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UNDERSTANDING CONTROVERSIES IN URBAN CLIMATE CHANGE ADAPTATION

A case study of the role of homeowners in the process of climate change adaptation in Copenhagen

by Nina Baron and Lars Kjerulf Petersen

This article explores the controversies that exist in urban climate change adaptation and how these controversies influence the role of homeowners in urban adaptation planning. A concrete 'Sustainable Urban Drainages System' (SUDS) project in a housing cooperative in Copenhagen has been used as a case study, thereby investigating multiple understandings of urban climate change adaptation. Several different perspectives are identified with regard to what are and what will become the main climate problems in the urban environment as well as what are considered to be the best responses to these problems. Building on the actor-network inspired theory of 'urban green assemblages' we argue that at least three different assemblages can be identified in urban climate change adaptation. Each assemblage constitutes and connects problems and responses differently and thereby involve homeowners in different ways. As climate change is a problem of unknown character and outcome in the future, we argue that it can be problematic if one way of constituting urban climate change adaptation becomes dominant, in which case some climate problems and adaptation options may become less influential, even though the enrolment of these could contribute to a more resilient city. Furthermore, the case study from Copenhagen also shows that the influence and involvement of homeowners might be reduced if the conception of future climate problems becomes too restricted. The result would be that the potential benefits of involving urban citizens in defining and responding to problems related to climate change would be lost.

Keywords: Climate change adaptation, assemblage theory, controversies, sustainable urban drainage systems (SUDS), water management

Authors: Nina Baron and Lars Kjerulf Petersen
Department of Environmental Science, Aarhus University.
Email: nba@envs.au.dk

Introduction

As the effects of global warming are becoming evident, climate adaptation is attracting growing attention, also in northern countries. The expectation is that the northern parts of the world face a future with higher sea levels, increase in average rainfall and more extreme weather events such as cloudbursts and storm surges. A number of floods and storms in recent years have shown the vulnerability of large cities towards extreme weather events, also in the most developed parts of the world. Climate change adaptation is therefore becoming a high priority issue in larger cities, not least in Copenhagen, the capital of Denmark and the empirical basis for this article.

At the same time, climate change is a problem of unknown character and outcome in the future. Models exist to predict how climate change might come to affect different parts of the world, but it remains to be seen whether these predictions hold true. As a result, adaptation measures planned or taken today are unavoidably based on estimates and expectations. Response is not to an already known situation but to imaginations of the future, which are multiple, leaving the issue of what climate problems we will face and how best to adapt to them open to controversy.

One of the controversies in urban climate change adaptation is the question of how private home and property owners should be involved. In an urban context, with high population density, all significant adaptation planning will include or at least affect private housing. Damage occurs both to private and public areas, and measures taken may transcend borders between public and private property. Therefore, cooperation between private homeowners and public organizations is often a central part of urban adaptation planning. Furthermore, studies suggest that it may be a benefit in itself if citizens are directly involved in climate change related work or can see the connection between climate change and their everyday life (Macnaghten 2003, Brace and Geoghegan 2011, Baron and Petersen 2015). Involvement makes the climate issue more visible and in turn may make citizens more engaged, both in terms of mitigation and adaptation. Conversely, studies suggest that in cases where full responsibility has been taken by public authorities, engagement on the part of citizens may diminish. For instance, flood risk can gradually disappear from the minds of residents, also where climate change might be expected to increase this risk and concern among residents about climate change and their interest in taking personal measures diminish (Baron and Petersen 2015).

In this article, we analyse and discuss how controversies regarding urban climate change adaptation influence the way homeowners become part of this adaptation process. We investigate the multiple understandings of urban climate change adaptation based on a case study of a concrete 'Sustainable Urban Drainages Systems' (SUDS) project in a housing cooperative in Copenhagen and the connections of this case to broader adaptation planning at the municipality level. SUDS presents a way in which rainwater can be handled locally. It is the method most often mentioned in relation to possible measures that can be taken by homeowners, and is seen by many as an important contribution to urban climate change adaptation. SUDS is also heavily debated in local administration and among actors working with water supply, sewerage and drainage systems. A case study regarding SUDS therefore allows us to explore the connection between imaginations of future climate change, urban climate adaptation planning, and the role of homeowners in securing their homes and properties against the effects of climate change.

We start with a short description of SUDS. Thereafter we present our theoretical framework that centres on the perspective of 'urban green assemblages' as a way of understanding the multiplicity in urban climate adaptation (Blok 2013, Farías 2010). After a description of the methods used, the empirical section presents our findings by telling a number of narratives that follow the trail of our data collection. On the background of those narratives, we argue for the existence of three different assemblages. Each assemblage connects materials, technology and weather events with homeowners and municipality professionals in different ways. The article concludes by arguing how the three different assemblages define different 'main problems' related to future climate change and different 'best solutions' for urban climate change adaptation, thereby also assigning different agency to SUDS and homeowners. By identifying these differing definitions and differing roles the article aims to contribute to a better understanding of controversies in urban climate change adaptation.

SUDS is not one technology but the name for a collection of different types of solutions and technologies with the aim of draining or using rainwater locally. The most used and best known SUDS technologies are soakaways, green roofs, rainwater beds and permeable surfaces as well as open drainage waterways and reservoirs for excess rainwater. All these solutions aim to absorb, evaporate and/or channel rainwater so it does not end up in the sewage system. The Danish name for SUDS is LAR, which in most cases is short for 'local drainage of rainwater' (Lokal Afledning af Regnvand), but by some people also understood as short for 'local use of rainwater' (Lokal Anvendelse af Regnvand). In the latter understanding, the concept is expanded to look at rainwater also as a resource, e.g. collection of rainwater for use in toilets and washing machines, or to water gardens. The multiplicity encompassed in just the term itself is a useful hint to the many controversies at play in urban climate change adaptation.

Theory

Catherine Leyshon (née Brace) and Hilary Geoghegan (2012) argue how climate change is an 'uncertain imminence', meaning that the issue we are discussing today and seek to adapt to is something which is not predictable. They therefore argue that adaptation plans and technologies can be seen as 'anticipatory objects', as objects which are given meaning on the background of expectations of a future situation. The anticipatory nature of the objects can evidently give rise to controversy, which we clearly identify in the adaptation planning of Copenhagen as a whole, as well as in relation to SUDS. To explore these controversies, we find it useful to introduce the theoretical perspective of 'urban green assemblages'.

Anders Blok argues that urban green assemblages can be especially useful to understand the differing ways in which sustainable city planning is practiced and negotiated. Blok defines urban green assemblages as "ensembles of heterogeneous actors, humans and non-humans, that orient themselves towards the practical redesign of urban eco-socio-technical relations in the direction of (some sense of) 'sustainability'" (Blok 2013:19). Blok argues that by analysing how different actors are enrolled and act in different assemblages it is possible to understand the controversies that exist in sustainable urban planning, especially when examined in relation to actual projects.

Blok's concept of urban green assemblages is a further development of Ignacio Farías and Thomas Bender's (2010) 'urban assemblages'. Blok, as well as Farías and Bender, build their theoretical understandings mainly on Bruno Latour's (2005) actor-network theory (ANT). A central aspect of the ANT perspective is the conception that both humans and non-humans are involved in socio-material processes and networks, and are therefore relevant to include when analysing social processes (Callon 1986, Murdoch 2001). A central point in Latour's work (2005) is that both humans and non-humans can and must be seen as actors. He argues that to understand transformations in society we have to look at how these actors continually dis- and reassemble in actor-networks. An urban assemblage perspective, building on the theory of Latour, therefore offers a special sensibility towards the role of non-human actors in urban developments (McFarlane 2011). However, the assemblage concept can also be traced back to Deleuze and Guattari's concept of *agencement*. *Agencement* is the French word for fitting together or arranging a number of different elements, and Deleuze and Guttari use the word to describe the connections between heterogeneous elements such as things, technologies, human bodies, symbols and so on. By studying these *agencements* or assemblages, it is possible to gain insight into how the world consists of multiple realities (Farías 2010).

When Farías and Bender introduced the concept of urban assemblages it was a reaction against the dominant theoretical perspective of 'critical urbanism' within urban studies. Their aim was therefore to be able to explain urban development not only as the result of one single dominant and determining force, e.g. the power of capitalism, as critical urbanism seemed to do (Farías 2011). Instead, with the concept of urban assemblages they sought to argue how urbanity consists of numerous urban assemblages existing side by side. This means that several urban 'realities' can be identified within the same urban context (Farías 2011, Hinchliffe 2010). This furthermore implies that the same actors can have many different roles, as each actor can play different roles depending on how they are connected to other actors. Actors' options are never pre-defined, but depend on how they are enrolled and activated in different assemblages. The same objects can have different roles depending on how they are connected to other actors. To understand how the same actor is connected to and activated in different constellations, it is useful to trace the assemblage in which the object is enrolled.

When the world in this way is looked at as multiplicity, it implies not only that many present 'realities' exist side by side, but also that imaginations of the future can be multiple. In each assemblage some potential future is imagined, depending on the collection of enrolled actors. Thus, climate problems are potentially constructed differently in different assemblages. Multiple climate problems and adaptation solutions therefore exist side by side, supported by multiple types of knowledge or expertise. Here lies a potential for controversies, as Leyshon and Geoghegan (2012) also argue.

Analyzing assemblages is a way to open up those controversies by following how different problems, solutions, knowledges, technologies and imaginations of the future are dis- and reconnected. With this assemblage approach we are therefore able to ask what kind of future climate problems are part of the controversies, how those problems are constructed, and how those constructions become part of urban climate change adaptation practices. These are the questions we are aiming to answer in this article.

Methods

The assemblage approach requires empirical exploration in order to unfold the complex and situated connections that exist between the variety of actors involved in different assemblages (Coutard and Guy 2007, McFarlane 2011). Applying ANT's rule of following the actors (Latour 2005:12, Venturini 2009), we aimed to follow SUDS technologies through the multiple settings in which they are discussed and carried on. With this we have been able to acquire insight into how SUDS technologies are connected to different actors in different settings. This process led the research in various directions, because the connections uncovered from one limited

group of actors pointed towards other assemblages of actors. This way the research moved from an isolated focus on a single housing cooperative, to also include the planning level of the utility company and the Municipality of Copenhagen. This development of our data collection is presented in more detail in the following empirical chapter.

In an urban context housing often consists of apartment buildings rather than single-family detached or terraced houses, and in Copenhagen apartment buildings consist mainly of condominiums, rented housing or housing cooperatives representing different forms of occupancy, ownership and legal responsibility. The starting point for the present study was plans for a SUDS project in A/B Park, a housing cooperative of a type common in Nordic countries. Residents share ownership of the building they live in, and decisions regarding building maintenance are made at annual general meetings for all members and, during the year, delegated to an elected executive committee. A/B Park, with its 500 apartments, is quite large for its kind. It was chosen as a case because its residents were considering a large SUDS project at the time of the study, making the cooperative an interesting object for exploring how an adaptation project driven by homeowners could turn from idea into reality. That the project never came to fruition does not make the case any less interesting.

The first author of this article followed the executive committee of A/B Park, consisting of nine members, from the summer of 2012 to the winter of 2014 in its work to launch its SUDS project. She witnessed meetings of the executive committee, attended two annual general meetings, and carried out four individual interviews with members of the executive committee and their advisor. At the meetings, it was possible to follow how the SUDS project was discussed and thereby how the agency of these technologies was constructed through the ways in which they were connected to other actors. During the fieldwork in the housing cooperative, development of this specific project was revealed to be significantly influenced by changes in the construction of SUDS solutions at the municipal level. We therefore decided to perform interviews also with actors outside A/B Park, conducting six interviews of municipal employees, municipal advisers and employees in the local utility company. All interviews have been transcribed and, together with the field notes from the meetings, have been coded and analysed with focus on different constructions of SUDS, climate change adaptation and the role of homeowners. Finally, we also found it relevant to examine the various political and technical plans and strategies presented in relation to climate change adaptation by Copenhagen City Council in the period from 2009 to 2014 (The City of Copenhagen 2009, 2011, 2012). With the help of this varied data, we have been able to acquire insights into how the actors enrolled in the climate adaptation planning in Copenhagen are connected in different assemblages.

A SUDS project that was never implemented

In this section we present our empirical findings. We cannot present all the data that has been acquired from the different sources, but we will give an account of the patterns that appeared in the data. We will do so by telling a narrative that follows the trail of our data collection, starting at the housing cooperative A/B Park and moving towards different departments of Copenhagen Municipality and the local utility company HOFOR.

The person who first had the idea for a SUDS project in A/B Park is Jan. Jan is an architect and specialist in building economy. In 1997 Jan was living in A/B Park, at which time he met Søren. Søren was working in Copenhagen City Council's energy and environment department. Søren and Jan decided to try to implement a major SUDS project in A/B Park. Jan designed a system to collect rainwater from roofs and use it in toilets and washing machines, and to drain rainwater falling on the ground through soakaways. This would make it possible to disconnect A/B Park's rainwater system from the public sewage system. Jan and Søren contacted the city council and the utility company for funding, but the utility company refused. The reason given was that they preferred their pipes to be flushed through regularly so they did not need to go down and clean them manually.

In 2011, a new government came to power in Denmark, initially wanting to set a green agenda. At this point Jan had moved out of A/B Park, but the public debates leading up to this change in government made him think that there would be a renewed chance of securing financial support for the SUDS project. Around the same time, Lise, a member of A/B Park's executive committee, ran into Søren, who told her about the old SUDS project and added:

> at the moment there is a lot of money in Copenhagen City Council you can apply for, because they have realised that it will cost them even more money to secure the whole thing [the sewage system] against cloudbursts themselves. So if they can get some housing associations or large homeowners to do some of these things, then the council can save money in the long run.

This sparked Lise's interest in the idea of a SUDS project in A/B Park, and Søren introduced her to Jan. Jan showed her the old plans and posters he had made for the project back in 1997. Together Jan and Lise then presented the project to all of the executive committee, in spring 2011. The committee was positive towards the idea from the beginning. As one of the other committee members describes:

> economically it makes sense [...] as soon as you start to reuse then you save some financial resources, not to mention the environment [...] you actually do something good for the Earth we live on.

Reuse of water was a central part of the project both for Jan and for the committee. As Jan argues:

> from a political point of view, everyone sees the water falling on their heads, but not everyone has necessarily considered that the groundwater reservoirs are polluted and are nearly depleted on Zealand [the island on which Copenhagen is situated and which constitutes the catchment area for the city's water].

Lise further comments: "it's a real shame how we use vast amounts of drinking water to flush toilets and wash our clothes." However, as A/B Park was in the process of renovating their sewage system at the time when the idea was presented to the committee was presented, they expressed a wish to finish this before taking any decisions related to the SUDS project.

On 2 July 2011 a cloudburst, now notorious in Denmark, hit Copenhagen. In parts of the city up to 177 mm of rain fell in just a few hours. When the cloudburst was most intense, rainfall was measured as falling at more than 3 mm per minute (Vejen 2011). Large areas of the city became flooded, roads closed for several days, railway tracks were undermined, and the incident resulted in expenses for insurance companies in the region of € 65 million (Forsikring og Pension 2012). The rainfall was defined as at least a 100-year event by the Danish Meteorological Institute (Andersen 2011), but was discussed in connection with another cloudburst that hit Copenhagen and the northern part of Zealand just one year earlier, 14 August. Here 'only' 90 mm fell, but still numerous basements, restaurants and shops in Copenhagen were flooded and several roads closed (Nielsen 2010).

Many of the basements in A/B Park were flooded in the 2011 cloudburst, but due to the newly renovated sewage system the damage was not as significant as in many surrounding buildings. However, in the autumn of the same year the committee returned to Jan and told him they were interested in his SUDS project. The cloudburst had given the committee members an additional reason for wanting the project and their perspective had broadened:

> Copenhagen City Council has a dimensioning problem [regarding the diameter of sewage pipelines] – in general and not only when there is a cloudburst – and therefore our project will mean something. It means something when you make a SUDS project, because then we do not pour water into the sewage system, but instead we use some of the water.

In this way the SUDS project was seen not only to contribute to climate adaptation of A/B Park itself, but to the overall adaptation of the city as a whole.

Jan was asked to make a more detailed project proposal, including a financial plan. The plan was based on extensive subsidies and funding from the municipality and the local utility company responsible for sewerage. The expenses for A/B Park were planned to be a quarter of the total cost. The whole project was then presented at A/B Parks' general meeting in the spring of 2012, where it was approved by a majority of residents. The committee was granted permission to move forward with the SUDS project, under the condition that it would be in line with the financial plan presented.

Jan submitted the application for funding, but when A/B Park received a reply to their application they were only granted a quarter of what they had requested. In the eyes of the committee the project is beneficial not only for their own property but for climate adaptation of Copenhagen as a whole, so they do not find it reasonable that they should bear the majority of the cost. They do not, however, find it feasible to pay the extra expenses themselves, so it is unlikely that the project will be implemented. At this point of time, we decided that if we wanted to understand this development it was not enough to do empirical research within A/B Park. We had to follow the actors, and that trail let us towards the planners and engineers working in Copenhagen Municipality and the local utility company.

Administering the climate change adaptation of Copenhagen

As it turned out when we approached Copenhagen Municipality, several different departments of the administration are involved in climate adaptation. Also the Utility Company plays a central role. Consequently, we set out to explore where urban climate adaptation and the SUDS technologies are discussed and constructed and selected those that were most involved in such activities for further scrutiny.

The climate adaptation team

We started with the municipality's climate adaptation team which plans and coordinates the adaptation work of the city council. Here we talked to Anders. Anders is a biologist by training. He participated in introducing SUDS into the work of the council. This progressed very slowly at the beginning, he explains, but then became established with the first climate adaptation plan of Copenhagen, which was published in the summer of 2011. This plan presents possible responses to several different expected effects of climate change: rising sea levels, heat islands, stronger winds and more rain. The major part of the plan is devoted to issues related to flood risk and increase in rainfall. The report states that precipitation is expected to rise by 25-50 % and the intensity of heavy downpours by 20-50 %. Two solutions to handle increased rainfall are then presented. The main solution is to install SUDS technologies. The second solution presented, assigned the revealing name 'Plan B', consists of methods to divert surplus rainwater to somewhere nearby where it will cause no or little damage (The City of Copenhagen 2011). Anders explains how cloudbursts were not really a part of this first adaption work, as they were seen as

something which might first be relevant sometime in the future, and it was also difficult to convince people that there was a need for such a big change in the water infrastructure. The plan was finished and sent to political approval by city council officials and technical advisers in June 2011. Shortly after, on 2 July, the heavy cloudburst hit Copenhagen. The cloudburst in 2011 changed the direction and focus of the climate adaptation team, Anders explains.

After having approved the first climate adaptation plan in August 2011, in response to the cloudburst a month earlier the politicians of Copenhagen requested more preparatory planning; this time with special focus on cloudbursts. This led to the Cloudburst Management Plan, which was concluded in October 2012. This plan presents a radically different perspective on the role of SUDS. The cloudburst plan argues that the severe downpour experienced in 2011 together with newer calculations show that the methods suggested in the first Climate Adaptation Plan from 2011 were not sufficient to handle this kind of extreme rainfall. Even by using the 'Plan B' approach, only a minor part of the requirement for rainwater drainage in the case of cloudbursts was addressed (The City of Copenhagen 2012). The Cloudburst Management Plan therefore suggests that stormwater instead must mainly be led out onto the streets and transported by various routes to the sea. Anders argues as follows: "you can say that the cloudburst meant that cloudburst planning overtook SUDS and the day-to-day rainfall". Now, all energies were directed to working with the cloudburst plan, and work with SUDS was pushed to one side. At the moment of writing, Copenhagen's climate adaptation team, together with the local utility company HOFOR, is in the process of turning the Cloudburst Management Plan into concrete climate adaptation projects all over the city; e.g., making cloudburst roads to transport the water or creating large retention areas, for instance lowering the water level in one of Copenhagen's central lakes. Implementation of the Cloudburst Management Plan was once again made topical by yet another '100-year incident', when a cloudburst of almost the same severity as the one in 2011 hit Copenhagen in the early hours of 31 August 2014, pouring up to 134 mm of rain over the city.

The Center of Urban Design

The next entity to which our studies led us was the municipality's Centre of Urban Design. It is to this entity private homeowners send their applications if they want economic support for larger renovation or improvement projects. In the Centre of Urban Design they also work with climate adaptation. Signe is an architect and Diana a landscape architect. Signe works with private apartment buildings and Diana with redesign of urban courtyards. They tell how their work incorporates an aim of disconnecting at least 30 % of the rainwater from private courtyards and roofs in Copenhagen from the public sewage system. This is by no means a regulatory standard to which they have to comply but a guideline they "really, really want to follow". Disconnecting 30 % of stormwater by means of SUDS solutions is here seen as the way the city can handle the expected increase in rainwater. At the Centre of Urban Design, every time they fund a project or receive an application for changes in courtyards or buildings, they consider the options for integrating SUDS solutions. It is not always possible to install SUDS, however, as buildings and neighbourhoods differ. Diana explains,

> it's alright to say that we should disconnect at least 30 % of all rainwater [...] but if the block is very narrow it is difficult to reach the 30 % with the normal solutions we have today, also because in our projects there is a relatively modest amount of money to use for this.

A neighbourhood in Copenhagen called Sankt Kjelds has been selected by Copenhagen City Council as a special innovative climate neighbourhood. Part of the project is handled by the Centre of Urban Design. In Sankt Kjelds they aim to disconnect more than 30 % of stormwater, as they have a larger budget for climate solutions. A special aim in the in the Sankt Kjelds project is to involve local citizens as much as possible in both creating and implementing climate solutions. In the Centre of Urban Design SUDS is seen as a solution to increased precipitation – both in Sankt Kjelds and in the city as a whole – and the potential is seen to be best exploited in cooperation with homeowners and citizens.

The Utility Company

The final entity we found to be directly connected to the development of A/B Park's SUDS project was the Utility Company HOFOR. HOFOR receives many applications from homeowners who would like to implement SUDS projects. Peter works in HOFOR and is an engineer by training. He talks about one of these applications:

> Now this housing association begins talking about installing SUDS and they know that the stormwater they get is something which is streaming downhill from a lot of other places. Why do they have to install SUDS? Shouldn't they just wait for that public cloudburst solution to come? Then they will get a watercourse on each side they can pour their water into. They want to do something, because they are standing in water up to their knees, I understand that, but they just can't do anything that helps. It has to be done further away and on a larger scale.

Peter relates to this individual project in the context of the large cloudburst plan from 2012 for the whole municipality. In this particular case, he does not think it makes sense to implement a SUDS project, as the residents' problem would be better solved by the forthcoming public solutions, he argues. Also, from a more financial perspective he does not think that SUDS makes sense everywhere: "There is no reason for taking the most expensive square metres if it helps just as much to disconnect a lot of gardens up in Vanløse [a suburban area a little outside central Copenhagen]". Therefore, HOFOR's strategy is that "when people contact us, we try to look at the (cloudburst) plans (...). If a project makes sense in relation to the plans, they might as well implement it". For him SUDS solutions are only relevant in carefully chosen areas upstream of central Copenhagen.

Three different urban climate adaptation assemblages

When analyzing these different narratives, at least three different assemblages come into view. All three assemblages connected different technologies, weather events, people, organizations and scientific facts in different ways. We will here present them in turn.

Assemblage 1: Independent solutions to private sites rainfall
Copenhagen is expected to receive more rain in the future and it is possible to identify an assemblage relating to this issue. Here, the problem to solve is the 30 % increase in precipitation and the solution is to take care of the rainfall very locally. This is the assemblage from which the first climate adaptation plan originated; a plan where SUDS is constituted as the main solution. It is also this assemblage that shapes the practice of disconnecting 30 % of rainwater from sewerage in as many places as possible, as Signe and Diana at the city council's Centre of Urban Design demonstrate. In this sense, all parts of the city are looked at independently in relation to how they will be able to drain or in other ways handle the extra rainfall they will receive. Each private site would play a role in handling its own rainwater. Key actors in this assemblage include climate change scenarios predicting higher average rainfall, home and property owners throughout Copenhagen, certain municipal departments, the funding schemes they administer enabling property owners to install SUDS solutions, the existing sewerage infrastructure, and various techniques to retain rainwater locally. This assemblage is partly maintained by the practices of the committee of A/B Park, and especially by the practices of the Centre of Urban Design.

Both private households and public institutions have an active role in this assemblage; private home and property owners having to handle the rainfall on private sites, and public professionals on public areas. This means that homeowners here are centrally located in the assemblage. As SUDS is connected as a response to the extra 30 % of rainfall, SUDS has to be installed as widely as possible. Homeowners can respond to the main problems of this assemblage by installing SUDS. For the public actors, the city council and the utility company having as many homeowners as possible install SUDS is the 'best solution', because this can reduce pressure on the public sewage system as well as the general risk of flooding.

Assemblage 2: Connected solutions to rain handling
Another assemblage is oriented towards the issue of collective and connected stormwater solutions. Here, a central actor is extreme rainfall events. Day-to-day rainfall is not a part of this assemblage. In contrast to the aforementioned assemblage, private sites, public streets, parks and squares are not independently connected to climate adaptation; instead the entire city is enrolled as a connected system. This also means that SUDS technologies are constructed by not only their connection to rainfall in isolated parts of the city, but to rainfall in the city and the surrounding area as a whole as well as the resulting movement of water on (and in) the ground. This implies that SUDS is given a much more peripheral position than is the case in the aforementioned assemblage. Other central actors in this assemblage include the cloudburst incident in 2011, the Cloudburst Management Plan, the municipal climate adaptation team and the utility company.

The exclusion of day-to-day rainfall as an actor, as well as the somewhat different position of SUDS in this assemblage, also gives a new position for homeowners. As SUDS solutions here are connected to the entire sewage system as well as the extensive cloudburst plan under implementation, the individual SUDS project is only included if it fills a hole in the public planning. This new and diminished role is partly constituted by the redirection and blocking of previous funding to local SUDS solutions. In cases where a building will get "a watercourse on each side that they can pour their water into", SUDS is disconnected from the projects. In this way, the options for agency of homeowners follow the plans and practices of the public water managers. The homeowners' roles are defined by public plans and strategies, and directly shaped by funding schemes. The overall plan has to be completed before it is possible to position private homeowners roles and actions. In most cases, collective systems are constituted as the 'best solution', because they are seen as the most efficient and simplest way of adapting the city to a future with more rainfall and cloudbursts. Therefore, homeowners play only a minor role, if they have one at all.

Assemblage 3: Rainwater as valuable resource
In the third assemblage SUDS is again connected in new ways. Here SUDS is not only connected to local drainage of rainwater, but also to rainwater as a resource to be collected and used, not simply diverted. This assemblage is central to the understanding of the SUDS project in A/B Park. This assemblage stretches far beyond the city. Here, it is not only the rainwater falling in the city that is enrolled, but fresh, clean and non-polluted drinking water for the whole of Denmark and even further afield. The broader adaptation planning of the city is not part of this assemblage. The need to protect natural resources is here a central actor. Climate change is not only connected to increases in precipitation but also to longer periods of dry weather and pollution of aquifers by agricultural use of pesticides, which together increase the risk for water shortages. SUDS is therefore not only a solution to increased rainfall but also to longer dry periods and other threats to the freshwater resource.

In this final assemblage homeowners are again a well-connected actor. Here the homeowners' actions are connected not just to protecting their own property and its immediate vicinity but also to safeguarding water resources at a national level. As all rainwater is seen as a resource, as much as possible has to be collected. The more homeowners who that install SUDS solutions to use rainwater the better. The concept of self-sufficiency is also enrolled in the assemblage. SUDS is thereby maintained as an important part of the assemblage, even though it is not necessarily defined as the most efficient way to protect against flooding.

Understanding controversies around SUDS and the role of homeowners

Multiple main problems

The assemblage analysis above shows how the three different assemblages enroll different ways of imagining future climate change. In the first assemblage the main problem is constituted around climate models predicting a 30 % increase in precipitation in the areas of Copenhagen. The second assemblage also connects strongly to climate models but, even more importantly, to concrete experiences of extreme weather. In this assemblage the cloudburst in Copenhagen in 2011 has a very significant position. The experience of how much damage an extreme rain event can cause shapes cloudbursts as an imminence which already feels very real. Finally, the last assemblage creates another background for imagining the future. This assemblage also enrolls actors outside Copenhagen. This brings not only stormwater but resource scarcity in general forward as relevant problems to be concerned with.

Thus, space and time are enrolled in different ways into the three assemblages (Farías 2010), creating different imaginations of the future (McFarlane 2011). Here the assemblage approach shows its value, as it makes it possible to follow connections between actors across the traditional divisions of local and global. The three assemblages identified in the above analysis show that also 'the global' is diverse and can be connected to localized actors in various ways.

Multiple best solutions

This further means that depending on how the main problem is defined, different responses acquire the position as 'best solutions' to future climate challenges. In the second assemblage collective and connected rainwater solutions are enrolled as the 'best' solutions as they have the position of the only way the cloudburst problem can be handled. However, severe rainfall events are only one of many different possible ways climate change is imagined. In the remaining assemblages, other future issues are included, such as water shortages, pollution of drinking water and more day-to-day rain. In these other conceptions of climate change, different adaptation measures come to be seen as the 'best' solutions, among other SUDS.

As our empirical findings show, diverse items of expertise are part of the controversies around urban climate change adaptation. Specific knowledge and expertise are part of the practices in the different municipality groups and departments and in the utility company. Also in the SUDS project of A/B Park the expertise of Jan, the architect, had played a central role. It is thus possible to identify different types of expertise enrolled in the three different assemblages. In the first assemblage oriented toward independent and local SUDS solutions, knowledge about the increase in everyday rain is central, so is expertise in the capacity of different SUDS solutions, earth types, local pollutions and citizens involvement. The same knowledge is included in the third assemblage, but here also expertise of water quality and ground water levels are centrally placed. However, in the second assemblage a different type of expertise is centrally positioned. Here hydraulic models for the whole city are strongly connected actors, and insight in them is an important knowledge to have. Also detailed knowledge about the effects of cloudburst in 2011 and the capacity of different types of water storages and mechanisms to slow down the speed of the water are important.

Hence, the controversies around the use and effects of SUDS technologies, is not so much about one type of expert knowledge meeting the lay knowledge of the local citizens. Rather, it is a struggle between different types of knowledge and different types of expertise. With this we can understand the controversies around SUDS and the role of homeowners in a new way. When first meeting these controversies they may come across as merely technical debates about the capacity of SUDS technologies. However, by deconstructing the controversies into different assemblages, we have aimed to show that the controversies are a much a struggle between different ways of imagining the future, and thereby different ways of defining the problems we have to solve, as it is a process where experts struggles to find the 'best solutions, to an already defined problem.

One current 'best solution'

At the moment one of the assemblages is dominant. Copenhagen mostly follows the path of cloudburst oriented problem definitions and solution. As Diana from Centre of Urban Design relates, they support at most twelve SUDS projects per year, a quite small fraction of the 300 projects which currently are part of the overall cloudburst plan, recently approved by the City Council (The City of Copenhagen 2015).

Based on our empirical data we will argue that the defining actor for this development clearly was the cloudburst in 2011, supported by the slightly smaller cloudburst events in 2010 and 2014. Right after the event in 2011 a large number of connections between actors were made or broken. In this transformation the cloudburst events tied the connections in a large network of alliances. Both economic and political actors were included in this new assemblage established in relation to the cloudburst events. This meant that earlier connections to the SUDS technologies were broken. Today this rather sudden dis- and reassembling of nearly all actors connected to some kind of urban climate change adaptation means that one assemblage came to be the dominant. One 'main problem' and the connected 'best solution' is leading money-, policy- and waterflows in a single direction.

Reflections and concerns

The important question to raise is whether this is a problem. As all three assemblages orient themselves towards different future problems, the extent and type of which are not currently known, this questions is very difficult to answer. However, we will round up the article by raising a few concerns.

Firstly, even though cloudbursts might present the largest and most challenging problem at present, nobody knows if water shortages will turn into a more serious problem, as already is the case in many other big cities. In the same way, nobody knows if the future will bring unforeseen problems in connection with more day-to-day rainfall. If one main problem attracts so much attention that the other possible problems are forgotten or pushed aside, the future resilience of the city may be compromised. Including a broader scope of expertise in the planning process might make Copenhagen better prepared for other types of future challenges.

Secondly, we return to the role of private homeowners. The ability of one assemblage to define the present course of development and reduce the influence of other assemblages might not only mean that other potential climate-related problems are overlooked; this study also reveals that homeowners can become marginalized in climate adaptation planning. In the present dominant assemblage, homeowners are rendered marginal in the broader adaptation planning. In the two remaining assemblages, homeowners are on the other hand assigned an active role defining problems and solutions.

As mentioned in the introduction, several studies indicate that it can be beneficial if citizens are given an active and influential role in the preparation of climate change plans and projects (Macnaghten 2003, Brace and Geoghegan 2011, Baron and Petersen 2015). In this way they are more likely to develop ownership of the projects as well as a general concern and interest in climate issues. Furthermore, other studies argue how local knowledge can provide a useful contribution to other types of knowledge, as local people often have a closer connection to, and thereby more detailed understanding of, e.g. high water lines and special local challenges, that could prove useful for the planners of climate change adaptation (Karvonen 2011, Agger 2010, Ingold 2000). Last but not least, the case study of A/B Park demonstrates that by excluding homeowners from being part of defining problems and solutions, concrete resources might also be lost. The executive committee of A/B Park was very interested in the SUDS projects and found it so relevant that even though they were not willing to pay the full price they were nonetheless planning to allocate significant funds to the project, not to mention their energy and time. By not involving private homeowners, there is the risk that the potential represented in this kind of public engagement and resources relating to climate issues are left unexploited.

Conclusion

This article reveals how several assemblages can be identified in urban climate change adaptation. This means that multiple understandings of future climate issues and how to respond to these exist side by side. This implies that multiple understandings of the role of homeowners exist in this urban context. Some assemblages construct a reality where homeowners play an important role through installation of SUDS in and around their homes; others establish the public system as being able to solve the problems more efficiently. At the moment the development in Copenhagen moves towards a perception of cloudbursts as the largest future climate challenges. This means that economy and policy resources are lead towards large connected and collective cloudburst managing solutions. In this process homeowners are left with a very reduced role. It is in other words important in an assemblage analysis not only to acknowledge the diversity of actors, knowledges and imagined futures but also the processes through which some assemblages may become dominant. From this realization we argue in favour of not letting one construct of problems and solutions in relation to climate change adaptation push away the others all together, as the present multiplicity of urban green assemblages has the potential to create a more resilient city with the capacity to respond to a broader scope of climate change and environmental issues. Furthermore, in the move towards reducing the role of private homeowners, the potential benefits of involving urban citizens in defining and responding to problems related to climate change are lost. On the background of the present assemblage analysis we therefore advocate allowing multiple imaginations of future climate change to exist and be included in present urban climate adaptation planning.

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Nina Baron is assistant professor at the Emergency and Risk Management programme at Metropolitan University College. She holds a Ph.D. in environmental sociology from the Department of Environmental Science, Aarhus University, and specializes in climate adaptation, citizen actions and risk perceptions.

Lars Kjerulf Petersen, Ph.D., is senior social scientist at Department of Environmental Science, Aarhus University. He investigates a broad variety of issues pertaining to environment and society, including climate change adaptation as well as household energy prosumption, urban green structure and household waste handling.

Literature

Agger, A. 2010. Involving citizens in sustainable development: evidence of new forms of participation in the Danish Agenda 21 schemes. *Local Environment* 15:541-552.

Andersen, M. M. 2011. Skybrud over København - 3. udgave. Accessed 23.10.2014.

Baron, N. and L. K. Petersen. 2015. Climate change or variable weather: rethinking Danish homeowners' perceptions of floods and climate. *Regional Environmental Change*: 15 (6):1145-1155.

Blok, A. 2013. Urban Green Assemblages: An ANT View on Sustainable City Building Projects. *Science & Technology Studies* 26 (1):5-24.

Brace, C. and H. Geoghegan. 2011. Human geographies of climate change: Landscape, temporality, and lay knowledges. *Progress in Human Geography* 35 (3):284-302.

Callon, M.. 1986. Some elements of a sociology of translation: the domestication of the scallops and the fishermen of St. Brieuc Bay. In Law, J. (ed.) *Power, action and belief: A New Sociology of Knowledge*, 196-233. London: Routledge and Kegan Paul.

Coutard, O.and S. Guy. 2007. STS and the City: Politics and Practices of Hope. *Science, Technology & Human Values* 32 (6):713-734.

Farías, I. 2010. Introduction: Decentering the object of urban studies. In Bender, T. and I. Farías (eds.) *Urban assemblages: how actor-network theory changes urban studies*. London: Routledge.

Farías, I. 2011. The politics of urban assemblages. *City* 15 (3-4):365-374.

Farias, I., and T. Bender (eds.) 2010. *Urban assemblages: how actor-network theory changes urban studies*. London; New York: Routledge.

Forsikring og Pension. 2012. Vejrskader. Press briefing 18. april 2012. Accessed 23.10.2014.

Hinchliffe, S. 2010. Working with Multiples: A Non-Representational Approach to Environmental Issues. In Harrison, B. and P. Anderson (eds.) *Taking-place non-representational theories and geography*. Farnham, Surrey, England; Burlington, VT: Ashgate.

Ingold, T. 2000. *The perception of the environment: essays on livelihood, dwelling and skill*. London; New York: Routledge.

Karvonen, A. 2011. *Politics of urban runoff : nature, technology, and the sustainable city*. Cambridge, Mass.: MIT Press.

Latour, B. 2005. *Reassembling the social : an introduction to actor-network-theory*. Oxford; New York: Oxford University Press.

Leyshon, C. and H. Geoghegan. 2012. Anticipatory objects and uncertain imminence: cattle grids, landscape and the presencing of climate change on the Lizard Peninsula, UK. *Area* 44 (2):237-244.

Macnaghten, P. 2003. Embodying the environment in everyday life practices1. *The Sociological Review* 51 (1):63-84.

McFarlane, C. 2011. Assemblage and critical urbanism. *City* 15 (2):204-224.

Murdoch, J. 2001. Ecologising Sociology: Actor-Network Theory, Co-Construction and the Problem of Human Exemptionalism. *Sociology* 35 (1):111-133.

Nielsen, K. 2010. Skybruddet der kom bag på alle. DR. Accessed 23.10.2014.

The City of Copenhagen. 2009. *Københavns Klimaplan*. Copenhagen.

The City of Copenhagen, Technical and Environmental Administration. 2011. *Copenhagen Climate Adaptation Plan*. Copenhagen.

The City of Copenhagen. 2015. København klar med 300 skybrudsprojekter. Accessed 27.11.2015.

The City of Copenhagen, Technical and Environmental Administration. 2012. *Cloudburst Management Plan 2012*. Copenhagen.

Vejen, F. 2011. Tropisk styrtregn over København d. 2. juli 2011. Alle danske monsterregns moder...! *Vejret - tidsskrift for vejr og klima* 33 (3).

Venturini, T. 2009. Diving in magma: How to explore controversies with actor-network theory. *Public Understanding of Science* 19(3): 258–273.