. Climate is a suitable topic to exercise a rational, “scientific” design approach because it is driven by natural forces and has many facets due to its high dynamics. The fact that climate asks for a “scientific” way of designing and that the design outcomes can be quite surprising shows that climate-responsive design can also be used to trigger student’s “out of the box” –thinking and imagination. In short- design for and with urban climate can be fun!

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