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The use of climate knowledge in urban planning

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Abstract

It is a well established fact that the urban landscape creates a climate which influences, for example, human comfort, air quality and energy consumption. However, in spite of this knowledge, it has been recognised that climate issues often have low impact on the urban planning process in practice. The reason for this lack of influence is an important question for which answers must be sought among climatologists, planners and the planning process.

The main objective with the present study was to investigate if, how and when knowledge about the climate is used in the urban planning process. The research strategy was developed in an interdisciplinary research group involving climatologists and planners. Case studies involving different interview techniques and historical data were carried out by different actors involved in urban planning at the municipality level in three cities in Sweden. The study showed that urban planners were interested in climatic aspects but the use of climatic information was unsystematic and the results confirmed that climatology has a low impact on the planning process. The low impact is a result of several constraints which could be related to five explanatory variables i.e. conceptual and knowledge based, technical, policy, organisational and the market. The discussion part of the paper presents some key conclusions which address these constraints. It is important that urban climatologists meet the planners demand-driven needs by providing them with good arguments, suitable methods and tools. Urban climatologists are also encouraged to improve the awareness of the importance of urban climate not only among planners but also among decision-makers and the public. However, as planning is a political activity which not always is based on or even related to scientific knowledge, some of the identified constraints could only be counteracted through improved institutional capacity in the social context of planning.

Keywords: Urban climate; City structure; Land use; Environmental planning

1. Introduction

1.1. The urban climate — a short background

The urban landscape creates a local climate different from that of the surrounding rural landscape. The most well-documented effect is the urban heat island and studies show urban–rural temperature differences up to 12°C during clear and calm nights (Oke, 1981). Cities with varied land use, however, often comprise a mosaic of warm and cold areas as distinct urban land use changes, for example, the change between park and built-up area can produce intra urban temperature differences up to 7°C (Spronken-Smith and Oke, 1998; Upmanis et al., 1998). The street geometry is also important for the urban temperature pattern. The sky view-factor (SVF), Fig. 1, has been shown to be

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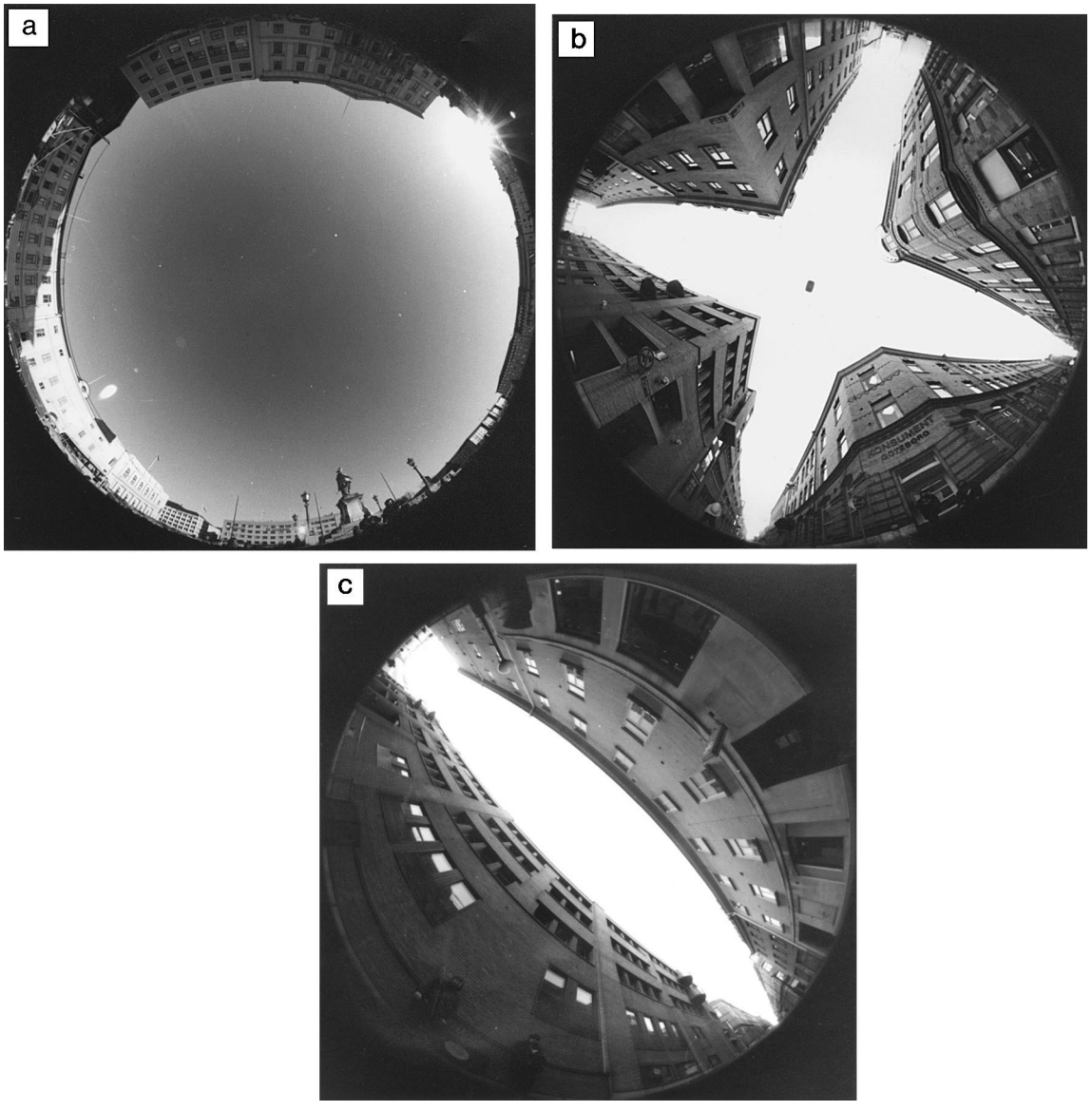

Fig. 1. The street geometry is important for the radiation balance which controls the temperature pattern in the city and in turn has an effect on for example energy consumption and ventilation in the city. The sky view factor (SVF) is a measure of the street geometry and the photos shows three sites, located within a distance of 200 m in central Göteborg. (a) Open square, SVF=0.93; (b) street intersection, SVF 0.47 and (c) street canyon, SVF=0.29.

well correlated with surface temperature but not with air temperature within the city (Bärring et al., 1985; Eliasson, 1992, 1994). However the mean SVF for a city has been shown to have a good correlation with the maximum urban heat island (air temperature) for different cities (Oke, 1981; Park, 1987). The thermal characteristics of the materials in the city (asphalt, brick, glass etc.) differ from those found in the countryside (trees, grass, bare soil etc.). In general, construction materials used in the city contribute to heat island intensity by their greater ability to store heat. Oke et al. (1991) argue that differences in materials (i.e. thermal admittance) and structure (i.e. street geometry) are equally the two primary causes for the heat

island. Other less important factors that might cause the urban heat island are anthropogenic heat sources, air pollution and decreased evaporation (Oke, 1987).

The urban landscape influences the wind pattern and regional wind speed is usually reduced by the city. Trees and buildings usually reduce the effect of the wind but may also create local areas with higher windspeeds and eddy circulations (Lee, 1987; Oke, 1987). The urban wind pattern also includes weak airflows which are induced by temperature differences in the city. Two examples of this micro-advection are country breeze which is induced by the heat island and directed from rural areas towards the city centre (Goldreich and Surridge, 1988; Eliasson and Holmer, 1990; Haeger-Eugensson and Holmer, 1999) and park breeze which is an outflow of cool air from parks (Eliasson and Upmanis, 2000).

During daytime the air in the city is often drier than in rural areas while the opposite condition prevails at night (Chandler, 1967; Lee, 1991; Holmer and Eliasson, 1999). Increased amounts of water vapour combined with high levels of air pollution in cities may promote cloud formation and subsequently precipitation over the city (Oke, 1987).

1.2. The impact of climatic information in urban planning

The examples given above clearly show that the climate in the city is dependent on factors such as land use, building geometry and building materials. The urban climate is thus, to a large extent, a result of human modification of the local climate in situ . The rapid changes in temperature, wind and humidity generated by the urban landscape influences comfort and health of the people as well as energy consumption and air quality. There are thus many reasons for urban planners to design whilst bearing climate in mind. A long tradition of climatic consideration in urban design can be traced back more than 2000 years when, for example, the Roman architect and engineer Vitruvius, in his book 'The Ten Books on Architecture', discussed the layout of towns and individual buildings according to various climatic influences (Morgan, 1960). Climatic considerations for organisation and design of built-up areas have always been a natural part of local building tradition (Glaumann, 1993; Westerberg, 1993). However the change from traditional building to industrial building generated a series of publications on climatic design. Aronin (1953) minted the word 'architecture' and other important works have been contributed by Olgyay (1963) and Givoni (1969). The energy crisis during the 1970s was also important for the incorporation of climate aspects in urban design (Evans, 1980).

During the last two centuries climate researchers have gathered a huge amount of data on urban climate and knowledge about the urban climate is, today, relatively good. Guidelines and tools for urban planning such as climatic maps have been developed (Oke, 1984; Bitan, 1988; Lindqvist and Mattsson, 1989; Givoni, 1991; Golany, 1996) and the literature gives several examples of specific projects where climatic aspects have successfully been incorporated in the planning process (Balázs, 1989; Evans and Schiller, 1996). One Swedish example is the project 'Norra Älvstranden' which included a new development of a housing district on a former shipbuilding yard located on the northern shore of the Göta River in the city of Göteborg. Climate researchers were involved from the very beginning of the project and '*the main purpose was to carry out a consequential analysis of an existing general and detailed plan before a public exhibition*' (Lindqvist, 1991, p. 16). The idea with the climatic analysis was to demonstrate how to avoid negative climatic effects and make use of positive ones. The investigation, which included both field measurements and wind tunnel studies, especially pointed at the existing and potential wind exposure problems due to the dominating strong south-west winds. The investigation resulted in several recommendations including illustrations and models, see Fig. 2. According to Lindqvist (1993) the architects and planners involved in the project were interested in the information but in general they did not want to change the design of the area. The main principle of the design was a close view and contact with the water which came in conflict with the climatic aspects. Some action was taken in order to try reduce the negative effect of the wind but the total impact of the climatic considerations was low and today the area is known as a windy place.

1.3. Purpose of the present study

Most researchers agree on the fact that, in spite of the available knowledge about the climate and some

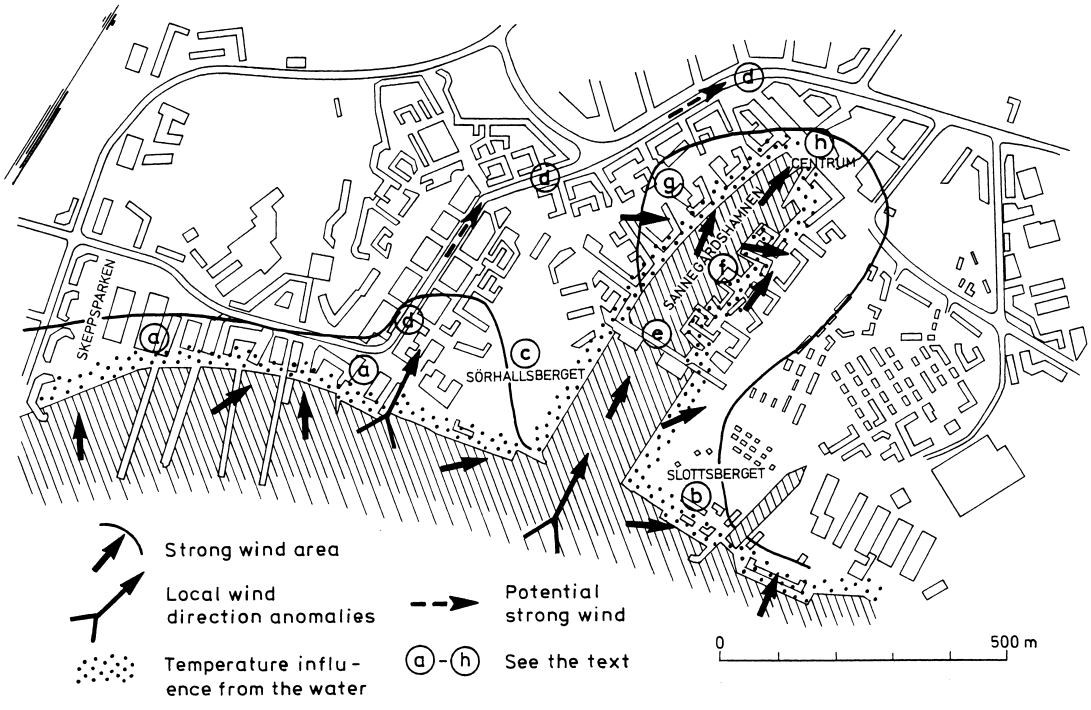

Fig. 2. Local climatological map for a detailed plan of one part of the former shipbuilding area 'Norra Älvstranden' in Göteborg, Sweden (After Lindqvist, 1991). Area a and d are areas were the climatologists assessment of negative wind effects have turned out to be justified and the areas are today known as windy places. Area b, c, e, f and h are not yet constructed but (Lindqvist, 1991, p. 22) describes the climatic impact on the planned activities.

good examples of climatic design, the impact of climate in the urban planning process in practice is usually low (Oke, 1984; Lindqvist and Mattsson, 1989; Pressman, 1996). If this is so and consequently why this is so are two interesting questions, especially as the integration of climatic considerations into the planning process has been considered important for such a long time. Transferring scientific research into tools applicable for urban planning ought to be a great challenge for urban climatologists. It is evident from the discussion above that there are many examples of climatologists who have tried to develop their scientific results into user-friendly tools. Communication of results, a key factor for success, is a possible area in which urban climatologists have not succeeded. Do climatologist really know what the planners need in order to incorporate climatic factors in the urban planning process? Should climatologists concentrate on developing methods such as climatic maps, should they perform massive information campaigns or should they concentrate on real-world measurements? The present study aimed to answer these and other questions important for a successful integration of knowledge about the climate in urban planning by asking individuals involved in urban planning, **if, why** and **when** climate is considered in the planning process. The target group for the study comprised not only climatologists but also planners. Planners not aware of the importance of climate can hopefully learn something from the study but more important, if the results show that communication between climatologists and planners has succeeded and urban planners are aware of the importance of urban climate, answers must be sought in the planning process.

2. Methodology

2.1. Research design

The basic hypothesis for the present study was that Climate Knowledge has a low impact on the urban

planning process despite the abundance of scientific studies in urban climatology and climatic design. This hypothesis was based on literature surveys and the outcome of an expert meeting at the Swedish Council for Building Research in Stockholm, who also initiated and financially supported the study. The main objective with the study was to prove this hypothesis by an investigation which aimed to answer the questions: **if**, **how** and **when** Climate Knowledge is used in the urban planning process. Climate Knowledge has, in this context, a broad definition as 'knowledge about the climate important for physical planning'. Thus, this definition includes knowledge about climatic phenomena on both local and regional scale. The research design was developed through discussions in an interdisciplinary research group, which apart from the present author involved researchers at the Department of Urban Planning and Design at Chalmers University of Technology (Chalmers) in Göteborg, Sweden and at the Norwegian Institute for Urban and Regional Research (NIBR) in Oslo, Norway. The interdisciplinary research group identified several problems as the cause of this lack of impact. These problems were related to conceptual, knowledge based, methodical and institutional explanations. In this context 'institutional' has a broad definition as 'informal and formal rules in a society', and therefore, includes factors such as ideology, policy and the structure of the organisations. The theoretical framework of the study, including the hypothesis, the problems and their related explanatory variables are shown in Fig. 3.

The research strategy is based on the qualitative case study methodology described by Merriam (1988) and Yin (1989). The study includes different types of interviews and discussions with different actors at the municipal level in three cities in southern Sweden (Fig. 4). The questions used in the study were formulated in relation to the hypothesis presented above (Table 1).

The study was carried out in different stages. First, semi-formal meetings were held with an expert group in each of the three cities. During these meetings the aim of the project was presented and a dialogue established. Secondly, questionnaires were sent to individuals involved in the planning process in the three cities and to climate consultants. The third stage involved an analysis of the answers from the questionnaires. The results were discussed in the interdisciplinary research group and formed the basis for design of the semi-structured interviews. In a final stage, semi-structured interviews, each lasting about

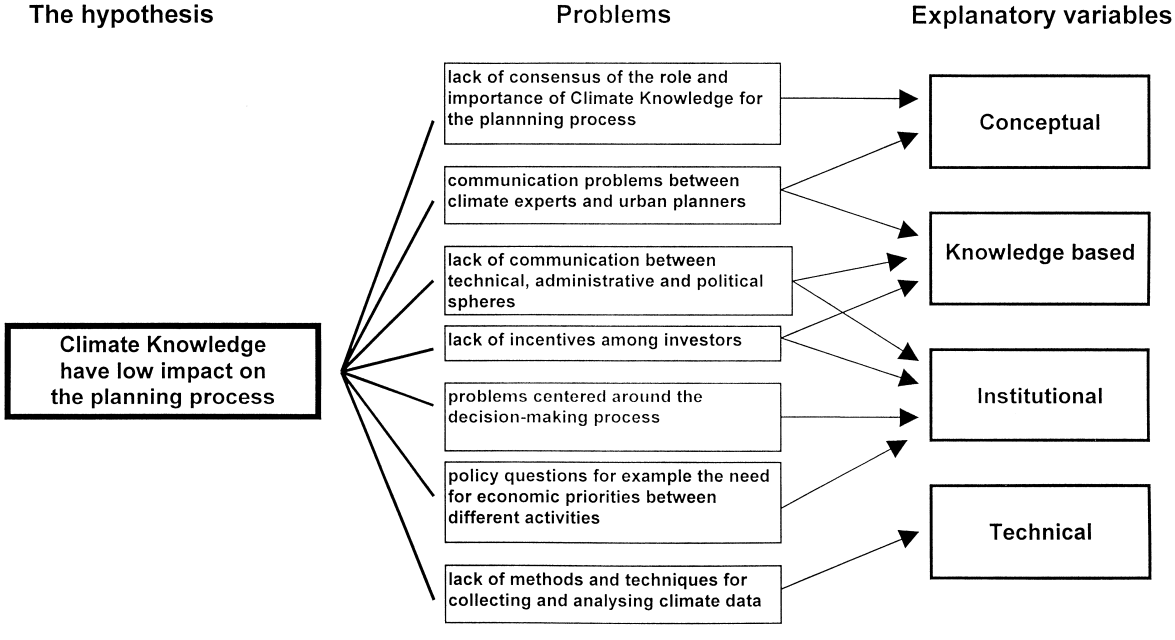

Fig. 3. Theoretical framework of the study, including the hypothesis, problems and related explanatory variables.

Fig. 4. Map over the southern Scandinavia including the location of the three Swedish cities involved in the study.

2 h, were carried out with key-informants who met certain criteria, (Table 2). Before the interviews the key-informants were asked to select some detailed plans which exemplified specific projects where climatic information had been or should have been involved. The discussion part of the interview were centered around these historical documents. The answers and the discussion were documented by an assistant during the interviews.

The generalisation of the case study results and thus the test of the formulated hypothesis were made by an 'analytic generalization'. Yin (1989) describes the analytic generalization as '*a method of generalisation in which a previously developed theory is used as a template with which to compare the empirical results of the case study*'. As the case study strategy is characterised as being particularistic, descriptive, heuristic and inductive, the analytical generalization is more appropriate than the 'statistical generalisation' used in surveys and experimental research strategies (Merriam, 1988; Yin, 1989).

Table 1
Information wanted from questionnaires and interviews

Access to climate information at the three cities
Level of knowledge
Use of climate information
Which parts of the organisation use climatic information
Motives and barriers for use of climatic information
Methods and techniques of finding and using climatic information
In which phase of the planning process climatic information is used
The weight of climatic information in the final decision-making
Differences between planning levels

Table 2
Criteria for selection of key informants. The semi-structured interviews should include at least one individual

One from each city
One with experience of climate planning
One with restricted experience of climate planning
One representing the planning system
One working at the detailed planning level
One working at the comprehensive planning level
One representing a body to which a proposed measure is referred for consideration
One in a senior position

2.2. The data base

The study was concentrated in three cities in southern Sweden, Fig. 4. The city of Göteborg, located on the Swedish west coast, is, with its population of about 500 000 people, Sweden's second largest city. Göteborg is characterised by industry and trade. Industry also dominates in the city of Trollhättan (55 000 inhabitants) which has an inland location 75 km north of Göteborg. The third city Tidaholm is an old craft centre with 13 000 inhabitants located in an agricultural area, 150 km northeast of Göteborg (Fig. 4). This selection of sites enabled investigation and comparison of the impact of Climate Knowledge on the planning process in cities with different conditions and population site density.

As the main purpose of the study was to investigate if, how and when Climate Knowledge is used in the urban planning process it was important to select actors involved in issues related to urban climate. A criteria-related selection strategy (Merriam, 1988) was, therefore, used and informants representing different professions and roles in the planning process were selected. This included architects, urban planners, landscape architects, planning engineers, consultants and politicians. In Sweden, people from several professions may work as urban planners as there is no professional certification for planning practitioners. Historically, however, the Schools of Architecture at the Technical Universities in Sweden have provided a 5 year common education for archi-

tects and urban planners. Most urban planners in Sweden have this education or a shorter more technical education as planning engineer. The informants used in the present study have backgrounds representative of the Swedish planning culture.

The two main planning levels in Sweden are the detailed and comprehensive planning levels. The detailed plan which regulates land use and construction is legally binding for about 5 years. The comprehensive plan includes an agreement between the central and local governments and it should be a policy document showing the future plans for the development of the municipality. It should be revised on a running basis, about every 3–5 years for the whole of, or parts of, the municipality. However, from a legal point of view the comprehensive plan only has an indirect authority related to conflicts about detailed plans and building permits. As a consequence of the common education of architects and urban planners, Swedish planning by tradition tends to be associated mostly with design. During the last few decades, however, environmental issues have gained more attention and the introduction of the Environmental Impact Assessment (EIA) procedure has influenced physical planning. EIA is today a part of both The Swedish Planning and Building Act as well as The Swedish Environmental Code. The traditional planning process in Sweden is based on consultation which is a democratic process. Public influence on the planning process has also for a long time been regulated by laws. This means that both different divisions within the city administration as well as external organisations and individuals have the opportunity to influence the Swedish planning process.

3. Results

The results presented below are based on data from questionnaires, semi-structured interviews, informal discussions and historical documents. Altogether 41 questionnaires were sent to different actors involved in climate issues. Thirty-one of these questionnaires were answered and returned giving a 75% response rate. In total, 11 semi-structured interviews were conducted with individuals meeting the criteria presented in Table 2. Quotations are written in italics.

3.1. Conception and knowledge

The majority of respondents of the questionnaires in all the three cities were aware of the existence of local climate in the city. They were also aware that urban climate can be influenced by strategic urban planning. The semi-structured interviews, informal discussions, and historical data, however, revealed that theory and practice are not always in phase. Climatic factors are often an integral part of environmental and comfort aspects of planning, and therefore, not necessarily perceived to be important in themselves. Several interviewees said that they did not think of climate in terms of pure climatic aspects. The consequence was that they often included some climatic considerations in their work without being aware of it.

The questionnaires also revealed that a majority think that they have knowledge about the urban climate but several of the respondents gave comments such as "*Yes, but not a complete training, or even adequate*" and '*My knowledge is insufficient*". Both the questionnaires and semi-structured interviews showed that the level of knowledge varied from individual to individual. Everyone knew of the importance of exposure to wind and solar radiation but only a few were aware of related climatic phenomena, for example cold air drainage, heat island and turbulence. It was, however, clear that most individuals felt uncertain about their own knowledge and wanted more information. The respondents had learned about urban climate at a few university courses, at seminars provided by their office or from self studies but none of them had had any long training in urban climatology. The majority of the involved actors seem however to combine their theoretical knowledge with a personal experience of the city, for example: "*I know that this part of the city is very foggy and wet (as I go through it with my bicycle every day)*". This was particularly evident in the two smaller cities where one individual often acquires an overall understanding as a result of working at both comprehensive and detailed planning levels.

3.2. Using information about the climate

From the questionnaires it was shown that information about the climate is used in urban planning. A majority of the respondents from all three cities,

answered Yes to the question 'Is Climate Knowledge used in the planning process?'. However most of the respondents wrote comments as '*partly*' and '*not always*' and my conclusion was that the use of climatic information is unsystematic. The semi-structured interviews and the historical documents confirmed this conclusion but the interviews also gave a picture of planners who systematically weigh the pros and cons of many different aspects including climatic aspects. It is, however, difficult to decide how frequently the urban planning process in the three cities involves climate issues. One important reason for this is the problem of conceptualising climatic aspects, discussed above and illustrated by the following comment '*Climatic aspects are of secondary importance and embedded in a broader context*'. If this is true, there is apparently a risk that climatic aspects are totally abandoned in the planning process.

3.3. Motives and barriers

The most common motive given for using information about the climate is that climate affects personal comfort. A good building environment should have '*a nice climate*', '*not too windy but free from air pollutants*', '*sunny but also shady*' and it should '*not be too dry or too wet*'. A minority of interviewees mentioned use of information about the climate in relation to urban ventilation and energy consumption.

The barriers to the use of climatic information, revealed during the study, are not easy to rank. From the interviews and especially through the discussion centered around specific projects it was, however, possible to identify different barriers that counteracted the importance of climatic aspects in the final decision phase of the planning process. It was difficult to determine which barriers were most frequent or had the greatest impact. The barriers are, therefore, presented in alphabetical order in Table 3. The study showed that 'communication problems' in general and especially between planners and investors/politicians is an important barrier. In some cases it was a result of language differences but in others the planners did not feel that they were sufficiently informed to argue for the importance of climate. 'Conflicting interests' were another barrier revealed during the study. Several examples of specific projects where an unfavourable climate environment was chosen in spite of the access to a good climatic environment were given during the interviews. In these specific projects knowledge about the climatic impact was not a constraint. Instead, the fear of formal complaints from different stakeholders, for example from neighbours who felt that their view would be spoiled by the planned buildings was an effective deferent as it is well known that formal complaints to the authorities will prolong the planning process and thus increase costs. The 'economy' barrier was also more directly evident in for example the difficulties in motivating an extra investigation about the climate due to the cost. 'A lack of knowledge' was another important barrier found among planners, investors, politicians and others involved in the planning process. The study also showed that information about the climate had 'low priority' in many projects. Higher priority was often given to other areas such as for example building design or traffic security. Interviews with climate consultants revealed that they often found that '*the formation of the buildings*' or the '*architects vision of the design*' totally dominated most projects in which they had been involved. Several of the interviewees stated that '*changed or unclear policies*' are significant barriers. Different examples such as election year, change in political majority, public-private partnership, new central policies and legislations concerning division of responsibilities between central and local government and financial support systems were given. However, the effect was similar, that is the design of the specific project was decided before it went through the democratic planning process, '*predetermined projects where it is only possible to exert an influence on minor details*'. The results also indicated that 'time' may be an important barrier. A normal democratic process for a project at the detailed planning level is about 1–2 years in Sweden. Every additional change

Table 3
Identified barriers (in alphabetical order) which counteract the impact of climate in urban planning

Communication problems
Conflicting interests
Economy
Lack of knowledge
Low priority
Policy, changed or unclear
Time

will prolong the process and increase costs. It is thus important that climatic aspects are considered at the beginning of the process.

3.4. Existing methods

The methods for finding and using climatic data varied a lot between individuals and specific projects. Some people used climatic maps, statistics, computer programmes, literature and other defined sources of information while others used their own experience of the area or some undefined rules. The results from the questionnaires show that more than 50% of the respondents in the largest city (Göteborg) had employed consultants for climatic investigations. One third of the respondents in Göteborg also answered that they use climatic maps in their work. In the two smaller cities the most common method used was literature surveys.

3.5. Differences between the detailed and comprehensive planning level

The differences in purposes and weight between the detailed and comprehensive planning level exert an influence on how the urban planners feel that they can influence the two main planning levels, illustrated by the following quotations "*The detailed plan is more detailed and easier to influence...*", "*The comprehensive plan usually includes radical suggestions, visions and ideas but it is difficult to influence*", "*The comprehensive plan is politically sensitive, it is, therefore, difficult to influence and it can be pointless*". A majority of the respondents are of the opinion that climatic aspects are mostly discussed on the detailed planning level. However, half of the respondents think they are also discussed at the comprehensive level. In the two smaller cities a few people are engaged both in comprehensive and detailed planning. This close connection between the two levels makes it easier to involve climatic aspects in the design discussion.

3.6. The status of climate knowledge in the planning process

The results indicated that the planning system in Sweden today offers some support for climatic considerations. Interest in environmental issues has increased the importance of local climatology which is mentioned in check lists for the planning process in the cities of Göteborg and Trollhättan. The answers to the questionnaires, however, showed that a majority of the involved actors are of the opinion that climate is of minor importance in the planning process. A few individuals think that '*climatic aspects have a large impact in some projects*'. A majority answered that climatic aspects are discussed mostly in an early phase of the planning process although some individuals thought that these issues were discussed in all phases of the process.

Both urban planners and climate consultants have been asked if they could see any change of the awareness and use of information about climate during the latest decades. No clear answer was given to this question which is probably an effect of climatic aspects often being an integral part of other related aspects such as comfort, environment and energy. During the 1970s the Swedish planning arena was dominated by energy issues which included climatic aspects. From an environmental and climatic point of view the 1980s were a reverse of this as the market and design aspects was in focus and the construction was dominated by large-scale projects. Long-term planning considerations, important for climatic aspects, was of low priority and construction of housing districts was limited. However, environmental, health and comfort issues have gained more attention during the 1990s this providing firmer ground for climatic considerations. An indication that questions about climate are regarded as important and may have a greater impact in the future is that 'local climate' is included in the EIA check lists used by planners in the city of Göteborg. Some of the interviewees stress the importance of the supply and demand in the housing market. The importance of the purchasers' knowledge and demand have increased during the recent building trade recession which can be illustrated by the following quotation. "*Today it is important that the new housing districts have a good building environment as purchasers are hard to please and thus the investors need to adjust to the purchasers demand*".

3.7. The need for new methods and increased knowledge

In all the three cities a majority of the planners expressed a demand for increased knowledge about

climate and a need for improved tools for its incorporation in the planning process. The planners showed a strong interest in training in the form of courses and seminars but they emphasized that they needed training based on discussion of real world examples rather than long theoretical lectures, ''*We are pragmatic people*''. The reason given for increasing the level of knowledge is that they want to be able to argue for climatic considerations and to make adequate judgements, ''*I wish that I had enough knowledge to be able to argue for a climatic investigation, when needed, and thereafter consult an expert*''. The need of an expert opinion is said to be important in order to influence and increase the interest among the decision-makers. Some examples of answers given by the respondents to the questions regarding the type of information and tools needed for better considerations of the urban climate are given in Table 4.

A majority of the respondents and interviewees had positive experience of climatic maps and similar tools. A local climatology map has been developed for the city of Göteborg but use of the existing map is limited. All of the three cities have started to use Geographical Information Systems (GIS) but progress is variable. However, a majority of the involved actors are positive about the use of digital climatic maps.

4. Discussion and conclusions

The results showed that Climate Knowledge had low impact on the planning process. This proved the formulated hypothesis. However, a majority of the respondents say that they use climatic data. I think that this contradiction depends on the fact that most planners are very uncertain about their own knowledge of urban climate. Thus, if there is a conflict between different interests in the end of the process, they do not have enough arguments to support the use of climatic data. The results showed that several constraints on the influence of Climate Knowledge could be identified, Table 5. These constraints are closely related to the problems formulated in the theorethical framework, see Fig. 3.

The resulting framework presented in Fig. 5 relates the identified constraints to different explanatory variables and gives some key conclusions which address the constraints. The explanatory variables used in Fig. 5 differ somewhat from those used in the theoretical framework (Fig. 3). The institutional variable defined as 'informal and formal rules in a society' has been divided into three variables, policy, organisational and the market.

The results showed that the lack of knowledge, the planners lack of confidence in their own knowledge and the fact that climate is often embedded in broader issues resulted in a lack of arguments as well as communication problems. As a result, the urban planners asked for improved access to information, methods and techniques suitable to the urban planning process. One way for urban climatologists to meet these demand-driven needs is to constantly provide planners, investors, decision-makers and the public with good arguments why climatic aspects should be used in urban planning. Good communication between climatologists and planners and the chain planners, investors, decision-makers and the public is certainly a key factor for success and training courses and development of user-friendly tools must be made through a cooperation between climate experts and planners. It is also very important that this information about climate is a continual process rather than a single campaign.

The constraint 'other priorities' (Fig. 5) could also be a result of lack of knowledge about the importance of climate and communication problems. However, being a researcher in natural science it is easy to forget that all planning is a political activity which is not

Table 4
Information and tools needed in order to address the importance of climatic aspects in the planning process, quotations from the questionnaires

'Easily accessible literature is missing'
'Literature, handbook, education'
'Knowledge linked to specific projects. . .seminars with interdisciplinary discussions'
'Courses and seminars'
'Simple techniques/methods for an overstrained planner'
'Maps and models for climatic assessments'

Table 5
Constraints on the influence of Climate Knowledge in the planning process

Climatic aspects are an integral part of environmental and comfort aspects
The planners feel uncertain about their own knowledge and lack arguments
Lack of knowledge
Communication problems between climatologist and planners and between planners and investors/decision makers
Lack of easily accessible techniques and literature
Other priorities such as traffic security and design aspects
Changed or unclear policy which results in for example predetermined projects where it only is possible to exert an influence on minor details
Fear of formal complaints from other stakeholders
Time, everything that prolongs the planning process increases costs
Limited budget, a climatic investigation increases costs
Status of the planning
Supply and demand in the housing market

always based on or even related to scientific knowledge. It is apparent that the prevailing policy has a great influence on many of the constraints listed in Table 5and improved institutional capacity (Malbert, 1998) may certainly have a positive influence on these constraints (Fig. 5). The two constraints 'fear of formal complaints' and 'time and costs' are strongly related to each other. The consultation based Swedish planning process is a democratic but slow process. This can explain why planners and administrators are afraid to push for certain issues which could meet opposition among stakeholders. Formal complaints from, for example neighbours could have an effect on both the time and cost of the planning process. A growing approach among researchers of urban planning and design is to argue for a focus on commu-

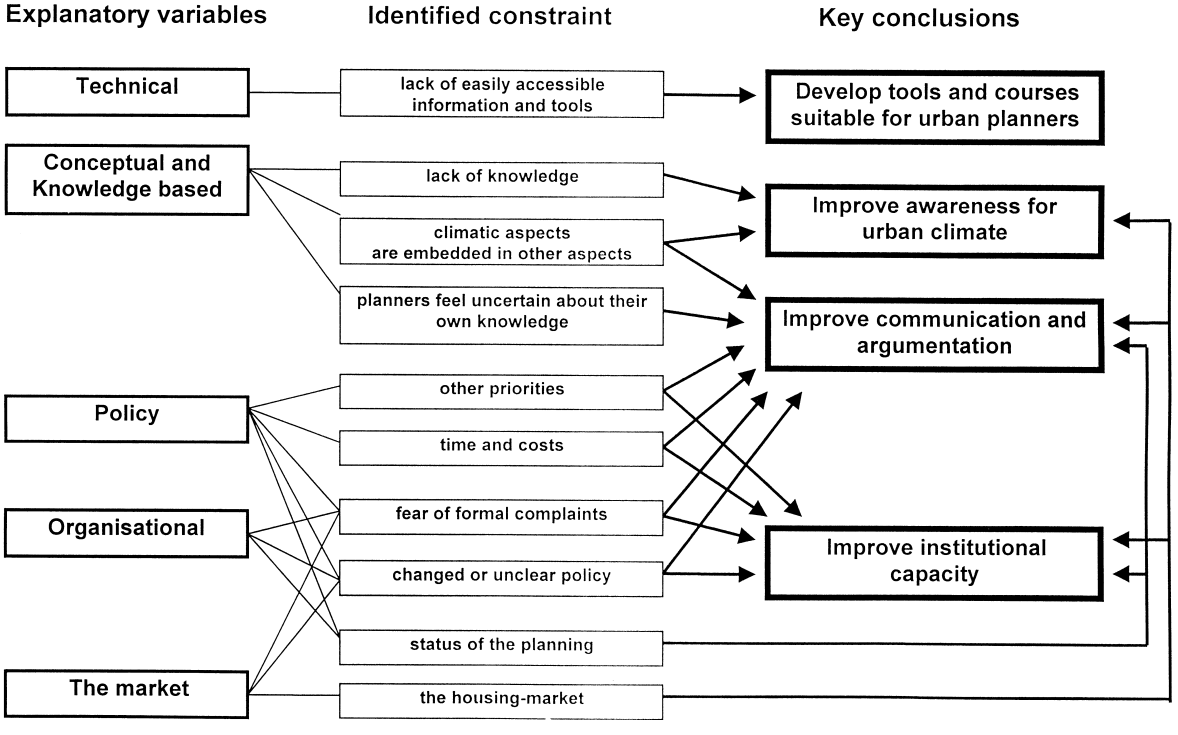

Fig. 5. Resulting framework including explanatory variables, identified constraints and key conclusions.

nication and learning in the planning process. This 'communicative approach' does not speed up the planning process but its purpose is to prevent time-consuming complaints from stakeholders (Malbert, 1998).

The 'predetermined projects' identified in this study is an example of when planning becomes a rationalisation of already taken decisions and it is also an example of the establishment of 'partnerships', involving investors and decision-makers. Even though 'predetermined projects' have always existed, it has been shown that policy changes in Sweden during the latest decade have accepted a type of public-private partnership which more openly comes in conflict with the expectations of a traditional consultation process (Flyvbjerg, 1998; Elander, 1999).

Apart from the need for improved institutional capacity the majority of constraints related to policy and organisation (Fig. 5) could probably be slightly counteracted by increased knowledge and argumentation among planners and other actors together with an early involvement of climatic data in the process.

From a climatic point of view, the comprehensive planning level is very important as it gives a good view of the interaction of the different climatic effects produced by the city and the surrounding rural landscape. This information is important in order to understand how changes in land use will affect the local climate. However, the study showed that most planners felt that it was difficult to influence the comprehensive plan mostly due to its '*visionary character*' and '*weak legal binding*'. This can be explained by both policy and the structure of the organisation but as the status of the different planning levels is a political question a discussions of their advantages and disadvantages is outside the scope of this paper. From a climatic point of view, however, all planning levels are important for climatic considerations. In order to improve the influence of Climate Knowledge at both levels it is thus important to improve both communication and argumentation among planners, decision-makers and the public as well as the institutional capacity.

The supply and demand of the housing market seems to be another important constraint for climatic consideration. Public awareness is thus very important. However, as it is more easy to act as an informed consumer when there is a good supply of available housing this constraint must also be ruled by improved institutional capacity.

Finally, it is important to point out that even though every step of this study, from the first design to this final version, have been discussed in the interdisciplinary research group consisting of both planners and climatologists, the study has been carried out and is presented from the view of an urban climatologist. This was also the intention from the Swedish Council for Building Research when initiating the research project. The advantages of using an urban climatologist for the investigation of the application of Climate Knowledge in urban planning are many as climatologists should be the ones providing planners with information about the urban climate. Most of the actors involved in this study were very positive to the use of Climate Knowledge in the planning process and this is a certainly a good basis for a cooperation between climatologists and planners. Some of the identified constraints could be addressed by this cooperation and in three first key conclusions shown in Fig. 5 urban climatologist are encouraged to take active part. These are:

- Improve awareness for urban climate.
- Improve communication and argumentation.
- Develop tools and courses suitable for urban planners.

However, the study has also revealed a lot of interesting questions which are related to the policy and the planning process. As these questions are not easily developed by a researcher in natural sciences they have only briefly been discussed in the present paper. However, for a researcher with deeper knowledge of the social context of planning several interesting topics could be formulated. Apart from those presented above especially two issues are of interest. The present study involves data from historical documents that have been presented by the interviewees. However, a more comprehensive investigation of historical documents in order to see if information about the climate has been considered during the latest century would be of great interest. Another important constraint with the present study is that it focuses on urban planners, climate consultants a few politicians and other experts. An interesting question is how the people living in the city, 'the public' relates to climatic

aspect. Is climate comfort important for the individual?

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References

Aronin, J.E., 1953. Climate and Architecture. Reinhold, New York.

Balázs, K., 1989. Comparision of low and medium rise housing developments in wind tunnel-energy and wind climate aspects. J. Wind Eng. Indust. Aerodynam. 32, 111–120.

Bärring, L., Mattsson, J.O., Lindqvist, S., 1985. Canyon geometry, street temperatures and urban heat islands in Malmö, Sweden. J. Climatol. 5, 433–444.

Bitan, A., 1988. The methodology of applied climatology in planning and building. Energy and Buildings 11, 1–10.

Chandler, T.J., 1967. Absolute and relative humidities in towns. Bull. Am. Meteorol. Soc. 48, 394–399.

Elander, I., 1999. Partnerships and democracy — a happy couple in urban governance? Second draft of a chapter which will be published in a volume within the framework of the EU COST CIVITAS Action A9- 'The transformation of European cities and urban goverance' Preliminary date of publication is January 2000. The Swedish Council for Building Research, Stockholm, 21–22 April, 1999.

Eliasson, I., Holmer, B., 1990. Urban heat island circulation in Göteborg, Sweden. Theor. Appl. Climatol. 42, 187–196.

Eliasson, I., 1992. Infrared thermography and urban temperature patterns. Int. J. Remote Sens 13 (5), 869–879.

Eliasson, I., 1994. Urban-suburban-rural air temperature differences, related to street geometry. Phys. Geog. 15, 11–22.

Eliasson, I., Upmanis, H., 2000. Nocturnal airflow from urban parks — implications for city ventilation. Theoretical and Applied Climatology, in press.

Evans, M., 1980. Housing, Climate and Comfort. Architectural Press, London.

Evans, J.M., Schiller, S., 1996. Application of microclimate studies in town planning: a new capital city, an existing urban district and urban river front development. Atmosph. Environ. 30, 361–364.

Flyvbjerg, B., 1998. Rationality and Power: Democracy in Practice. The University of Chicago Press, Chicago.

Givoni, B., 1969. Man, Climate and Architecture. Applied Science Publishers, London.

Givoni, B., 1991. Impact of planted areas on urban environmental quality: a review. Atmosph. Environ. 25B (3), 289–299.

Glaumann, M., 1993. Klimatstudier som underlag för bebyggelseplanering. Published by the National Swedish Institute for Building Research, TN:33 Gävle, Sweden (in Swedish with an English summary).

Golany, G.S., 1996. Urban design morphology and thermal performance. Atmosph. Environ. 30 (3), 455–465.

Goldreich, Y., Surridge, A.D., 1988. A case study of low level country breeze and inversion heights in the Johannesburg area. J. Climatol. 8, 55–66.

Haeger-Eugensson, M., Holmer, B., 1999. Advection caused by the UHIC as a regulating factor on the nocturnal UHI. Int. J. Climatol. 19, 975–988.

Holmer, B., Eliasson, I., 1999. Urban-rural vapour pressure differences and their role in the development of urban heat islands. Int. J. Climatol 19, 989–1009.

Lee, D., 1987. Ill wind in the streets. The Geographical Magazine, 348–351

Lee, D.O., 1991. Urban-rural humidity differences in London. Int. J. Climatol. 11, 577–582.

Lindqvist, S., Mattsson, J.O., 1989. Topoclimatic maps for different planning levels: some Swedish examples. Building Res. Prac. 5, 299–304.

Lindqvist, S., 1991. Local climatological maps for planning. GUNI report 32, University of Göteborg, Department of Physical Geography.

Lindqvist, S., 1993. Stadens klimat — kan man planera det? Planera för en bärkraftig utveckling, The Swedish Council for Building Research.

Malbert, B., 1998. Urban planning participation: linking practice and theory. Dissertation in Urban Design and Planning. Department of Urban Design and Planning, School of Architecture, Chalmers University of Technology, Göteborg, Sweden SACTH, 1988 1(A).

Merriam, S.B., 1988. Case Study Research in Education. Jossey-Bass, San Fransisco, USA.

Morgan, M.H., 1960: Vitruvius, The Ten Books On Architecture. Dover Publications, New York.

Oke, T.R., 1981. Canyon geometry and the nocturnal urban heat island: comparision of scale model and field observations. J. Climatol. 1, 237–254.

Oke, T.R., 1984. Towards a prescription for the greater use of climatic principles in settlement planning. Energy and Buildings 7, 1–10.

Oke, T.R., 1987. Boundary Layer Climates. Routledge, London.
Oke, T.R., Johnson, G.T., Steyn, D.G., Watson, I.D., 1991. Simulation of surface urban heat islands under ideal conditions at night. 2. Diagnosis of causation. Boundary-Layer Meteorol. 56, 339–358.
Olgyay, V., 1963. Design With Climate. Princeton University Press, New Jersey.
Park, H-S., 1987. City size and urban heat island intensity for Japanese and Korean cities. Geogr. Rev. Jpn 60, 238–250.
Pressman, N.E.P., 1996. Sustainable winter cities: future directions for planning, policy and design. Atmosph. Environ. 30 (3), 521–529.
Spronken-Smith, R.A., Oke, T.R., 1998. The thermal regime of urban parks in two cities with different summer climates. Int. J. Remote Sens. 19, 2085–2104.
Upmanis, H., Eliasson, I., Lindqvist, S., 1998. The influence of green areas on nocturnal temperatures in a high latitude city (Göteborg, Sweden). Int. J. Climatol. 18, 681–700.
Westerberg, U., 1993. Klimatplanering-fysik eller symbolik? Published by the National Swedish Institute for Building Research, SB: 55 Gävle, Sweden (in Swedish with an English summary).
Yin, R.K., 1989. Case study research-design and methods. Applied Social Research Methods Series, Vol. 5, Revised Edition. Sage Publications, USA.

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