ECOSYSTEM BASED APPROACHES TO CLIMATE ADAPTATION

– Urban Prospects and Barriers

Scientific Report from DCE – Danish Centre for Environment and Energy No. 83 2014

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Data sheet

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Abstract:	This report analyses the prospects and barriers of applying ecosystem based approaches systematically to climate adaptation in urban areas, taking the case of green roofs in Copenhagen Municipality. It looks at planning aspects of green roofs in Copenhagen as well as citizen views and preferences regarding green roofs using policy document analysis, interviews with city planners and deliberative valuation methods.
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Preface

This report provides the findings of a pilot study on ecosystem based approaches to climate adaptation in the municipality of Copenhagen. It looks at prospects and conflicts in relation to systematically introducing ecosystem services in dense urban areas for the benefits of inhabitants. It investigates attitudes, experiences and views of city planners and introduces and tests a novel participatory process of involving citizens. We have chosen to focus on the case of green roofs as an urban space where competition for use is minimal compared to ground level space. The approach combines spatial analysis using Geographic Information System, environmental sociology and environmental economics. Policy document analysis was conducted along with qualitative interviews with selected city planners and one deliberative valuation workshop with inhabitants of a social housing block in Sct. Kjelds' Neighbourhood, Copenhagen.

The pilot project was financed through the Coordination Unit for Climate Adaptation (KFT) as one of several studies during 2012 that look at different aspects of climate adaptation in Denmark. Flemming Olsen, Chairman of the estate board of Øbrohus was key to recruiting respondents to the workshop and finding workshop venue; Kanslergården social housing block hosted the workshop venue. VegTech cordially allowed us to use and manipulate green roof photos for visualisation purposes. Finally, but not least, Dr Jim Smart, senior lecturer at Griffith School of Environment, Australia, former colleague at Aarhus University, gave inspiration to carrying out the deliberative workshop as well as valuable advice on the choice experiment design and interpretation.

Executive Summary

This report presents a study of ecosystem based approaches to climate adaptation in urban areas. It takes the case of green roofs in Copenhagen municipality as a means of creating urban habitats that have the potential to alleviate the negative climate impacts in terms of expected higher rate and volume of surface run off as well as urban heat islands. At the same time, these habitats may also enhance a wider set of benefits derived from ecosystem services such as biodiversity, recreation, mobility, social inclusion and aesthetics.

Ecosystem services are the benefits that people obtain directly or indirectly from ecosystem functions such as the protection from storm surges, air quality regulation, food, fibre and freshwater. Ecosystem-based approaches to adaptation are understood as the use of biodiversity and ecosystem services to help people adapt to the adverse effects of climate change.

Urban areas are characterised by compact built environments and impermeable surfaces that modify energy exchanges and hydrological processes compared to rural and more natural areas. Moreover, urban populations are growing, leading to higher rates of urban sprawl and concentration of people and infrastructures. Cities are therefore especially prone to the negative consequences of changes to the climate system. But by working actively in urban settings with Nature's capacity to absorb and control negative impacts of climate change, it is increasingly believed that we are capable of creating sustainable resilient cities.

ES.1.1 Objectives

The main objective of this pilot study is twofold: i) to investigate the prospects and conflicts of systematically integrating an ecosystem-based climate change adaptation in the municipality of Copenhagen, where we take the case of ecosystem services provided by green roofs; and ii) to test the feasibility of conducting deliberative valuation using mixed methods to assess preferences for greening residential buildings and areas.

At citizen level, we undertake a deliberative valuation workshop for local inhabitants to test the acceptance and preferences towards green roofs as a multifunctional way of adapting to climate change. The type of outcome can help policy makers better understand motivations and wishes regarding how the city should look like and function, the degree to which they would be willing to undertake action and the role of the municipality in creating incentives.

At policy level, we undertake policy document analysis of Copenhagen plans and strategies and supplement these with interviews with city planners to understand how the green roof policy has developed, barriers and conflicts, the extent to which an ecosystem based approach is integrated in planning and which aspect may promote the inclusion of green roofs as an ecosystem service in the city adaptation policy.

The dual perspective of citizens and city planning gives an example of how mixed method approaches can deliver integrated knowledge of how urban landscapes are perceived and used and what future developments citizens and planners would like to see happen. This study is designed as a pilot study to shed light on these aspects.

ES.1.2 Ecosystem Services from Green Roofs

Green roofs have the potential to provide both private and public benefits. They represent new habitats, where there have not been any for a long period of time (in the case of retrofitting) or where existing habitats have recently been eliminated (in the case of developments on green- or brown fields). The habitats on green roofs are almost exclusively determined by humans and require some level of maintenance. Choices as to the depth of substrate matter and hence the type of vegetation that can be introduced on roofs largely determine the type and quality of ecosystem services provided along with consideration of access for people. Ecosystem services from green roofs range from **habitat services** that create new habitats for flora and fauna; **regulating services** such as adaptation to climate change by mitigating urban heat islands and improving surface water run-off under normal everyday rain showers or climate change mitigation by providing alternatives to fossil fuel based transport through popular walking/cycling corridors across urban areas, optimizing solar cell performance or sequestering carbon in vegetation, prolonging the longevity of normal roofs by protection from UV radiation; **provisioning services** such as urban food production; and **cultural services** including improving quality of life through improved recreation opportunities, physical and mental well-being, enhancing land values or using greening activities to enhance social inclusion.

ES.1.3 Direct disadvantages of Green Roofs

Despite the potential long list of benefits in terms of ecosystem services from green roofs, there are a number of disadvantages that may answer for the relatively rare occurrence of green roofs in Denmark to date. **Quality of installation** is one major concern of many stakeholders, given the lack of Danish standards and guidelines, education, research and fairly few years of experience in Denmark. This is also related to the fact that green roofs are not part of traditional Danish building culture. **Costs of establishing a green roof** is another major obstacle for the large-scale introduction of green roofs in cities. Different types of green roofs place different requirements on the statics of buildings, which may need reinforcement. The roof surface will need proper preparation before several protection and absorption layers are installed with the vegetation layer on top; this demands specific knowhow and materials. **Regular maintenance costs** adds to the direct costs of green roofs, needing bi-annual removal of unwanted vegetation and leaves, which is far from trivial at roof level. Finally, **conflicts of interests** with the functioning of green roofs may occur, where rain water harvesting is a preferred option for use in domestic appliances or irrigation, or the statics of a building is not able to carry the weight of both green roof and solar cells.

Figure ES.1 Build-up of a green roof
Graphics: Britta Munter, Aarhus University

ES.1.4 Potential for retrofitting green roofs in Copenhagen

Using the National Building Registry (BBR), we conducted a simple analysis of the maximum technical potential of green roofs on flat or nearly flat roof surfaces. Total roof area in the Municipality of Copenhagen represents more than 1300 ha, of which flat roofs take up some 13 % (171 ha). The large majority of flat roof buildings in the municipality are used for commerce, service, transport and public administration (52 %); whereas private housing represents 16 %, regional and state 15 % and municipal institutions about 6%. If, conservatively, we would assume a similar uptake of green roofs on flat roofs in Copenhagen as on the average coverage of green roofs in Germany (where 14 % of the total number of roofs are green), this would represent some 240.000 m2.

ES.1.5 Planning Aspects of Green Roofs in Copenhagen Municipality

Policies and plans begin to mention green roofs in the 2008 'Waste Water Plan', followed by the 2009 'Climate Plan', where green roofs were included as an example of green infrastructure delivering adaptation potential. In 2009, a specific green roof policy was politically decided and later integrated in the 2011 'Municipality Plan', the 2011 'Climate Adaptation Plan' and 2012 'Climate Plan 2025'. Local plans and municipal guidelines now incorporate green roofs. The green roof policy requires that all new buildings with a roof slope below 30 degrees should have green vegetation to the extent that this is acceptable in terms of aesthetics and practicality. It is expected from present local plans that about 200.000 m^2 of green roofs will be installed on new buildings over the coming years. No qualifications of the green roof requirements exist in terms of the area that vegetation should take up on new roofs, the type or the performance of green roofs. There is no direct financial incentive provided to cover parts of the costs of installing green roofs and also retrofitting green roofs on existing buildings is not included in the policy.

Municipal policies in Copenhagen clearly indicate a growing recognition of ecosystem services in general and of the services that green roofs offer an urban population in particular. Green roofs constitute an element in urban green infrastructure that is increasingly articulated as providing a range of services to the urban population, including aesthetics, more pleasant atmospheres of urban spaces, rain water retention, reduction of heat in buildings and urban spaces and adding to a general greening of the city and a greener urban identity. Thus, green roofs move from 'merely' providing patches of urban nature to offer a range of benefits, which in combination are anticipated to make green roofs – as one among several green infrastructure elements – an asset of the future city. Likewise, green roofs are perceived to offer services that will manage some of the future rains and in combination with other climate adaptive measures prepare the city for the impacts of present and future climate changes.

However, the term ecosystem services is absent from the policy discourse. Along with development of the policies to address the city's overall strategy of climate adaptation, the acknowledgement of green roofs and related ecosystem services progress and become more central. However, measures, standards and initiatives are not very specific while green roofs are often mentioned as examples of a greening of the city or of the benefits (i.e. services) of urban nature.

Table ES.1 Summary of enablers and barriers for green roofs in Copenhagen Municipality.

Enablers	Barriers/conflicts
Green roof policy has been established and implemented showing political leadership and will to continue	No qualification of the performance of required green roofs (size of green roof compared to building ground plan, type of green roof, water retention capacity, biodiversity, aesthetics etc.)
Agrotech establishing a test-centre for green roofs will over time help clarify performance of different types of green roofs	Lack of national standards and guidelines: Copenhagen Municipality has no national basis for making performance requirements within their green roof policy Copenhagen Municipality has a weak position in the negotiation with developers on the specificities of green roofs The municipal utility company has insufficient documented evidence of the water retention capacity of green roofs, making it difficult for private housing owners and developers to apply for a refund of rain water connection to the sewage system
Growing recognition within the different administrative units of the Municipality of the diverse benefits and ecosystem services provided by green roofs	Lack of national research into the qualification and (monetary) quantification of the ecosystem services and benefits provided by green roofs
Little competition for space in dense urban areas compared to ground level	Novel measure in Denmark with yet relatively few and short term experiences Among civil and building engineers a dominant perception that green roofs offer more problems than they solve and should therefore be avoided No education currently offered at Danish engineering universities on the construction and workings of green roofs
Requirement of green roofs in local plans lead to substantial implementation of green roofs in particularly new neighbourhoods (ca. 200.000 m^2 green roofs expected over the coming years)	Through requirements on green roofs on new buildings, the municipality imposes a private cost on developers with no Danish research on the subsequent social welfare benefits

The acknowledgment of the diversity of ecosystem services provided by green roofs (and also other green infrastructure) makes it possible that green roofs can be considered in relation to other policy areas than climate adaptation, such as climate mitigation, urban design and architecture, common urban identity as an Eco-Metropolis and green growth. Most of these services reflect the city's conceptualisation of urban sustainability, with emphasis on the natural environmental dimension and the social dimension. Providing more than one service reduces the vulnerability of green roofs in urban development; if developers for budget reasons exclude green roofs from the project, it is not only the aesthetics or water retention that is omitted but a larger range of benefits.

ES.1.6 Citizen Views and Preferences regarding Green Roofs

Citizen views and preferences regarding greening urban space in general and green roofs in particular were investigated during a 3-hour long deliberative valuation workshop with inhabitants of the Øbrohus housing block in Sct. Kjelds neighbourhood in December 2012. Respondents were indirectly asked to reveal their preferences for different characteristics of green roofs that could be envisioned on their building. A monetary valuation was made as to their willingness to accept a monthly rent increase for getting a green roof that they could have access to. 19 individuals participated. The process was built around a convivial setting of coffee/tea and a tasty three-course dinner. The workshop took place in the common rooms of a neighbouring housing block.

The deliberative setting allowed for an integration of the social context of participants and group dynamics, enhancing the reality of the hypothetical choice situations and opening up for learning processes, preference building. The setting gave a common space for individual statements and deliberation of wishes and perceptions regarding the physical surroundings in the neighbourhood in general and in Øbrohus in particular.

Table ES.1 Average Willingness-to-Pay.

Scenario	Average WTP (DKK/month)
Standard extensive green roof with solar cells which retains 50 % of rain water & recycles 50 % rain water in building	500
Standard extensive green roof which retains 50% of rain water & recycles 50 % rain water in building	380
Standard extensive green roof with solar cells which retains 50 % of rain water	358
Semi-intensive green roof with garden which retains 50 % of rain & recycles 50 % rain water in building	287
Standard extensive green roof which retains 50 % of rain water	238
Semi-intensive green roof with garden which retains 50 % of rain water	145

Results of the quantitative analysis show a significant preference towards the establishment of a green roof both in session one, where no requirement to pay for the green roof was included and session two, where a monthly rent increase was introduced as a payment vehicle. Introducing the payment vehicle in terms of the monthly rent increase did not change the preference direction. Statistically significant relative preferences remained stable in the two sessions. The most preferred attribute levels in both sessions proved to be the standard sedum-moss green roof combined with solar cells as well and the option to recycle excess rain water in the building. In neither of the two sessions did the stand-alone semi-intensive green roof or high biodiversity indicate any significant preference. The relative importance of the significant attributes roof type and water are fairly balanced with roof type representing 53 % and water 47 %. Average monthly WTPs for options range on average from 145 DKK to 500 DKK, depending on the characteristics of the roof.

ES.1.7 Conclusions

Green roofs represent one example of using Nature's capacity to help people adapt to the adverse effects of climate change, while potentially also providing a whole variety of other benefits that enhance quality of life and urban sustainability. This is opposed to human-made technical solutions to e.g. increasing temperatures or increasing water run-off, which only provide the *one service*. Therefore, comparing options that use ecosystem based approaches to e.g. climate adaptation with human made 'grey' infrastructures ought to take into account the wider benefits (and disbenefits) of ecosystem services delivered by green infrastructures and permeable surfaces.

If implemented systematically at large scale, green roofs may potentially contribute significantly towards urban sustainability. If, however, we look at individual benefits of green roofs, such as run-off management alone, they may not prove to be economically sound investments. This assessment may very well change when including considerations of enhanced aesthetical values, potential increased property value, recreation opportunities and habitats for biodiversity. Deciding upon systematically implementing green roofs in urban areas (and not uniquely on new buildings) will therefore need to comprise many aspects and involve transdisciplinary cooperation (e.g. between biologists, engineers, architects, planners and economists). Some benefits will accrue to private building owners (e.g. increased private property value or extended longevity of roofs), whereas other benefits may go to different beneficiaries: the neighbourhood and local authority (e.g. reduced risk of flooding and reduced pressure on urban drainage system) and yet other benefits may accrue to the wider society (e.g. establishment of new habitats for biodiversity).

For a large-scale systematic implementation of green roofs in Copenhagen on both existing and new buildings, Copenhagen Municipality could introduce new and/or extend existing policy instruments: i) the **current mandate of green roofs** through the building code or local plans could be extended to include existing buildings (applicable when large renovations are undertaken) and introduce minimum performance standards and a minimum ratio of green roof to building ground plan; ii) Provide **direct financial incentives** to compensate for some of the initial and non-negligible installation costs while providing society with a range of desirable public services; iii) make the **current indirect financial incentives** more flexible by permitting a partial refund of sewage connection fee; and iv) develop **performance standards** on that give quantifiable advantages of green roof buildings compared to nongreen roof buildings. Introduction of green roofs at a larger scale could potentially provide local retention of water, and thus reduced costs for 'grey' adaptation measures for the municipality, and would moreover contribute to extension of green spaces, making city spaces more liveable for people. Copenhagen Municipality could choose to mix these policy instruments to create the basis for a truly systematic ecosystem based approach to not only climate adaptation but also to the wider variety of ecosystem services that permeable surfaces and habitat creation can offer in dense urban areas.

Sammendrag

Denne rapport præsenterer et pilotstudie omkring økosystem baserede tilgange til klimatilpasning i byområder. Den tager grønne tage i Københavns Kommune som et eksempel på hvordan by-habitater kan skabes med potentialet til at formindske nogle af de negative effekter ved klimaændringer såsom forhøjede mængder og hyppighed af regnmængder og varme-ø effekter samtidig med at de ekstra by-habitater fremmer en lang række andre økosystemtjenester som fx biodiversitet, friluftsliv, mobilitet, social inklusion og æstetik i byrummet.

Økosystemtjenester er de fordele som vi får direkte eller indirekte fra økosystemernes funktioner. Fordelene kan være beskyttelse imod stormflod, regulering af luftkvalitet, mad, fiber og drikkevand. Økosystembaserede tilgange til klimatilpasning forstås som det at bruge biodiversitet og økosystemtjenester til at hjælpe os med at tilpasse os og beskytte os imod de negative effekter ved klimaændringer.

Byområder kan karakteriseres ved kompakt bebyggede rum og store områder af uigennemtrængelige overflader som asfalt, tage og fortove. De uigennemtrængelige overflader og tæt bebyggede rum fører til ændringer i den naturlige energiudveksling og i de hydrologiske processer set i forhold til landlige omgivelser. Med klimaændringer henimod varmere temperaturer og hyppigere og kraftigere regnskyl har byer derfor en ekstra udfordring i forhold til energiudveksling og hydrologi. Dette studie ser på aspekterne omkring byplanlægning og borgeropfattelser i forhold til om og hvordan en økosystembaseret tilgang kan bruges til klimatilpasning.

S.1.1 Formål

Hovedformålet med dette pilotstudie er flg.: i) at undersøge muligheder og konflikter ved systematisk at integrere en økosystembaseret tilgang til klimatilpasning i Københavns Kommune, hvor vi tager eksemplet med grønne tage; og ii) at teste gennemførligheden af 'deliberative' (inddragende) værdisætningsworkshops der bruger blandede metoder for at estimere borgeres præferencer i forhold til grønne tage på beboelsesbygninger.

Vi har udført en deliberativ, dvs. inddragende værdisætnings-workshop for en gruppe lokale beboere for at undersøge borgernes accept og præferencer for grønne tage. Resultatet af workshoppen kan hjælpe beslutningstagere til bedre at forstå motivationer og ønsker til hvordan byen skal fungere og se ud i fremtiden; i hvor høj grad borgere er villige til selv at betale og selv at sørge for at konstruktionen af de grønne tage gennemføres, og hvad kommunens rolle kunne være i forhold til at skabe bedre incitamenter og rammer.

På det politiske niveau foretager vi en policy dokument analyse af Københavns planer og strategier og supplerer disse med interviews med byplanlæggere for at forstå udviklingen af grønne tage politikken, barrierer og konflikter og i hvilken udstrækning økosystembaserede tilgange er integrerede i

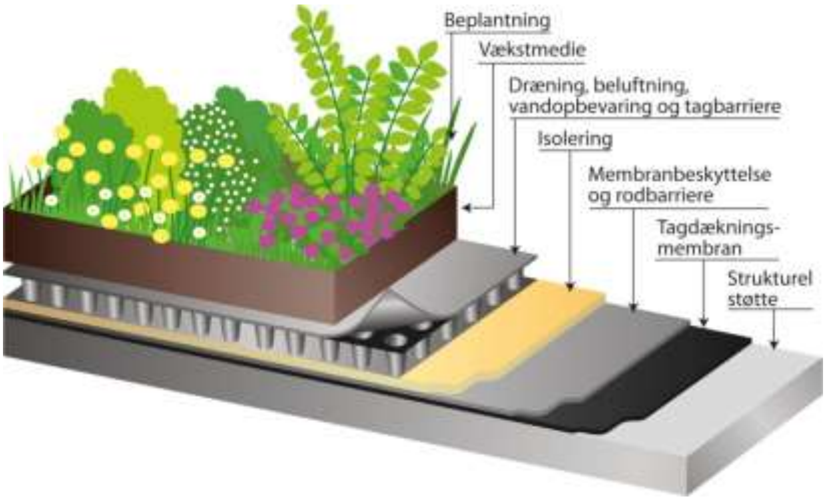
planlægningen og hvilke aspekter vil kunne fremme grønne tage som et habitat der bidrager med en hel række økosystemtjenester i byrummet.

S.1.2 Økosystemtjenester fra grønne tage

Grønne tage har et potentiale til at levere både private og offentlige fordele. De udgør nye habitater på steder hvor der ikke i lang tid har været nogen naturlige habitater (i tilfældet af grønne tage på eksisterende bygninger) eller hvor der indtil fornyligt har været habitater (i tilfælde af udvikling af nye byområder). Grønne tage habitater bestemmes i overvejende grad af mennesker og kræver et vist niveau af vedligeholdelse. Valg af type og dybde på vækstmediet på det grønne tag og i hvor høj grad der skal være adgang på taget bestemmer i høj grad hvilke slags og hvilken kvalitet økosystemtjenester det grønne tag vil kunne levere. Økosystemtjenester fra grønne tage inkluderer **habitattjenester** hvor nye habitater skabes for flora og fauna; **regulerende tjenester** som for eksempel tilpasning til klimaændringer ved at reducere varme-ø effekter; forbedre overfladevand nedsivning; reduktion af klimagas udledning ved at skabe populære grønne mobilitets korridorer for gående og cyklister der fortrænger fossil baseret transport; optagelse af CO_2 i vegetation; eller ved at forlænge tagenes levetid gennem beskyttelse imod nedbrudende UV-stråler; **forsynende tjenester** som fx by-haver hvor frugter og grøntsager kan produceres; og **kulturelle tjenester** ved fx at forbedre livskvalitet gennem forbedrede muligheder for friluftsliv, fysisk og mental velvære, forbedrede ejendomsværdier eller ved at bruge begrønningsaktiviteter til at fremme socialt samvær og inklusion.

S.1.3 Direkte ulemper ved grønne tage

På trods af den potentielle lange liste over fordele ved grønne tage i form af økosystemtjenester de kan levere, er der en række ulemper ved grønne tage som oftest er grunden til at der ikke findes flere grønne tage i dag end det er tilfældet. **Kvalitet af installationen** er en bekymring hos flere aktører, grundet manglende nationale standarder og guidelines, forskning og undervisning og relative få års erfaring i Danmark. Dette er også et udtryk for at grønne tage ikke er EN del af Danmarks traditionelle bygningskultur. **Installationsomkostninger** er en anden hæmsko for en storskala etablering af grønne tage i byer. Forskellige typer grønne tage stiller forskellige krav til bygningsstatik, og dermed udgifter til forstærkning/ændringer i bygningerne; taget kræver den rette forberedelse før de forskellige grønne tag elementer lægges på; og begge dele kræver specifik viden og materialer. **Regulære vedligeholdelsesomkostninger** afhængig af tagtypen kan være fra to gange årlige lugning og fjernelse af blade på ekstensive tage til samme grad af vedligeholdelse som parkanlæg for intensive tagflader. **Interessekonflikter** kan også være en hindring for udbredelsen af grønne tage, fx hvis man ønsker at al høste regnvand fra tag til toiletskyl, vaskemaskiner eller vanding, hvis bygningen ikke kan bære både et grønt tag og solceller uden (endnu) større investeringer, eller hvis anden brug af tag udelukker en vegetation.



Figur S.1 Opbygning af grønt tag.
Grafik: Britta Munter, Aarhus Universitet

S.1.4 Potentiale for retrofit med grønne tage i Københavns Kommune

Vi foretog en enkel analyse ved hjælp af det nationale bygningsregister (BBR) til at estimere det maksimale tekniske potential for grønne tage på flade eller næsten flade tagflader. Det samlede tagareal i Københavns Kommune udgør mere en 1300 ha, hvoraf flade tage udgør 13 % (171 ha). Størstedelen af bygninger med flade tage benyttes til handel og service, transport og offentlig administration (52 %), privat beboelse udgør 16 %, regional og stats ejendomme 15 % og kommunale institutioner omkring 6 %. Hvis vi antog en lignende dækning af grønne tage som i Tyskland (hvor 14 % af alle tagflader er grønne), ville det udgøre omkring 240.000 m² af de flade tage.

S.1.5 Planlægningsaspekter omkring grønne tage i Københavns Kommune

Københavns Kommune begynder at nævne grønne tage i Spildevandsplanen fra 2008, efterfulgt af Klimaplanen i 2009, hvor grønne tage inkluderes som et eksempel på grøn infrastruktur ved klimatilpasningspotentiale. En politik specifik omkring grønne tage blev vedtaget i 2009 og senere integreret i Kommuneplan 2011, i Klimatilpasningsplanen fra 2011 og i Klimaplan 2025 fra 2012. Lokalplaner og kommunale vejledninger har nu grønne tage indarbejdede. Kommunen har sat som mål i Kommuneplanen at den så vidt muligt sætter krav til grønne tage i nye lokalplaner og i deres guideline for miljø i byggeri og anlægs, bl.a. i den udstrækning at det passer ind æstetisk i kvarteret. Det forventes gennem de eksisterende lokalplaner at omkring 200.000 m² grønne tage vil blive etablerede indenfor den kommende årrække. I de eksisterende krav indgår der endnu ikke specificering omkring hvilke typer grønne tage det drejer sig om, hvor stor en andel af de enkelte nye tage de skal dække eller hvilken virkningsgrad de skal opfylde. Der findes ingen direkte finansielle incitamenter som dækker en andel af etableringsomkostningerne. Retrofit dvs. etablering af grønne tage på eksisterende bygninger er ikke omfattet af politikken.

De kommunale politikker i København indikerer tydeligt at der er en voksende forståelse for og accept af tjenester fra økosystemer generelt og omkring de tjenester som grønne tage potentielt kan levere en bybefolkning specifikt. Grønne tage udgør et element i en grøn infrastruktur i de kommunale politikker, som i stigende grad nævner fordele som forbedret æstetik, mere behagelige byområder, optag af regnvand, reduktion af varme i bygninger og i byrum og bidrag til en generel begrønning af byen som led i en mere grøn identitet. Grønne tage flytter i politikkerne fra at være mere end nogle grønne stykker natur i byen til at være elementer der tilsammen bidrager med en række økosystemtjenester der sammen med de øvrige grønne infrastrukturer bidrager til at gøre København en attraktiv by der kan modstå fremtidige negative effekter fra klimaændringerne. Selve termen 'økosystemtjenester' er dog ikke brugt i policy diskursen. Eftersom administrationen anerkender multifunktionaliteten af grønne tage, kan de indgå i flere politikområder end lige omkring klimatilpasning. Grønne tage kan dermed indgå i forbindelse med bydesign og arkitektur, reduktioner af klimagasudledninger, identitet som en Eco-Metropolis og grøn vækst. Dermed passer grønne tage ind i byens koncept for bæredygtighed med vægt på de naturbaserede og sociale dimensioner.

Tabel S.1 Opsummering over katalysatorer og barrierer/konflikter.

Katalysatorer	Barrierer/konflikter
Grønne tage politik er vedtaget og inkorporeret i Kommune Planen. Det viser politisk lederskab og vilje til at fortsætte udbygningen af grønne tage.	Kravene til nye grønne tage indeholder ikke en systematisk kvalificering af størrelse, virkningsgrad eller kvalitet af økosystemtjenester og biodiversitet (andel grønt tag på det nye tag, type grønne tag, vandretentionskapacitet, biodiversitet, æstetik etc.)
Agrotech har etableret et nationalt testcenter for grønne tage som over tid vil hjælpe til at præcisere virkningsgraderne af de forskellige typer grønne tage.	Mangel på nationale standarder og guidelines fører til flg. svagheder: • Københavns Kommune har ingen national forskningsbaseret basis for at stille krav til virkningsgrader i deres politik omkring grønne tage • Københavns Kommune har en svag position i forhandlingerne med bygherrer ang. hvordan de grønne tage skal se ud/virke • Det kommunale forsyningsselskab har ikke tilstrækkelig dokumenteret bevis for vandretentionskapaciteten af de grønne tage, hvilket gør det svært for private beboere såvel som bygherrer at ansøge om at få en tilbagebetaling af regnvandstilslutningsafgiften.
Stigende anerkendelse indenfor de forskellige administrative enheder i kommunen af rækken af fordele og økosystemtjenester fra grønne tage.	Mangel på national forskning indenfor kvalificeringen af grønne tage samt en (monetær) kvantificering af økosystemtjenester og fordele fra grønne tage.
Lille konkurrence omkring brug af plads på tage i forhold til på grundplan i tætte byrum	Nyt tiltag i Danmark med relativt få og kortvarige erfaringer. Blandt civil- og bygningsingeniører en dominerende opfattelse at grønne tage bringer flere problemer end de løser og at de derfor bør undgås Indtil nu udbydes der ingen (videre)uddannelse indenfor grønne tage på danske tekniske universiteter.
Krav om grønne tage i lokalplaner fører til signifikant flere grønne tage, især i nye kvarterer (ca. 200.000 m^2 grønne tage forventes over de kommende år).	Kommunen pålægger bygherrer private omkostninger gennem krav om grønne tage uden at have forskningsbaseret viden om de sociale og offentlige gevinster i Danmark.

S.1.6 Borger opfattelser og præferencer omkring grønne tage

Vi undersøgte borgeropfattelser og præferencer omkring grønne områder generelt og grønne tage specifikt under en 3-timer lang deliberativ værdisætningsworkshop med beboere fra Øbrohus i Skt. Kjelds kvarteret i december 2012. Respondenter blev spurgt om at afgive deres præference for forskellige karakteristika ved grønne tage som de kunne forestille sig på deres egen bygning. Den monetære værdisætning blev foretaget baseret på deres vilje til at acceptere en månedlig huslejestigning for at få et grønt tag som de vil have adgang til.

19 beboere deltog. Processen var bygget op omkring en behagelig ramme med kaffe/te og en velsmagende 3-retters middag. Workshoppen fandt sted i beboerlokalet i et nærtliggende andet alment boligbyggeri.

Den deliberative ramme gør det muligt for den enkelte at bruge sin sociale erfaringsbaggrund i gruppediskussionen, så de individuelle erfaringer bliver en del af gruppens dynamiske diskussion. Det forøgede realiteten af den hypotetiske valgsituation i værdisætningen og desuden åbnede for en læringsproces og dannelse af præferencer undervejs.

Undersøgelsen omfattede en første session hvor deltagerne ikke skulle tage hensyn til hvad de ville betale og en anden session hvor de blev bedt om at angive hvor meget de ville betale som et valg mellem forskellige scenarier. Betalingen var en månedlig huslejestigning for at opnå et grønt tag. Resultater af den kvantitative analyse viser at deltagerne i gennemsnit har en signifikant positiv præference overfor etableringen af et grønt tag på deres bygning under begge sessioner. Den mest foretrukne løsning under begge sessioner var et standard sedum-mos tag kombineret med solceller og hvor der er mulighed for at genanvende overskydende regnvand i/ved bygningen. Under begge sessioner viste analysen ikke nogen signifikante præferencer i forhold til biodiversitet eller semi-intensivt grønt tag. Deltagerne viste sig at lægge nogenlunde samme vægt på tagtype og vandtilbageholdenhed, henholdsvis 53 % og 47 %. Gennemsnitlig månedlig betalingsvilje for de forskellige scenarier varierede fra 145 kr. til 500 kr.

Tabel S.2 Gennemsnitlig betalingsvilje.

Scenarie	Gennemsnitlig betalingsvilje (kr./mdr.)
Standard ekstensivt grønt tag med solceller som tilbageholder 50 % regnmængde og hvor 50 % regnmængde bliver genanvendt i/ved bygning	500
Standard ekstensivt grønt tag med solceller som tilbageholder 50 % regnmængde	358
Standard ekstensivt grønt tag med solceller som tilbageholder 50 % regnmængde	358
Semi-intensivt grønt tag med nytte-/prydhave på tagterrassen og som tilbageholder 50 % regnmængde og hvor 50 % regnmængde bliver genanvendt i/ved bygning	287
Standard ekstensivt grønt tag som tilbageholder 50 % regnmængde	238
Semi-intensivt grønt tag med nytte-/prydhave på tagterrassen og som tilbageholder 50 % regnmængde	145

S.1.7 Konklusioner

Grønne tage er et eksempel på hvordan naturen kan hjælpe os til at tilpasse os de negative følger af klimaændringer og som samtidig giver os en lang række andre fordele der fremmer livskvalitet og bæredygtighed. Menneskeskabte løsninger på klimatilpasninger, kaldt de 'grå løsninger', opfylder til sammenligning oftest kun et formål ad gangen. Når man ønsker at sammenligne de 'grå' og de 'grønne' løsninger på fx klimatilpasninger bør man derfor inddrage alle de forskellige fordele (og ulemper) som de grønne løsninger i form af grønne infrastrukturer og gennemtrængelige overflader også kan bidrage med.

Hvis grønne tage blev implementeret systematisk i stor skala har de potentialet til at bidrage signifikant til bæredygtighed i byer. Men hvis vi ser på de individuelle fordele fra grønne tage såsom regnvandshåndtering alene vil de højst sandsynligt ikke vise sig at være en sund økonomisk investering. Den beregning kan meget vel ændre sig hvis også værdien af større æstetisk værdi i nabolaget, højere ejendomsværdi i bygning, muligheder for friluftsliv og habitater for biodiversitet blev inddraget, således at de ikke-prissatte konsekvenser også bliver medtaget. Derfor bliver man nødt til at tage mange forskellige aspekter i betragtning som kræver tværdisciplinært samarbejde både mellem fagdiscipliner (biologer, ingeniører, arkitekter, planlæggere, økonomer) og administrative enheder (fx HOFOR, Center for Park og Natur, Center for Byggeri, og Økonomiforvaltningen), hvis en systematisk implementering skal være mulig. Private ejere vil opnå nogen af fordelene (fx længere levetid af deres tag eller højere ejendomsværdi), mens kvarteret eller kommunen som helhed vil opnå andre fordele (fx reduceret risiko for oversvømmelse og mindre pres på kloaksystemet) mens samfundet som sådan vil kunne opnå helt tredje fordele (fx biodiversitetsforbedring).

For at opnå en stor-skala systematisk implementering af grønne tage i København på både nye og eksisterende bygninger kunne Københavns Kommune overveje at introducere nye instrumenter og/eller udvide eksisterende: i) **kravet om grønne tage** kunne udvides til eksisterende bygninger (når større investeringer skal foretages) og introduktion af minimum virkningsgrader og minimums størrelse på begrønning i forhold til samlede tagflade; ii) yde **direkte finansielle** incitamenter som delvis kompensation for installationsomkostninger; iii) gøre de eksisterende **indirekte finansielle** incitamenter mere fleksible ved at tillade delvis tilbagebetaling af kloaktilslutningsafgiften; og iv) udvikle **præstationsstandarder** som giver håndgribelige fordele til bygninger med grønne tage i forhold til bygninger uden grønne tage. Københavns Kommune kunne vælge en kombination af disse instrumenter for at skabe grundlaget for en systematisk økosystembaseret tilgang til ikke kun klimatilpasning men også samtidig til de andre økosystemtjenester som gennemtrængelige overflader og habitatskabelse kan tilbyde tætbebyggede byområder.

1 Introduction

1.1 Background

Adaptation to climate change in urban settings is critical for the well-functioning of society and hence the wellbeing and survival of citizens (Bulkeley, 2013). Two trends make adaptation to climate change crucial in urban areas: i) humanity is rapidly urbanising[1] and ii) there are significant technical, social and institutional vulnerabilities due to uncertainties and surprises in climate impacts that cannot be avoided[2]. In addition, there is a significant degree of structural rigidness in urban built environment and infrastructure. Changing the capacity or function of infrastructure or changing the resilience of built environment in order to resist negative climate impacts is both costly, time consuming and disruptive. Large-scale physical adaptation actions in urban areas are therefore not made for short-term solutions nor are they frequently undertaken.

Cities are characterised by denser housing, diversity in the urban population and compact built environment, modifying energy exchanges and hydrological processes. Heat islands lead to higher temperatures in cities than in rural areas, and pavements, streets and buildings lead to a higher rate and volume of surface runoff of rainwater. Additionally, more people are at risk in situations of extreme weather events.

Policymakers and urban adaptation strategies are increasingly accepting and calling for the need to work actively with ecosystem-based adaptation approaches, i.e. nature's capacity to absorb and control impacts of climate change. Using an ecosystem based approach can be more economically, socially as well as ecologically effective compared to focusing exclusively on technical, traditional solutions. However, only few studies have investigated pros and cons of adapting through ecosystem based approaches and the novel approach has yet to be mainstreamed into adaptation strategies.

Brief about Ecosystem Services:

Ecosystem Services are the benefits people obtain directly or indirectly from ecosystem functions such as protection from storm surges, air quality regulation, food, fibre and freshwater. Ecosystem-based approaches to adaptation are defined as 'the use of biodiversity and ecosystem services to help people adapt to the adverse effects of climate change' (Convention on Biological Diversity).

[1] Europe hosts 75 % of its population in urban areas which is projected to grow to 80% by 2020 (EEA, 2011). Across the world more than half of the world population (3.3 billion) now live in urban areas with projections suggesting that by 2050, more than 70 % will base their livelihoods in cities (UNFPA, 2008).
[2] Impacts of climate change include for instance extreme weather-related events, the gradual evolution of the climate that leads to abrupt changes in ecosystems and their services, or the incremental rise in sea-level and coastal erosion.

1.2 Objectives

The main objectives of this pilot study is twofold: i) to investigate the prospects and conflicts of systematically integrating an ecosystem-based climate change adaptation in the municipality of Copenhagen, where we take the case of ecosystem services provided by green roofs and ii) to test the feasibility of conducting deliberative valuation using mixed methods to assess preferences for greening residential buildings and areas. To respond to these objectives, we adopted a dual perspective consisting of the perspectives of governing institutions and of citizens, respectively, and applied a case study methodology which included Copenhagen's use of green roofs in adaptive policy measures as an example of ecosystem services.

Through a deliberative valuation workshop for local citizens, we tested the acceptance of green roofs and preferences towards green solutions as a multifunctional way of adapting to climate change. The type of outcome of the deliberative workshop can help policymakers better understand motivations and wishes of citizens regarding how the city should look like and function. It also provides an indication of the willingness of citizens to contribute privately to a greening of urban areas. We were in particular interested in the following questions:

- What are people's perceptions towards integrating nature in dense urban areas?
- What ecosystem services provided by green roofs are important (if any) to people?
- What trade-offs are people willing to make to obtain (specific) ecosystem services from green roofs?
- How do people trade-off different characteristics of a green roof if they don't have to pay for it and how does this change if they do have to pay for it?

Through policy document analysis of Copenhagen plans and strategies, supplemented by interviews with city planners in Copenhagen, we examined the main question: How are ecosystems services, represented by the example of green roofs, positioned and perceived in urban policies and strategies to adapt to impacts of climate change? This included paying specific attention to:

- How has the green roof policy developed, how is it currently developing, and how is it implemented at present in Copenhagen?
- To what extent are ecosystem based approaches integrated in city planning?
- What are the institutional barriers and conflicts concerning aspects that can promote the inclusion of green roofs as an ecosystem service in the city adaptation policy?
- Which aspects may promote the inclusion of green roofs as an ecosystem service in the city adaptation policy?

By combining policy document analysis, interviews with city planners, and a deliberative valuation workshop with citizens, this study gives an example of how mixed methodological approaches can deliver integrated knowledge of how urban landscapes are perceived and used and what future developments citizens and planners would like to see happen.

The remainder part of the introduction briefly describes green roofs and the ecosystem services they can potentially deliver.

1.3 About Green Roofs and Ecosystem Services

This section provides a brief overview of green roofs and the potential ecosystems services that may be provided through the creation of natural habitats on existing or new roofs. Green roofs are first and foremost a technology that makes use of natural ecosystem functions to obtain a specific functionality and/or aesthetics. It involves the cooperation between disciplines of construction engineering, architecture, landscape architecture, biology, hydrology, and roofing craftsmanship.

1.3.1 Types of Green Roofs

Green roofs are typically categorised into extensive, semi-intensive and intensive green roofs (Prokopp et al., 2011):

- **Extensive green roof** – vegetation is sedum, herbs and grasses with a typical substrate level of 20-200 mm weighing between 60-150 kg/m². Average yearly water retention capacity is around 40-60 % and costs low compared to other types of green roofs. Maintenance is minimal in the order of 5 hours per year to remove unwanted vegetation.
- **Semi-intensive green roof** – vegetation is Grasses, herbs and shrubs. Substrate level varies from 120 mm to 250 mm, weighing from 120-200 kg/m². Average yearly water retention capacity is around 60 % and costs medium. Maintenance is minimal in the order of 5 hours per year to remove unwanted vegetation.
- **Intensive green roof** – vegetation includes lawn, perennials, shrubs and trees like in a normal garden or park. Substrate level varies from 150mm to 400mm, weighing about 180-500 kg/m². Average yearly water retention capacity is from 70 % to more than 90 % and costs are high. Maintenance is high at the same intensity as a ground-level garden.

For all three types of roofs it's possible to combine with access. On roofs with extensive vegetation, paths may be made for passage and dwelling, whereas on intensive roof gardens, grass vegetation may be used for access and dwelling.

1.3.2 Requirements

For green roofs established under local plans, the municipality of Copenhagen sets the maximum limit at 30 degrees. In other countries, such as Germany, experiences and experiments are made with steeper slopes than 30 degrees. There are retrofit examples of green roofs in Copenhagen with slopes steeper than 30 degrees (e.g. Birkegade).

A typical green roof is built up in several layers: drainage, filter and vegetation layer. The drainage layer retains water for times of drought, balances the supply of water and air to the growth medium while protecting the root proof layer from being mechanically damaged. Below the drainage layer, a root and water tight membrane protects the roof. The vegetation layer does not enter into direct contact with the roof material. The vegetation layer depends partly on the depth of the growing medium layer; different solutions exist to the type of growing medium. The larger and heavier the plants, more is required by the building. This may vary from 22mm to more than 500mm.

Denmark does not currently have a set of quality standards or guidelines for establishing green roofs or for assessing the performance of different types of green roofs. A recognised guidance for constructing and maintaining green roofs exist in Germany since 1982, and is periodically updated. The latest version dates from 2008 (FLL, 2008).

Figure 1.1 Build-up of Green Roofs.
Graphics: Britta Munter, Aarhus University.

1.3.3 Ecosystem services provided by green roofs

Green roofs represent a possibility to create new habitats, where there have not been any for a longer period of time (in the case of retrofitting) or in the case of elimination of existing habitats (in the case of developments on green- or brown fields). The habitats on green roofs are almost exclusively determined by humans and require some level of maintenance. Choices as to the depth of substrate matter and hence the type of vegetation that can be introduced on roofs largely determine the type and quality of ecosystem services provided along with consideration of access for people. Potential ecosystem services provided by green roof habitats are not necessarily different from ecosystem services provided by green infrastructures on land. Table 1.1 summarises the wide range of ecosystem services that can be produced from greening roofs. These range from **habitat services** that create new habitats for sedentary and migratory flora and fauna; **regulating services** such as adaptation to climate change by mitigating urban heat islands and improving surface water run-off or climate change mitigation by providing popular walking/cycling corridors across urban areas enhancing opportunities for non-fossil based transport, optimizing solar cell performance or sequestering carbon in vegetation; **provisioning services** such as urban food production;

and **cultural services** including improving quality of life through improved recreation opportunities, physical and mental well-being, enhancing land values or using greening activities to enhance social inclusion.

1.3.4 Disadvantages in establishing green roofs

Quality of installation. In Denmark, the experience from installing green roofs is still limited, as this is not part of the traditional Danish building tradition. Cooperation between different craftsmen, developers, architects and green roof companies is in its infancy. In order for green roofs to function, these need to be installed in completely safe ways by professionals. If a roof is not water tight before the installation of the green roof, the roof will not be water tight; likewise, if the installation of the green roofs perforates the water tight membrane of the roof, the roof will not be water tight either. Due to the novelty of this green technology in Denmark, any roof problems where there is a vegetation layer on top are often blamed on the green roof, whereas the problem may be with the normal roof or with poor craftsmanship (personal communication during interview). Lack of standards such as the German FLL (FLL, 2008) may be to the detriment of large-scale establishment of green roofs in Denmark.

Costs of establishing a green roof. Deciding for a green roof requires a thorough check of the statics of the building to ensure that the additional weight of the green layer is feasible and depending on the age, building code and type of green roof, reinforcement is needed. The green vegetation layer comes with a number of layers that represent the direct costs of the green roof. Depending on the objectives of the green roof, whether it should be a standard solution or should cater for specific needs such as optimizing on biodiversity or on water retention, costs differ.

Regular maintenance costs. Maintenance costs in terms of removing unwanted vegetation and checking drains vary between the types of green roofs. For an extensive green roof a typical frequency of maintenance required is twice yearly during a total of typically 5-6 hours. For an intensive green roof garden, the level and frequency of maintenance is at a level of a ground-floor garden and depends largely on aesthetic wishes.

Conflict of interests: Although the roof areas in urban settings are not subject to intense competition as ground floor areas, there are a couple of potential competitive usages of roof area. Rain harvesting for water used for irrigation of urban vegetation or use in toilets and domestic appliances is one example. Establishment of solar heating or solar cells is another, where costs and/or the static capacity of the building cannot carry both installations. The combination of solar cells and green roofs are, however, often referred to as increasing the efficiency in energy generation as green roofs lower the ambient temperature (e.g. Köhler et al., 2007) and examples are emerging in Denmark, for instance, the new city hall in Viborg.

Table 1.1 Ecosystem services from green roofs.

Habitat services	Regulating services	Provisioning services	Cultural services
Biodiversity/species protection: Creating new habitats for species permeability for migrating species connecting habitats by creating a green corridor /stepping stones	1. Climate change adaptation: mitigating urban heat island effect through evapo-transpiration creating lower ambient temperatures ameliorating surface water run-off to reduce the risk of flooding 2. Air regulation: cleaner air 3. Water management: sustainable drainage systems — attenuating sur-face water run-off through retention and absorption removal of pollutants from water	1. Water provision: Local use of rainwater for watering and/or process water in buildings after due cleansing	1. Recreation, well-being and health: (a) recreation (b) sense of space and nature (c) relaxation (d) physical and mental well-being (e) providing children and young people contact to more green surroundings (f) increase aesthetic experience through changing col-ours of living roofs (g) creates corridors and connections in the city for peo-ple
	2. Climate change mitigation: carbon sequestration encouraging sustainable travel through bik-ing/walking routes on green roofs connecting neighbourhoods optimizing performance of solar cells through a reduced ambient surface temperature decrease energy use in buildings through improved insulation/passive cooling	2. Food production and securi-ty: (a) direct food production on community roof gardens in-cluding honey	2. Land values: (a) positive impact on property and neighbourhoods (b) prolongation of the lifetime of the roof material through protection from UV radiation and reduction of surface temperatures on the roof (c) improves utilisation of area that is already in use
	3. Noise levels (a) reducing noise levels outdoor by absorbing noise waves instead of reflecting these (b) reducing noise levels indoor		3. Culture and communities: (a) local distinctiveness (b) opportunities for education, training and social inter-actions (c) opportunities for increased tourism through a brand-ing of a visually and functionally greener city (d) opportunities for working with and solving social prob-lems

Source: adapted from EEA, 2011.

1.4 About the Potential for Retrofitting Green Roofs in Copenhagen Municipality

We undertook a simple quantification of the potential for retrofitting green roofs in Copenhagen Municipality as a background information to the study. We used the National Building Registry (BBR) to assess the area of Copenhagen municipality covered by roofs. This represents more than 1300 ha or about 18 % of the total area of the municipality of Copenhagen (Total area represents 74,4 km^2). Considering flat roofs (or nearly flat roofs) to be the most cost efficient way of establishing green roofs on existing buildings, we identified some 13 % of the total roof area in Copenhagen (171 ha). Of the total flat roof built area, the majority of buildings are used for commerce, service, transport and public administration (52 %) followed by private housing (16 %), state or region property such as hospitals, prison and military institutions (15 %). Municipal institutions (day care, libraries, sport venues) represent the last part of flat roof built area of 6 %.

To obtain a more detailed knowledge, we focussed on a limited urban area and targeted the neighbourhood of Sct. Kjelds in the eastern part of central Copenhagen. This is also where we carry out the citizen workshop (Øbrohus). Of the total 881 buildings in the neighbourhood, some 34 buildings have flat roofs, representing about 14 % (38.178 m^2) of the total built area.

Figure 1.2 Roof types in Sct. Kjelds Neighbourhood.

1.5 Methods

1.5.1 Deliberative valuation workshop and choice experiment

Deliberative monetary valuation (DMV) is a fairly recent hybrid of economic and political approaches to valuing the environment, which raises the prospect of a transformative and moralising experience (Spash, 2007). It works by bringing together small groups of citizens to deliberate on the economic value of a public good, which can then be used to guide environmental policy (Wilson and Howarth, 2002). There is relatively few empirical analysis of DMV. DMV based studies include valuation of biodiversity (Szabo, 2011), wild deer management in the UK (Austin et al., 2014), wetland restoration (Gregory and Wellmann, 2001), national park management in Australia (James and Blamey, 2004), common pool fisheries in Brazil (Cavalcanti et al., 2010), wild goose conservation (MacMillan et al., 2006); and species conservation measures (Lienhoop and Fischer, 2009).

The background for the development of group-based deliberative valuation technique is an extensive body of literature criticising the theoretical foundations of applying the neo-classical framework of individual utility maximisation to valuing public non-market goods such as biodiversity or climate regulating services (e.g. Wilson and Howarth, 2002; Sagoff, 1998; van den Bergh et al., 2000; Parks et Gowdy, 2013). Concerns exist with regard to the legitimacy of the numbers produced by conventional valuation techniques and the methods (e.g. MacMillan et al., 2002; Spash, 2006; Bateman et al., 2008).

Critiques of conventional non-market valuation techniques (e.g. contingent valuation, hedonic and travel cost) question whether the hypothesis that individuals are sovereign, rational consumers who maximise their utility subject to a budget constraint and hold fixed a priori preferences is well-suited to the valuation of public goods. Evidence and theories from competing approaches suggest that people are not isolated individuals but citizens acting in a political-ethical-cultural context that influences their decisions (Sagoff, 1988).

Attempts have therefore been made to combine conventional stated preferences methods with participatory deliberation under the premise that deliberative sessions can improve valuation methods. DMV is argued to be a method to address in particular two main issues:

- how preferences are constructed (individually a priori formed preferences versus preferences formed through dynamic interaction between people); and
- the concern about the lack of prior information and knowledge concerning the object of valuation (the group setting allows for information input and discussion).

Expected results are increased validity of the resulting data (Szabó, 2011; Bateman et al. 2008; MacMillan et al., 2006), fewer protest answers (Lienhoop and MacMillan, 2007) and a valuation of public good that considers social equity and fairness (Sagoff, 1998; Wilson and Howarth, 2002).

In this study, we apply a two-stage deliberative process where the first stage involves information, reflection and debate and the second stage the preference elicitation. We use choice experiments as the stated preference method. Choice Experiments (CE) is based on neo-classical theory and simulates an ordinary trade situation in the markets where a consumer in a choice situation selects the good that would bring the consumer the highest utility (i.e. satisfaction). The goods are characterised by a bundle of positive and negative attributes[3]. CE makes it possible to estimate the average preference for each of the selected attributes and for the levels of the attributes compared with one another. It also allows for a ranking or a monetary valuation of the different alternatives compared to each other.

[3] An example of a choice situation could for instance be when purchasing a car. Attributes that influence the choice of car purchases include price, fuel efficiency, size, colour, brand etc. where each attribute has different levels (e.g. different levels of fuel efficiency).

Our workshop set up follows the mixed-method approach of Austin et al. (2014). The deliberative process was constructed to last 3 hours and included a three-course dinner as compensation for the time and energy spent by the respondents, and to further motivate their engagement with the issues. The outline of the workshop is described below. Discussions and questions naturally arose during the information input sessions.

Welcome and introduction to the workshop	
[Coffee & tea]	
PART I - Warming-up	Inquiry into participant's views on i) what are the main barriers to greening your neighbourhood and ii) what would you like to see happen if you had a wild card to green your neighbourhood? Participants were asked to write max. 10 words on each of these two topics and state this to the rest including their name and how long they had lived in Øbrohus
PART II – General information & discussion	Information input to the role of green urban spaces for urban dwellers Information input to climate change challenges in urban areas and examples of green infrastructure solutions Information input on green roofs – what do they look like, how do they function and what are the pros and cons of green roofs
[First course]	
PART III – Øbrohus visualisation and CE	Visualisation of green roofs on Øbrohus and introduction to CE survey First part of CE survey incl. facilitation
[Main course]	
PART III – Øbrohus visualisation and CE	Second part of CE survey incl. facilitation
[Dessert]	
PART IV – wrapping up	Debriefing and evaluation

Figure 1.3 Workshop Outline.

1.5.2 Policy document analysis and qualitative in-depth interviews

In the study, we used a qualitative approach to examine the perspective of local governance, in particular of Copenhagen Municipality, on including ecosystem services. We chose qualitative methods in order to produce data on the meaning and perceptions of key institutional actors who have experience with policies where ESS and potentially green roofs would be relevant (Denzin and Lincoln, 1998). In addition, with a qualitative methodology we also include a critical potential in the analytical design (Alasuutari, 2010; Sharp and Richardson, 2001). The aim was thus to gain access to the relevant representations rather than producing a representative overview (Kvale and Brinkman, 2008) of the perception and inclusion of green roofs/ESS in Copenhagen or in (Danish) cities.

Data for the analysis was produced through policy document analysis to identify the position and role of green roofs in Copenhagen adaptation policy across areas, supplemented by qualitative in-depth interviews to further specify the meaning of key aspects of the policy discourses on ecosystems services, climate adaptation and green roofs, and to probe into details and ambiguities of the policy documents. Furthermore, the combination of several qualitative methods for data production served as triangulation, ensuring the robustness of the findings (Bowen, 2009).

Policy document analysis is a form of document analysis (Bowen, 2009) and focusses on policies as these are represented by policy institutions in public and semi-public texts. Policy documents thus rarely if ever express the perceptions and position of a single policy actor but rather of the institution that develops and implements policies. Policy document analysis reveals ways in which policies emerge as political actions in the text and elicits the sometimes blurred and/or implicit governing logic of the policies (Packer, 2010), including the stated causal relations, intervention and relations to other policy measures/areas that constitute a policy (Andersen, 1994). Being a text analysis that includes political documents, the policy document analysis may moreover identify tensions and contested issues within and between governing actors and institutions (Sharp and Richardson, 2001), as well as drivers as these are seen (identified/addressed) by the governing institution.

The initial step in a policy document analysis is the compilation of an archive that comprises the relevant policy documents (Sharp and Richardson, 2001). We include Copenhagen policies that address climate adaptation and green roofs, identified through a web search among the documents issued by Copenhagen Municipality, through our interviewees and through internal references in already included documents (snowballing).

We analyse the texts through content analysis and coding (Bowen, 2009). The initial content analysis (Fereday and Muir-Cochrane, 2006) establishes an overview of how green roofs are represented, in which policies green roofs are considered, and of which ecosystem services green roofs are acknowledged to deliver with respect to urban climate adaptation. In addition, we note when issues not anticipated in advance have a recurring or strong position for the policy institutions understanding of green roofs/ecosystem series in relation to urban climate adaptation (Kvale and Brinkmann, 2008).

The coding process consists of a return to the texts where a set of predefined categories are identified through a meticulous re-reading. The categories are chosen to represent key aspects of the object of study (Kvale and Brinkmann, 2008), i.e. of barriers and enablers for green roofs and ecosystem services in urban climate adaptation. We follow a framework of logic of intervention, i.e. how is the policy issue perceived and established as a problem of policy, which policy is anticipated to address it at what benefits and costs, and who are anticipated to be policy actors in this and who are subjects of the policy (Andersen, 1994; Jensen, 2006):

- Perception of green roofs
- Ecosystem services of green roofs
- Other benefits of green roofs
- Significance for adaptation
- Policy actors
- Policy subjects
- Conflicting areas/costs
- Justifications

As policy documents are political statements, the document analysis in general only reveal the excluded positions by their absence. Moreover, the more specific details and nuances of significant issues and themes are often omitted from the text. Thus, we also conduct qualitative interviews with three policy makers who are central to the development and inclusion of green roofs as an example of ecosystem services in the Copenhagen climate adaptation policy and planning.

Qualitative in-depth interviews are useful to reveal the experience of people and the meaning that people make of these experiences, in particular contexts (Knox and Burkard, 2009). In our case, the interviews enable us to gain access to the experience of people who work with the object of investigation in practice, i.e. with climate adaptation and/or green roofs in urban planning. As green roofs in climate adaptation and ESS are recent phenomena in Danish urban planning, we furthermore take advantage of semi-structured and open-ended interviews attuned to the interviewee in his or her context (Kvale and Brinkmann, 2008) as a municipal planner. In line with Kvale (2008) we focus on the dialogue on subjects that inform our study rather than following a pre-defined set of questions, making space for potentially unexpected issues related to the topics we investigate.

The interviews are thus guided by a general interview guide that we adapt to the individual interviewee, in order to allow for the context specific setting of the interview (Kvale and Brinkmann, 2008). Inspired by multiple interview approaches (Knox and Burhard, 2009), the interviews follow in general a three step progress. The first step consists of the interviewee positioning him or her-self in relation to the institution which she or he represents and to the topics of the interview. In the second step, the interview focuses on the experiences of the interviewee relevant for the topics of the interview, while the third step probes into the (institutional) meanings that the interviewee ascribed to key issues and instances (themes, events, instances, relations). Of course, in practice the three steps greatly overlap and the line between them is blurred. Following the analytical process of the document analysis, we analyse the interviews through content analysis and to some extent through coding.

Our object of study is the inclusion of green roofs and the acknowledgement of ecosystem services in urban climate adaptation which in our case is an emerging policy area and approach, and we are interested in instances of conflicts. The interviews thus also serve as a source of information on the history and the progress of measures that included green roofs/ecosystem services in the urban policy development.

2 Planning aspects of green roofs in Copenhagen

The analysis presented in this chapter is based on the policy document analysis and the qualitative interviews with urban policy makers and planners introduced in section 1.5.2. In these two forms of data generation, we focus on the following issues, which inform the analysis of the position and inclusion of green roofs as an ecosystem service in the planning of Copenhagen:

- Perception of green roofs
- Ecosystem services of green roofs
- Other benefits and potential disadvantages of green roofs
- Significance for adaptation
- Policy actors
- Policy subjects
- Contested issues related to green roofs
- Justifications

In the next section, the chapter outlines the history of green roofs as an issue of planning in Copenhagen with a focus on the policy areas where green roofs are perceived to play a role. In the subsequent section, the perception and position of green roofs in the policies of these areas are discussed, followed by an overview of the policy actors and the role of residents and other stakeholders in developing the green roof policy issues and implementing them, and of key technical and financial issues of implementation. The final sections of the chapter discuss how green roofs are positioned in Copenhagen's climate adaptation policy and what are the enablers and barriers for making further use of green roofs in urban climate adaptation planning. The chapter is summed up in a concluding section.

2.1 Introduction of Green Roofs in Urban Policies

In the Municipality of Copenhagen, green roofs as a planning issue have a relatively short history. During the 2000s, attention to different measures to dispose of rain water locally increased and the Waste Water Plan 2008 included green roofs as an example of the benefits of green infrastructures (Copenhagen Municipality, 2008a). In 2009, the city published its Climate Plan and outlined a general approach to climate issues in the city (Copenhagen Municipality, 2009). At the time, climate adaptation was treated as a sub-field of mitigation and thus constituted one among several focus areas where green and blue urban spaces, i.e. potentially delivering multiple ecosystem services, were included or presented as relevant.

The then upcoming UNFCCC COP15, the aim to develop and brand Copenhagen as a green metropolis, the start on a strategy for climate adaptation and the political agenda to create a greener city led to an agreement by the board of directors and the mayors to go for a green roof policy in Copenhagen, coined by one interviewee in the reflection of the Technical and Environmental Department at time that 'How can we create a greener city that has already been developed? We can look up and create here both a visually and functionally greener city' (urban planner, Technical and Environmental Department, 2012).

In May 2010 the City Representation decided that all new buildings with a slope below 30 degrees should to the extent possible have green roofs. This strategy is now embedded in the urban greening approach of the 2011 Municipality Plan (Copenhagen Municipality, 2012a), the Climate Adaptation Plan (Copenhagen Municipality, 2011) and the Climate Plan 2025 (Copenhagen Municipality, 2012b). Based on the greening approach of these plans, requirements for green roofs are incorporated into local plans to the extent that green roofs are acceptable in terms of aesthetics and capacity of fitting in with the existing buildings. In addition to this, green roofs have been incorporated in various guidelines such as the Environment in Buildings and Development (Copenhagen Municipality, 2006). The Cloudburst Plan (Copenhagen Municipality, 2012c) addresses exceptionally heavy rains and green roofs are not specified as measure to manage these.

To date, some 30 locations in Copenhagen, part new developments, part retrofitting, have installed green roofs of varying size and type. These include iconic architecture such as the 8-Tallet (the Figure 8 building) in the Ørestad neighbourhood, the National Archives by the harbour front (where the municipality created a novel multifunctional use of space for parking below and intensive/semi-intensive green roofs above open for pedestrians, bikers, skaters and cyclists included the green roof in the green cycle track system, thus merging multiple green initiatives in the city), and also on existing private housing such as the 'Birkegade' project. Other examples of where green roofs have been incorporated into local plans so-far include the local plan for the city development of the North Harbour, the new Carlsberg neighbourhood and the local plans for 'Kalvebodbrygge'. In the medium and short run, planners estimate that *'based on the assumptions of new developments in the local plans since 2010, an estimated area of 200.000 m^2 green roofs should be established over the coming years on new buildings'* (Municipal planner, 2012).

Some other 7 locations are currently under development[4]. Although the municipality plan requires the implementation of green roofs on all new buildings with a slope below 30 degrees, there are no requirements as to the performance, size and quality of green roofs. For existing buildings, there are currently no requirements for establishing green roofs nor are there any targeted support mechanisms available for green roofs.

2.2 Perception and Position of Green Roofs

To understand how green roofs are integrated in planning strategies and plans for climate adaptation in Copenhagen, it is necessary to approach green roofs at two levels. Firstly, green roofs are integrated in the overall strategic approach based on using green and blue infrastructure to develop the city as an attractive, healthy, vibrant and cosmopolitan metropolis of the future, or as it was termed in the seminal 2007 urban vision, and 'Eco-Metropolis' that is the 'Climate Capital of the World' (Copenhagen Municipality, 2008b). Secondly, and more directly, establishment of green roofs is a concrete initiative that people encounter when moving around the city and which offers benefits to the city, e.g. water retention, recreation and urban habitats, and which is preconditioned on specific factors, e.g. technical requirements and funding.

[4] See following site for a list of sites: http://www.kk.dk/da/Om-kommunen/Fakta-og-statistik/Fakta-om-Koebenhavn/Groenne-tage.aspx

In the first aspect, green roofs are but one aspect of urban blue and green structures, and a longer history prepared the ground for the introduction of green roofs as an ecosystem service based element of the urban strategy and the strategy for climate adaptation. By the late 2000s, this perception specifically articulates services connected to a greening of the city, where for example 'Copenhagen's green structure is emphasised as a major preventive instrument, as green initiatives can have a broad a multifaceted impact. Experience in other countries and research projects emphasise using the green infrastructure of the city preventively…[and] that greening of the city's surfaces is an effective way of lowering the city's surface temperatures and contributes to reducing the urban heat island effect' (Copenhagen Municipality, 2011:43), and require 'that construction and open spaces are designed in such a way as to make sustainable urban drainage systems (SUDS) possible. The aim of sustainable urban drainage systems is to relieve the load on the sewer system and reduce the risk of floods and water damage. It may entail green roofs that can delay the storm water in reaching the sewer' (Copenhagen Municipality, 2011:72).

Urban policies thus also integrate green roofs in the general establishment of urban green and blue structures as a stated component in the development of the city and green roofs are often mentioned as examples when the benefits of green cities are discussed: 'When Copenhageners establish green roofs on their buildings, this will retain rain water while increasing the number of green spaces of the city[5]' (Copenhagen Municipality, 2012b:12)

The overall and dominating urban strategy of Copenhagen matured during the 2000s, and was coined in the urban vision *The Eco-Metropolis* (Copenhagen Municipality, 2008b) which reflects and is reflected in the urban plans 2009 *The Thinking City* (Copenhagen Municipality, 2010) and 2011 *Green Growth and Quality of Life* (Copenhagen Municipality, 2012a). It articulates green and blue elements as central elements in the reinvention of Copenhagen as a post-industrial cosmopolitan city of the future. The strategy centres on articulating a specific *urban identity* as a tolerant, global, mobile, diverse, sustainable, active urban setting for businesses and as a place that has distinct focus on enhancing the conditions for a pleasant, active and healthy diverse everyday lives; on establishing *green growth* based on knowledge intensive innovation and clean-tech as the motor of urban development and Copenhagen as an attractive and distinct urban place that invites citizens as well as businesses to locate; on further development of *green and blue spaces* to make the city attractive and sustainable, to promote liveable spaces in the dense city and spaces for being mobile and active and for recreation as well as to utilise urban nature to manage environmental problems such as air quality, climate changes and noise (Jensen et al, 2013). The 2011 Municipal Plan coins turning major challenges of climate change into opportunities as a central element in the overall approach of the urban strategy, and moreover targets a greening of the city as a basic element in future developments towards a city with 'green growth and quality of life' (Copenhagen Municipality, 2012a).

At the *concrete level*, green roofs are increasingly articulated to offer a range of benefits to the city and its citizens. These include not only climate relevant services of rain water retention, insulation, reduction of heat islands, im-

[5] 'Når københavnerne laver grønne tage på deres bygninger, opsuger det regnvandet, og samtidig øger det antallet af grønne områder i byen'

proved urban air quality (less polluted), but also cultural services related to enhancing the aesthetics, increased amiability and better atmospheres of urban spaces, stress relief and adding to a general greening of the city. Recreation is not articulated in connection with green roofs but often in relation to green and blue spaces/structures.

Especially the Climate Adaptation Plan lists a number of ecosystem services provided by green roofs when these are presented as a specific measure in Climate Adaptation. These services of green roofs are not conceptualised or labelled as ecosystem services, but listed as benefits of green roofs. The way these benefits are articulated and the types of benefits included do however fall within the conceptualisation of ecosystem services. The ecosystem services mentioned include rain water retention (of up to 50 per cent of annual average rain water flows), reducing heat island effect, reducing energy use in buildings, increasing respiration of water in the city, cooling of buildings, binding dust and CO2, and providing habitats, and potentially also recreation (Copenhagen Municipality, 2009:110).

Furthermore, a broad idea of the potential benefits appear to have evolved in the Technical and Environmental Department, which is articulated to a limited extent in the policy documents and much stronger expressed by our interviewees. This broad idea encompasses seeing green roofs as a possibility of creating at the same time a visually and functionally greener city with the potential for a wide range of multi-functional benefits, such as recreation, community gardening, transport connections, habitats for biodiversity, water retention, outdoor cooling effects and parking lots/other usages below. Green roofs are in addition recognised by city planners to pose a potential role in creating public spaces on private business areas, linking neighbourhoods while creating green corridors for fauna, plants and humans. It has been put in practice in places where planning clearly has failed in creating a nice environment for people to dwell in.

2.3 Policy Actors

The policy documents furthermore present the establishment of green roofs as an initiative that is based also on other actors being active, in particular developers, while the interviewees acknowledge funding and technical specifications as issues that need to be considered.

In the Climate Adaptation Plan, landowners and building owners are specifically articulated to have a necessary role for implementation of local rainwater management solutions, including green roofs which specifies that the responsibility for '[p]rotecting building and private service pipes for sewers and water supply will be .. individual' while it remains 'a public task to protect central and local government properties, including the municipal pipe network' (Copenhagen Municipality, 2011:50).

Moreover, at the Technical and Environmental Department, planners experience '*a clear demand for financial support towards green roof retrofitting, especially from housing associations. We could initiate a lot more by introducing some sort of a support fund over 2 to five years*' (urban planner, Technical and Environmental Department, 2012).

2.4 Implementation Issues

The municipality does not have a set of standards or guidelines for private citizens or developers who aim to establish green roofs on existing buildings or on new buildings. The Technical and Environmental Department provides however guidance when contacted.

Private landowners, housing associations and tenants may apply for direct co-funding for green roofs through the City Renewal Fund [Byfornyelsesfonden]. However, this is not dedicated to green roofs and competes with applications for renewal of e.g. inner yards and buildings.

Indirectly, financing of green roofs may be possible if stakeholders can provide sufficient documentation that the private parcel decouples rainwater from the sewage system. The utility company (Copenhagen Energy) can then repay the costs of connecting to the sewage system. This is coined by an urban planner who reflects that 't*he Municipality believes that the indirect support through repayment of connection costs is a strong policy measure. It will provide a boost in the implementation of green roofs and thereby also provide practical experiences with green roofs. When demand increases, it becomes a driving force for innovation in this area'* (Urban planner, Technical and Environmental Department, 2012).

2.5 Significance for Climate Change Adaptation

The Climate Plan (2009)[6] and the Waste Water Plan (2008) focussed on expanding the capacity of the waste water infrastructures for handling extreme rains (up to 10 year rains (Copenhagen Municipality 2009:106)) though a 'massive expansion of the capacity for storage and flow' for waste water, the plans also represent a rather fundamental change: Local handling of rain water is introduced as a principle that increases in significance and the Climate Adaptation Plan (2011) stresses that '[g]reen roofs and walls are highly effective and do not take up space. They are therefore particularly beneficial in the densely populated areas of the city and in areas that feature hard surfaces' (Copenhagen Municipality, 2011: 60) where green roofs as part of a green network reduce the risk of urban heat islands and flooding.

Green roofs appear in the initiatives as an element in local rain water management measures and to manage the heat island effect where for example The Climate Plan 2009 considers regulations that include local rain water management and 'establishment of green roofs and facades' (Copenhagen Municipality 2009:107) and which specifies green roofs and other green infrastructure with a potential for retention of rain in building regulations.

Apart from providing a concrete measure for sustainable urban drainage of rain water, green roofs are also articulated to be among the green and blue elements of urban development that enhance city spaces: 'A climate-proof and greener Copenhagen is a city with more trees, green roofs, green and blue spaces and a city that as well as being able to tolerate the weather of the future is also rich in nature experiences and options for outdoor activities' (Copenhagen Municipality, 2011:58). Green roofs are thus presented as a

[6] The 2009 Climate Plan is primarily focussed on reducing greenhouse gasses while climate adaptation is a section addressed in the plan. By 2012, when the latest Climate Plan was published, several urban plans addressing climate adaptation such as the Copenhagen Climate Adaptation Plan, the Waste Water Plan and the Cloudburst Plan had either been published or were in preparation. Thus, in the 2012 Climate Plan, climate adaptation was only mentioned briefly in relation to making the city a green, secure and pleasant place to live, and green roofs were only mentioned once, as an example of urban greening that serves climate purposes and enhanced liveability through more pleasant urban spaces.

habitat that has the potential to provide additional services to local rain water management. Among some planners, the greening of municipal planning is intimately linked to sustainable development. Green roofs are seen as a part of this greening of the city, bringing far more benefits than only climate adaptation.

2.6 Enablers

In the 2009 Climate Plan, the municipality considers green roofs as an element of what is articulated as ′greening′ og urban development. The ‘greening’ approach builds to a large extent on viewing the ecosystem services of urban nature as reducing costs or adding value in connection with specific planning initiatives, though the greening is not elaborated as an ecosystem service. Specifically in relation to rain water retention and in relation to urban heat islands, the plan articulates services of the urban green infrastructures. Green roofs are mentioned as a possible option under the focus area of Urban Development which is cost inefficient and which is more relevant for the focus area of Climate Adaptation: ‘vast initiatives to promote green roofs in all urban development areas (with a potential of more than 300,000 m^2 of green roof) does not yield a reduction of CO_2 above 200tons per year in 2015 and…the price per reduce ton CO_2 is very high. The main climate benefit of greening the city is in connection with climate adaptation’ (Copenhagen Municipality, 2009:94).

The greening initiatives are closely related to the municipal adaptation strategy, coined in statements like a ‘greener Copenhagen is a climate-proof Copenhagen’ (Copenhagen Municipality, 2011:57), and in a focus on adaptation initiatives that also serve other purposes, in particular that it supports the purpose of ensuring ‘that climate adaptation measures at the same time represent quality in themselves for the city’s people and businesses’ (Copenhagen Municipality, 2011:8). Green roofs associate with the green infrastructures and appear often as example of an adaptation measure that also benefits the general quality of the city, through a ‘greening’ of urban spaces. The emphasis placed on the wider benefits of green infrastructures makes space for expanding the role and position of ecosystem service measures such as green roofs as these support a more liveable Copenhagen, taking advantage of that ‘[a] climate-proof and greener Copenhagen is a city with more trees, green roofs, green and blue spaces and a city that as well as being able to tolerate the weather of the future is also rich in nature experiences and options for outdoor activities’ (Copenhagen Municipality, 2011:58).

Moreover, green roofs fit well with the stated focus on flexible planning approaches of the adaptation strategy (Copenhagen Municipality, 2011:9), that can enable new knowledge and novel elements to change the strategy as it develops and furthermore leaves space for experiments. The neighbourhood of Sct. Kjelds is an example of the way that Copenhagen works with flexible and experiential planning approaches based on multiple benefits of adaptation measures. However, in parallel with the low attention paid to the technical requirements of green roofs and the lack of standards within the area, the policies display a potential role for green roof initiatives. Policy documents represent these initiatives, including the greening aspect of green roofs, in relation to the municipality’s stated priority to develop and use a flexible planning approach in the development of climate adaptation measures for Copenhagen.

2.7 Barriers and Conflicts

Barriers and conflicts concerning present policy issues are rarely reflected in the policy documents. This section is thus largely based on the interviews that were conducted with urban planners.

Firstly, the evident lack of national guidelines and technical standards for green roofs constitute a barrier, in particular when reluctant developers or self-motivated citizens turn to the municipality for assistance, coined in the reflection of an urban planner: '*Copenhagen has kick-started a development on green roofs…before research institutions got started. We started before having guidelines and documentation in place…if we had chosen that route we would be 5 to 6 years delayed.*' (Urban planner, Technical and Environmental Department, 2012).

Despite a green roof policy and the integration of this policy into the municipal plan and local plans, the decision on the practical implementation of green roofs on new buildings are subject to negotiations between the municipality and the developers. Currently, there are no requirements or guidelines on the type of green roof or on the size of green roof needed to obtain a specific quality in ecosystem services such as biodiversity, rain water retention or community/access/recreation etc. At the same time, the requirements for green roofs in new local plans pose additional costs to developers who have an ingrained interest in reducing costs.

Related to this, and due to the lack of research on the performance of different types of green roofs in Denmark, there are no standardised indicators or documentation of how much rainwater green roofs may absorb and under which conditions. This makes it difficult when developing new buildings or retrofitting existing roofs to obtain a deduction in the costs of connecting to the sewage system because they need to document and argue with the municipal utility company on the amount of reduction of water to the sewage system, illustrated by the reflection of a planner that '*there is a need to build capacity of civil servants in dialogue with developers on local plans as the developers naturally ask: why do I need to invest in this?*'.

Another barrier for green roofs is the lack of systematic research in Denmark on green roofs and the developments of standards. "*The Municipality co-sponsors a Ph.D. student who is about to start at University of Copenhagen, but many more are needed*". Agrotech is finalizing a 3-year research on the technical capacity of green roofs and has started a testing centre for green roofs. Danish Technical University (DTU) however, has not entered the playing field yet. "*The development of standards for green roofs is essential*" such that they can be integrated in the specifications of building requirements. These could be inspired by the German FLL guidelines (FLL, 2008), which have been developed through 30 years. And which inspire many other countries.

Secondly, the decision to make a green roof policy for Copenhagen was questioned internally at the Municipality, as other areas did not have a specific policy while being part of the general plan. However, a green roof policy is perceived a benefit because:

'*if we can attribute this to a political decision, then you can simply draw that card and stand stronger in the argumentation. We have no problems in arguing for green roofs, but a policy shows a political leadership that this is what we want*' (Urban planner, Technical and Environmental Department, 2012).

Thirdly, and inspired by other metropolitan cities in Europe which have far more green roofs than Copenhagen, the future developments of the green roof policy is however articulated as dependent on municipal leadership:

'Strong leadership is essential in keeping the focus on green roof implementation during negotiations [with developers]. There is a reason why some cities are simply further ahead….Copenhagen/Denmark is 30 years behind…. Strong leadership has been the basis for green roof developments in Stuttgart with 2 million m² green roofs, in Chicago, Philadelphia, Portland, New York and Singapore' (Urban planner, Technical and Environmental Department, 2012).

And: '*The extent to which green roofs will play a role in the North Harbour depends on how firm Copenhagen stays with what it has stated through its local plan; it depends on a strong continuous leadership'* (Urban planner, 2012).

Fourthly, the municipal plans on waste water, climate mitigation and adaptation are located in another Centre of the administration than the Centre where the green roof policy is negotiated and implemented. Differences in perceptions of what green roofs contribute with to the city vary between the two centres and physical separation between the Centres makes day-to-day exchange and support less than optimal. *"The Centre implementing the green roof policy is very positive towards it but is subject to external pressure and opposing interests.".*

Fifthly, collaboration between the municipality and the utility company on the treatment of waste water has further led to a division of responsibilities: while surface water is the responsibility of the municipality to manage, water flows below the surface are the responsibility of the utility company. Households establishing measures for local management of water can receive a one-time reimbursement of the connection fee to the sewage system if they can provide adequate documented effects of the measures. The utility company defines what constitutes sufficient documentation. However, *'the utility company is very sceptical towards green roofs and has in the past stated that these roofs have no performance with regard to rain water retention'* (Urban planner, Technical and Environmental Department, 2012).

One of the main barriers of getting green roofs off the ground as experienced by the interviewee are preconceived attitudes by building engineers from the Municipal utility company that green roofs *"can do no good for rainwater detainment".* A testing of one type of extensive roof over one year in Copenhagen represents the basis for concluding this, whereas studies of green roofs in other countries test different types of green roofs, different types of vegetation and substrate layer, different slopes and this over several years. The interviewee has experienced that the case for green roofs falls on a fundamental theorem in engineering schools that *"all water should be kept away from buildings, whereas green roofs retain or soak water"*. In order for green roofs to take off in Denmark, according to the interviewee, this fundamental theorem would need to be revisited because without building engineers, this technology will never take off. *"Thinking new ways is exactly necessary if we are to plan for a sustainable climate adapted city development, where water is a resource and not perceived as a waste problem."* The German FLL guidelines.

Finally, through the requirements in the local plans to implement green roofs, the municipality imposes additional costs on investors and developers. These negotiate the local plans with the municipality and naturally ask for reasons as to why they should invest in green roofs. The Municipality would also stand more strongly in this dialogue with evidence on the wider economic benefits of green roofs.

2.8 Summary

In this chapter, we have investigated the position and role of green roofs in policies adopted in the municipality of Copenhagen, in particular policies addressing climate change and other policies of urban development that consider green infrastructures and/or green spaces.

Overall, policies from 2008 and onwards represent a growing recognition of ecosystem services in general and of the services that green roofs offer an urban population in particular, though the term ecosystem services is absent from the policy discourse (policy documents as well as among the interviewed policy makers). Along with development of the policies to address the city's overall strategy of climate adaptation, the acknowledgement of green roofs and related ecosystem services progress and become more specified. This is also shaped by the growing experiences with increased rains and flooding as actual impacts of climate change. This development is illustrated by the fact that in the latter documents, the municipality includes more specific estimates of the capacity for three types of green roofs for rain retention, and is reflected in the general push for all new buildings with roof slopes less than 30 degrees to establish green roofs and an objective of 200,000 m^2 of green roofs on new buildings. In the plans of the municipality, however, measures, standards and initiatives are not very specific while green roofs are often mentioned as examples of a greening of the city or of the benefits (aka services) of urban nature.

Moreover, green roofs constitute an element in urban green infrastructure that are increasingly articulated to provide a range of services to the urban population, including aesthetics, more pleasant atmospheres of urban spaces, rain water retention, reduction of heat in buildings and urban spaces and adding to a general greening of the city and a greener urban identity. Thus, green roofs move from 'merely' providing patches of urban nature to offer a range of benefits, which in combination are anticipated to make green roofs – as one among several green infrastructure elements – an asset of the future city. Likewise, green roofs are perceived to offer services that will manage some of the future rains and in combination with other climate adaptive measures prepare the city for the impacts of present and future climate changes.

The acknowledgment of the diversity of ecosystem services provided by green roofs (and also other green infrastructure) makes it possible that green roofs can be considered in relation to other policy areas than climate adaptation, such as climate mitigation, urban design and architecture, common urban identity as an Eco-Metropolis and green growth. Most of these services reflect the city's conceptualisation of urban sustainability, with emphasis on the natural environmental dimension and the social dimension. Providing more than one service reduces the vulnerability of green roofs in urban development; if developers for budget reasons exclude green roofs from the project, it is not only the aesthetics or water retention that is omitted but a larger range of benefits.

At a planning strategic level, the city acknowledges the complexity and uncertainty linked to climate change and includes green infrastructures in experiential and strategic planning aimed at enhancing Copenhagen's adaptation to climate change. This dimension also includes green roofs as an 'easy' measure that potentially has appeal to citizens, and is perceived to add to the strategic development of the city towards a flexible future governing.

The planning institutions furthermore articulate a joint ownership and responsibility for increasing the amount and quality of green roofs in Copenhagen. Especially urban developers and municipal planners are perceived as key policy actors that can push green roofs, while citizens are more implicitly assumed to desire green roofs and, potentially, maintain them. Table 2.1 below summarizes the types of enablers and barriers for green roofs in Copenhagen Municipality.

Table 2.1 Summary of enablers and barriers for green roofs in Copenhagen Municipality.

Enablers	Barriers/conflicts
Green roof policy has been established and implemented showing political leadership and will to continue	No qualification of the performance of required green roofs (size of green roof compared to building ground plan, type of green roof, water retention capacity, biodiversity, aesthetics etc.)
Agrotech establishing a test-centre for green roofs will over time help clarify performance of different types of green roofs	Lack of national standards and guidelines : Copenhagen Municipality has no national basis for making performance requirements within their green roof policy Copenhagen Municipality has a weak position in the negotiation with developers on the specificities of green roofs Municipal utility company has insufficient documented evidence of the water retention capacity of green roofs, making it difficult for private housing owners and developers to apply for a refund of rain water connection to the sewage system
Growing recognition within the different administrative units of the Municipality of the diverse benefits and ecosystem services provided by green roofs	Lack of national research into the qualification and (monetary) quantification of the ecosystem services and benefits provided by green roofs
Little competition for space in dense urban areas compared to ground level	Novel measure in Denmark with yet relatively few and short term experiences Among civil and building engineers a dominant perception that green roofs offer more problems than they solve and should therefore be avoided No education currently offered at Danish engineering universities on the construction and workings of green roofs
Requirement of green roofs in local plans lead to substantial implementation of green roofs in particularly new neighbourhoods (ca. 200.000 m^2 green roofs expected over the coming years)	Through requirements on green roofs on new buildings, the municipality imposes a private cost on developers with no Danish research on the subsequent social benefits

3 Citizen views and preferences regarding green roofs

The pilot deliberative valuation workshop took place close to the Øbrohus building and hosted a total of 19 participants living in Øbrohus. Øbrohus is a community housing project owned by AKB, a non-profit housing organisation and administered by KAB, a large non-profit housing organisation administrating some 50,000 homes in the larger Copenhagen region.

The main building of Øbrohus is 10 floors high with an architecture dating from the 1960s meaning that alterations need to be approved not only by the City of Copenhagen Building Authority but also by the head city architects. There is a very active board of tenants that organises activities for residents such as excursions, flea markets, breakfast and Christmas gatherings. It is also active in developing the building, such as an elevator accessible 300 m^2 roof terrace established in 2009-2010 on the 11th floor. This development was part-financed through a monthly rent increase of 50-71 DKK depending on the size of the apartments. Any decisions to make alterations in the building need a unanimous agreement from board meetings. About 2,5 years ago, the board of tenants proposed and received unanimous consent during a general assembly to develop a master plan for the housing unit comprising of regeneration and energy efficiency measures, renewable energy generation and local rain water management, hereunder the prospects of establishing a green roof. The process of developing the master plan is still on-going and no external funding has yet been secured or granted. Øbrohus consists of four buildings, of which two are apartment block with 200 and 45 apartments, respectively; the other two buildings are occupied by businesses.

3.1 The deliberative as a social context for making informed decisions on valuations

The deliberative valuation was conducted as a workshop, whereby social aspects and group dynamics were integrated in the choice experiments. The central part of the workshop was a valuation of alternative choices where participants were guided to informed choices through information and presentations made by the researchers (see Section 3.2).

The social context of the workshop was actively included to make the choices as informed and realistic as possible. Firstly, participants were engaged from the beginning which included an exercise aimed at expanding their imagination, and thus their understanding, of the situations on which the valuations should take place. During the exercise, participants in turn expressed wishes for a future Øbrohus in a hypothetical situation of unlimited funding and technological options. All statements were recorded on posters visible to the participants by the workshop convenors, confirmed by the individual participant and left without comment until all participants had expressed their wishes. Then the participants were invited to comment, with the limitation that arguments to prove the suggestions/wishes unfeasible or impossible to implement were banned.

The exercises were made to establish as shared space for valuating hypothetical situations that included different types of green roofs in combination with other measures. Furthermore, the exercise served to engage the participants' own everyday life experiences and thus move the hypothetical situations from the abstract to the concrete level motivating more real-life responses (Nielsen and Nielsen, 2007) in spaces shared by the group of participants.

Secondly, the participants were invited to comment and deliberate on the topics raised by the workshop convenors in relation to their own pool of experiences, which in our case was the social housing of Øbrohus. Through sharing views, perceptions, knowledge and experiences concerning green roofs and Øbrohus, the participants created a shared learning space where dialogue in a setting of trust and mutual recognition enhanced the established understanding (Agger, 2010). This motivated a more informed valuation of the choices that they were later exposed to, and included options for reflections on the potential role, benefits and disadvantages of green roofs in their individual and common household(s).

During the workshop, the participants largely articulated the topic of green roofs as an element in a future and transformed Øbrohus as their desired place of living. This included access to the social encounters and recreation in green spaces within the household and a merger of climate adaptive and climate mitigation initiatives. In a wider urban context, the participants integrated green roofs in a future development of the neighbourhood of Sct. Kjelds, which had more living spaces, less motorized transport and more social coherence, as well as sustainable markers such as climate adaptive initiatives.

Thus the deliberation on green roofs among the participants engaged their everyday life, their living space and wider urban neighbourhood where green roofs had an *instrumental position* – green roofs deliver water retention, recreation, reduced water use and energy efficiency (the latter two in combination with infrastructures to local recirculation of water and with solar panels). Furthermore and significantly, green roofs also showed to have a *symbolic position* – as representing and coining a different way of life marked by community feeling, local sustainable solutions and a local identity within the housing association of Øbrohus which is presentable to the city and wider urban world. Both positions were present in statements made by the participants and recorded on posters and digitally.

3.2 Choice Experiment set up and results

The following two sections describe the setup of the pilot choice experiment and the results.

3.2.1 Choice Experiment Setup

Øbrohus is a building in 10 stories with a 300 m^2 roof terrace with stairway and elevator access and black tar without access on the remaining 1570 m^2 roof. The black tar roof surrounds the roof terrace. The terrace itself has one small fir tree surrounded by artificial grass and a few attempts to grow plants in pots, but no permanent overwintering plants, hedges or flowers (see Table 3.1). The black tar roof and current roof terrace could not be integrated in the attributes of the two alternatives since they offer no possibility of biodiversity, water retention or permanent vegetation.

Table 3.1 Status Quo Alternative.

Current situation		Constant level
 Black tar roof without access, facing south	 Roof terrace in the middle of the main roof	**Status quo** Black tar roof with no biodiversity and no water retention. Current roof terrace with one small tree and some pots

The potential future roof design is described to respondents using a total of four attributes. The first attribute was the type of green roof that could be imagined on the roof of Øbrohus. This attribute aimed at the visual qualities of the roof and use opportunities from solar energy or spending time in the flower garden. Visualisations of how this could look like over the course of a year (green roofs change character over the growing season) was carried out by our graphical designer based on seasonal photos of the same green roof[7] presented during the workshop (See Annex 1 for visualisations made during the workshop). Table 3.2 presents the photos used in the choice experiment.

Table 3.2 Roof Type Attribute.

Roof Type	Levels
	Standard Sedum-moss green roof. This is the most basic green roof.
	Standard sedum-moss green roof combined with solar cells
	Sedum-moss-grass green roof. This is also termed a semi-intensive green roof, allowing for more diverse plant species.
 	Sedum-moss-grass green roof combined with a garden on the roof-terrace with hedges and flower beds.

The second attribute was the level of water retention provided by the two alternatives (Status Quo had 0 % water retention). We included two levels: 50 % of yearly rainfall would be retained by the green roof and the remaining 50 % would go to the sewage system; and 100 % retained but the part of rainwater not retained by the green roof would be recycled in the building or parcel, for instance for watering plants or for washing clothes (See Table 3.3).

[7] Original photos were cordially provided for use and manipulation by VegTech.

Table 3.3 Water Retention Attribute.

Water retention	Levels
50 %	Half of yearly rainwater is retained by the green roof
100 %	Half of yearly rainwater is retained by the green roof and the other half is recycled in the building

The third attribute was the level of biodiversity that the alternative would generate. We specified the level of biodiversity as low and high without characterising biodiversity any further. Participants in the survey were informed about the notion of biodiversity prior to the surveys. Depending on the choice of vegetation and substrate in a standard or semi-intensive green roof, biodiversity can be characterised as high or low, for instance by introducing rare species or common species (See Table 3.4).

Table 3.4 Biodiversity Attribute.

Biodiversity	Levels
	Low biodiversity
	High biodiversity

The fourth attribute introduced was a payment for the establishment of a green roof on the building where participants were living. The payment vehicle was a monthly rent increase varying from 30 DKK per month to 200 DKK per month. Participants were familiar with this type of payment vehicle, as the current roof terrace was financed partly through a monthly rent increase, differentiated by the size of the apartment. The increase levels used in the survey ranged from below to above the experienced rent increase (See Table 3.5).

Table 3.5 Cost Attribute.

Level	Attribute
30 DKK	Monthly rent increase
80 DKK	
120 DKK	
200 DKK	

The choice sets were generated using an orthogonal fractional factorial design estimated in NGENE. The orthogonal design ensures that attributes are independent or uncorrelated. Each of the choice sets consisted of two unlabelled alternatives and a constant, status quo alternative that did not vary across the choice sets. The alternatives were described by four attributes with either two or four levels (See Table 3.6 for a summary). The attributes were assumed to be generic across alternatives with effects coded attribute levels for roof type, water retention and biodiversity[8]. Rental increase was treated as continuous.

Table 3.6 Summary - Attributes and levels applied in choice experiment.

Attribute	Levels	acronyms
Type of roof	Standard sedum-moss green roof*	ROOF4
	Standard sedum-moss green roof combined with solar cells	ROOF3
	Sedum-moss-grass green roof	ROOF2
	Sedum-moss-grass green roof & flower garden on roof terrace	ROOF1
Water retention	50 % rain water retention from green roof & 50 % in sewers*	WATER1
	50 % rain water retention from green roof & 50 % recy-cled in building	WATER2
Biodiversity	Low biodiversity*	BIOD1
	High biodiversity	BIOD2
Rental increase	30-200 DKK/month	PX

Note: * Base level in regression analysis.

In all choice situations, participants could choose a status quo, which in Øbrohus is the black tar roof with a roof terrace. Attribute levels correspond to the columns in the choice situations (Please see Figures 3.1 and 3.2).

Each of the participants in the deliberative valuation workshop was asked to answer the choice questions in two rounds, round one contained six choice sets and round two eight choice situations. In the first round, participants received choice sets excluding the attribute rental increase. It was implied in this round, that participants could choose their optimal alternative without thinking of a budget constraint.

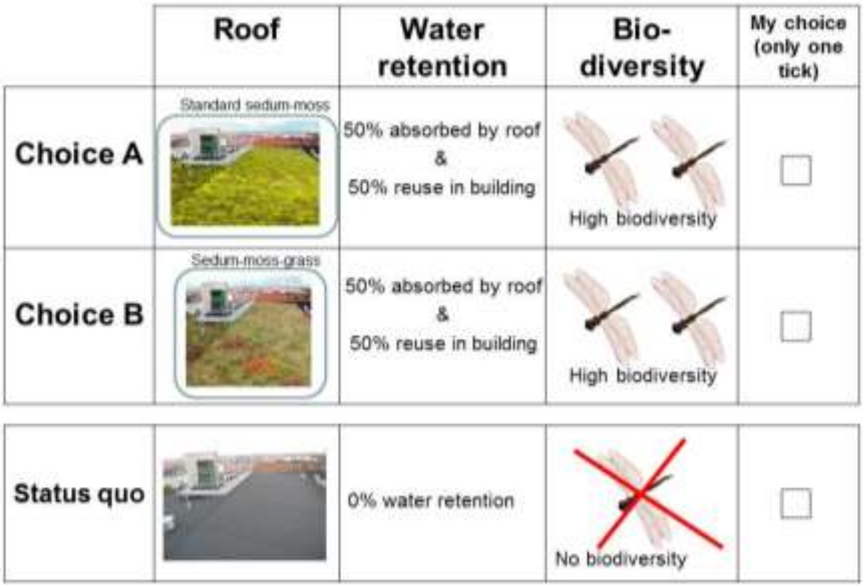


Figure 3.1 Example of a Choice Card, Session 1.

[8] An attribute with L levels is coded with L-1 indicator variables. All but one attribute levels are coded 1 on the corresponding indicator variable, and the remaining attrib-ute level is coded -1 on all indicator variables (the base level). Consequently, the pa-rameter estimates represent attribute departures from individual's average prefer-ence (which is at the base level).

In the second round, participants received a new set of choices, this time including the requirement to pay for the specific alternatives via a monthly rental increase. The background for undertaking the choice experiment in two rounds was to test the preferences towards different aspects of green roofs with (cf. Figure 3.2) and without (cf. Figure 3.1) a budget constraint, i.e. with and without a payment attribute in terms of a monthly rent increase.

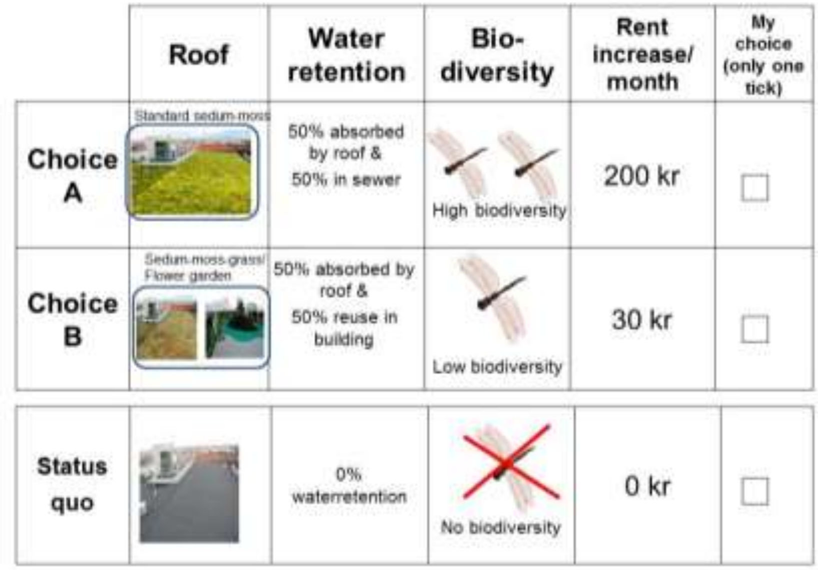


Figure 3.2 Example of a Choice Card, Session 2.

3.2.2 Choice Experiment Results

For the statistical analysis of the data, we used a simple conditional logit model (McFadden, 1974). The utility function resulting from choosing alternative *j* in choice situation *t* by person *n* is given by (Eqn1):

$$U_{njt} = \beta x_{njt} + \varepsilon_{njt}$$

$$n = 1, \dots, N; j = 1, \dots, J; t = 1, \dots, T,$$

Where β is a vector of utility weights that are homogeneous across individuals, x_{njt} is the individual- and alternative specific vector of characteristics of the choice, and ε_{njt} is the individual specific random term, assumed to be identical and independently distributed with an extreme value distribution (i.i.d. extreme value). The alternative specific constant (ASC) for an alternative, which may be included in x_{njt} , captures the average effect on utility of all factors that are not included in the model.

The conditional logit probability of individual *n* choosing alternative *j* of the available *J* alternatives in the choice set is (Eqn2):

$$P(j|X_{nt}) = \exp(\beta_{njt}) / \sum_{k=1}^{J} \exp(\beta_{nkt}),$$

where X_{nt} is the vector of attributes of all alternatives *j*=1,…,*J*. The MNL imposes a strict condition in terms of how changes in elements of x_{njt} can affect choice probabilities, termed the independence of irrelevant alternatives (IIA). The IIA property of the MNL model means that the ration of choosing over k remains the same no matter what other alternatives are available or what the attributes of the other alternatives are (Train, 2002).

The conditional logit model represents the utility U, which individual n would obtain with choice option j on a particular choice card. In session 1, this corresponds to (Eqn3):

$$U_{nj} = ASC_{SQ} \times SQ + P_{ROOF1} \times ROOF_1 + P_{ROOF2} \times ROOF_2 + P_{ROOF3} \times ROOF_3$$

$$+P_{WATER1} \times WATER_1 + P_{BIOD1} + BIOD_1$$

In session 2, this corresponds to (Eqn4):

$$U_{nj} = ASC_{SQ} \times SQ + P_{ROOF1} \times ROOF_1 + P_{ROOF2} \times ROOF_2 + P_{ROOF3} \times ROOF_3 +$$

$$P_{WATER1} \times WATER_1 + P_{BIOD1} + BIOD_1 + \ P_{PX} \times PX$$

P and ASQ denote estimated parameters. Please refer to Table 3.6 for a translation of the acronyms of the variables.

Results of the choice experiment will show us the extent to which the average individual preferred any of the options to the current situation. The results will also show us the average relative preferences for each level of the roof type, biodiversity and water retention, as well as the preference for each level of these options relative to preferences for the status quo.

Positive parameters indicate a positive preference for the attribute level and negative parameter a negative preference. For the non-monetary attributes, each of the estimated parameter values is relative to a base value specific to each of the attributes. The level and sign of the parameters are therefore relative to the base level of each of those parameters (see Table 3.6 for indication of the base levels).

We calculate the McFadden's Rho Square goodness of fit of the data by comparing the log-likelihood of the estimated model (L) with the log-likelihood of the zero model (L_0)[9]. In session 1, L is equal to -127.25 and L0 to -147.59. The resulting likelihood ratio is equal to 0.14. In session 2, L is equal to -108.34 and L_0 is equal to -125.63. By these log-likelihoods, the likelihood ratio index is similar to the ratio under session 1 (0.14). McFadden's Rho Square in multinomial logit models has an interpretation comparable to the proportion of explained variance in linear regression, but has typically lower values. A Rho square of 0.3 is held to be broadly equivalent to the level of fit achieved by a linear regression model with an R^2 value of approximately 0.6 (Hensher et al., 2007). A Pseudo-R^2 value of between 0.2 and 0.4 is thus considered to be a good fit (Louviere et al., 2000). Our results are somewhat below this, which may be attributable to the rather low number of participants.

Session 1

During the first choice session (without a payment attribute), results show a clear preference towards establishing a green roof and moving away from status quo (several attributes are statistically significant and the SQ is negative and significant). The high level of the alternative specific constant (SQ) indicates that the aversion for the current situation has not been captured

[9] The zero model is where all parameters are assumed to be zero. The Rho Square goodness of fit is calculated as a likelihood ratio = 1-L/L_0.

completely by the attributes included in the survey. Other aspects than the ones pre-described by us also play a role.

Table 3.7 lists the estimation results of the conditional logit model for session 1. In terms of the characteristics of the green roof, results generally indicate preferences for a green roof with clear additional resource use values attached. Results show a highly significant positive preference towards a standard sedum-moss green roof that is combined with solar cells ($ROOF_3$) compared to similar vegetation without solar cells (base level). The other two types of green roofs – a semi-intensive sedum-moss-grass green roof ($ROOF_2$) and a semi-intensive green roof combined with a garden on the roof terrace ($ROOF_1$) - proved to be of little interest as both attribute levels were insignificant. In terms of rain water utilisation ($WATER_1$), participants show a significant positive preference for a situation where rainwater is retained by the green roof and the remainder reutilized in the building, compared to a situation where excess rainwater from the green roof would be led to the sewage system (base level). A high biodiversity level (BIOD) proved not to be significant compared to a level of low biodiversity (base level).

Table 3.7 Parameter estimates of 1st choice session.

Variables	*Parameter*	*Standard errors*
$ROOF_1$ - Sedum/moss/grass & garden	-0,0004	0,9984
$ROOF_2$ - Sedum/moss/grass	-0,1711	0,3800
$ROOF_3$ - Sedum/moss & solar cells	1,0234***	0,0000
$WATER_1$ – 50 % retention from green roof & 50 % water recycling in building	0,4900***	0,0000
BIOD - High biodiversity	-0,0309	0,7548
SQ – alternative specific constant for the status quo alternative (no change)	-2,9771***	0,0000
Log-likelihood	-127,25	
Pseudo-R2	0,14	
Sample size	190	

***,**,* - significance at 1 %, 5 %, 10 %.

The parameter estimates of the 1st choice session can be illustrated in a ranking of preferences. Figure 3.3 shows how preferences for different attribute levels are placed in relation to each other. The current situation is visibly not a preferred situation for the respondents as it's placed below the nominal zero. Changing the current situation towards a standard sedum-moss green roof ($ROOF_4$) would improve average utility by 1,96 points. Changing the roof to a standard sedum-moss green roof that is combined with solar cells ($ROOF_3$) would improve utility to 1,02 points above the nominal zero. For rain water handling, respondents clearly prefer that 50 % of rainwater ($WATER_2$) is absorbed by the green roof compared to 100 % going to the sewage system (Status Quo) generating an improvement in utility of 2,49 points. The most preferred option, however, would be to recycle the excess rainwater from the green roof ($WATER_1$) which would increase utility up to +0,49 utility points, an increase of 3,47 points.

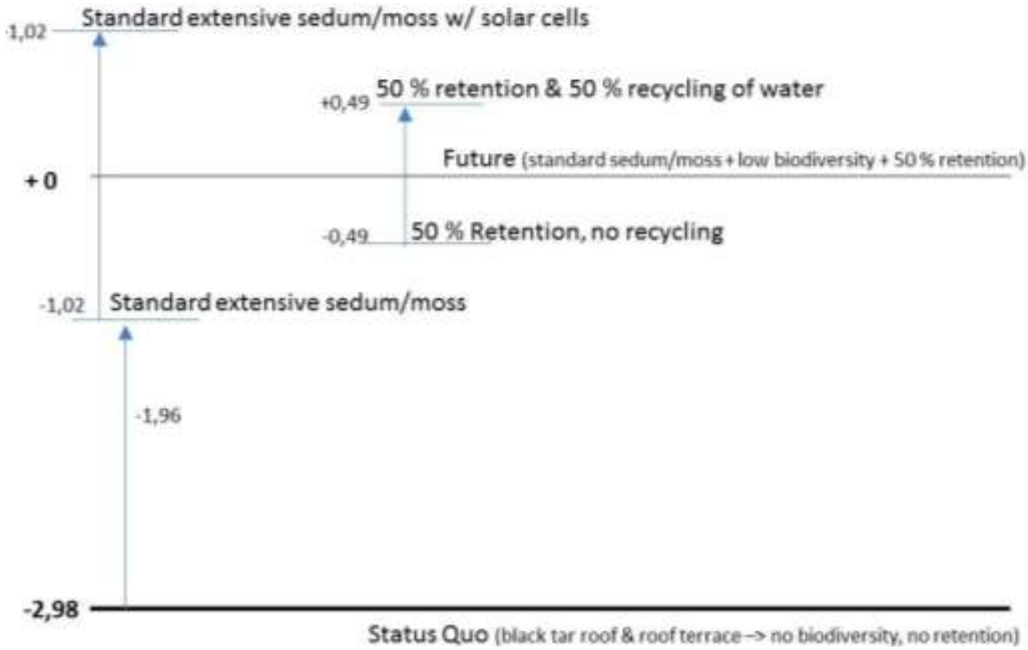


Figure 3.3 Preference Ranking, Significant Variables, Session 1.

Session 2

During the second choice session, where we introduce a payment requirement in terms of a monthly rent increase to pay for the choice alternatives, we also find that participants on average prefer any of the options to the current black tar roof (SQ is negative and highly significant), despite the requirement that they would need to pay a monthly rent increase to obtain this (PX) (cf. Table 3.8). On average, the rental rise did not make participants opt for the present situation (SQ remains negative as in choice session 1). As with session one, the high level of the alternative specific constant strongly indicates that we do not capture all aspects around the negative preferences for status quo.

In terms of relative preferences, we find similar to session 1 that a sedum-moss green roof combined with solar cells ($ROOF_3$) is preferred to a standard sedum-moss green roof without solar cells (base level). Participants on average do not prefer a semi-intensive green roof with sedum-moss-grass and a garden established on the existing roof terrace ($ROOF_1$) to a standard sedum-moss green roof (base level). We find no significant preferences for a stand-alone semi-intensive green roof ($ROOF_2$). Water retention combined with recycling of excess rain water ($WATER_1$) is preferred to simply letting the excess rain water run into the sewage system (base level). We find no significant preferences for high biodiversity (BIOD) compared to a green roof delivering low biodiversity (base level).

We observe, as expected, negative signs of the cost parameter (PX). Participants prefer not to pay additional rent, as this would decrease their utility.

Table 3.8 Parameter estimates of 2nd choice session

Variables	Parameters	Standard errors
$ROOF_1$ - Sedum/moss/grass & garden	-0,9117**	0,3693
$ROOF_2$ - Sedum/moss/grass	0,4176	0,2793
$ROOF_3$ - Sedum/moss & solar cells	0,9927***	0,3019
$WATER_1$ – 50 % retention from green roof & 50 % water recycling in building	0,6390***	0,2269
BIOD - High biodiversity	-0,1009	0,1255
PX – Monthly rental increase in DKK	-0,009***	0,0023
SQ – alternative specific constant for the status quo alternative (no change)	-2,8501***	0,4175
Log-likelihood	-108,34	
Pseudo-R2	0,14	
Sample size	142	

***,**,* - significance at 1 %, 5 %, 10 %.

While session 1 results can be used to look at how the average participant ranks different attribute levels, session 2 introduced a cost attribute in the choice situations (PX), which is used in the following to estimate monetary values for obtaining specific attribute levels or for calculating the WTP for different combinations of attribute levels (i.e. scenarios). Through the choice experiment, individuals implicitly make valuations of the attributes and their levels. This implicit valuation that individuals make can be calculated in part-worth utilities. Part-worth utilities describe the contribution that each attribute and level make to the individual’s changed utility under the hypothetical scenario. Part-worths are calculated by dividing attribute level parameters by the monetary parameter, which is also interpreted as the marginal utility of income (Eqn5):

$$WTA_i = -(\beta_i/\alpha)$$

where WTA_irepresents the willingness to pay a monthly rental increase for a particular level of attribute i relative to a specified baseline, β_i is the utility coefficient value associated with attribute i and α represents the utility coefficient value for a unit of subsidy. The coefficient α is negative as people normally loose utility as the price of an attribute increase.

Figure 3.4 presents part-worths of the significant parameters and illustrates these in a ranking, like in Figure 6. Looking specifically at preferences for a semi-intensive green roof combined with a roof garden ($ROOF_1$), the average participant would be willing to pay 216 DKK per month. However, participants would on average prefer to pay an additional 93 DKK per month for a standard sedum/moss green roof ($ROOF_4$) compared to the semi-intensive green roof with garden ($ROOF_1$). A standard sedum/moss green roof combined with solar cells ($ROOF_3$) would be the most preferred option for the average participant, with a willingness to pay of 429 DKK. Looking specifically at water management, participants would on average be willing to pay 247 DKK for a 50 % reduction of rainwater to the sewage system ($WATER_2$) and an additional 142 DKK to obtain the option of recycling excess water not absorbed by the green roof ($WATER_1$).

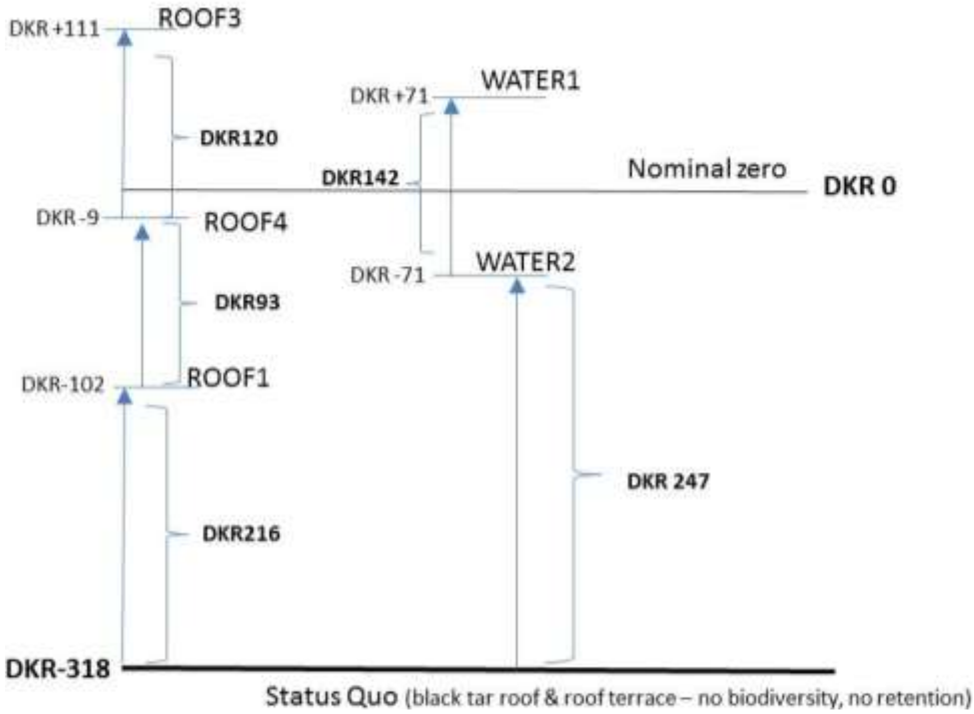


Figure 3.4 Part-Worth Ranking, Significant Variables, Session 2.

The part-worth utilities between the attributes ROOF and WATER do not differ substantially. The relative importance of the attributes' ranges can be calculated by taking for each attribute the difference between the highest and the lowest estimated part-worth utility of its level and sum the ranges of all attributes and then calculating the percentage contribution of each attributes to this sum. The resulting relative importance of the ROOF and WATER is 53 % and water 47 % respectively.

The part-worth utilities can be added to describe how much the average individual is willing to pay to go from the current situation to a specific future scenario. Average WTPs, presented in Table 3.9, show a willingness to pay in addition to the current monthly rent of between 145 DKK and 500 DKK, depending on the characteristics of the scenario.

Table 3.9 Average Willingness-to-Pay.

Scenario	Average WTP (DKK/month)
Semi-intensive green roof with garden which retains 50 % of rain water [$ROOF_1$+$WATER_1$]	145
Standard extensive green roof which retains 50 % of rain water [$ROOF_4$+ $WATER_1$]	238
Standard extensive green roof which retains 50 % of rain water & recycles 50 % rain water in building [$ROOF_4$+$WATER_2$]	380
Semi-intensive green roof with garden which retains 50 % of rain & recycles 50 % rain water in building [$ROOF_1$+$WATER_5$]	287
Standard extensive green roof with solar cells which retains 50 % of rain water [$ROOF_3$+$WATER_1$]	358
Standard extensive green roof with solar cells which retains 50 % of rain water & recycles 50 % rain water in building [$ROOF_3$+$WATER_2$]	500

3.3 Summary

Citizen views and preferences regarding greening urban space in general and green roofs in particular were investigated during a 3-hour long deliberative valuation workshop with inhabitants of the Øbrohus housing block in Sct. Kjelds neighbourhood in December 2012. 19 individuals participated. The process was built around a convivial setting of coffee/tea and a tasty three-course dinner. The workshop took place in the common rooms of a neighbouring housing block.

The deliberative setting allowed for an integration of the social context of participants and group dynamics, enhancing the participants' ability to deal with hypothetical choice situations in ways that position the choice situations in reality. Moreover, this methodological design opened up for learning processes, through which more informed and more conscious preference building could take place. The setting gave a common space for individual statements and deliberation of wishes and perceptions regarding the physical surroundings in the neighbourhood in general and in Øbrohus in particular.

The workshop was structured is several parts. After welcome and introduction to the workshop, Part I consisted of an inquiry into views on main barriers and wishes for greening their neighbourhood, based on individual reflections followed by a round of presenting their views. Opinions were captured on flip charts. Part II consisted of a range of general information input; first about the role of green urban spaces for urban dwellers in Copenhagen and in general according to studies and surveys; second about climate change challenges in urban areas and examples of how green infrastructure may contribute to solving some of these challenges; thirdly about green roofs; what they look like, how they function as well as benefits and disbenefits. Ample room was allowed for questions, discussions with and among participants during the general information input. Part III moved to the specific location of Øbrohus. Visualisations of how a green roof could look like were presented along with an introduction to the choice experiment and the attributes. The two choice experiment sessions were separated by the main course. Part IV was debriefing and evaluation of the workshop.

Results of the quantitative analysis show a significant preference towards the establishment of a green roof in both sessions. Introducing the payment vehicle in terms of the monthly rent increase did not change the preference direction. The level of the alternative specific constant (SQ), which captures unspecified preferences for the current situation indicate that we could not capture all aspects that describe the motivations and preferences for moving away from the current situation. The closer the SQ variable is to zero, the better we would be able to describe preferences. Statistically significant relative preferences remained stable in the two sessions. The most preferred attribute levels in both sessions proved to be the standard sedum-moss green roof combined with solar cells as well and the option to recycle excess rain water in the building. Whereas session one did not show a significant preference for a semi-intensive green roof combined with a garden on the existing roof terrace, the second session showed a slightly higher preference for this type of roof compared to the standard sedum-moss green roof. In neither of the two sessions did the stand-alone semi-intensive green roof or high biodiversity indicate any significant preference. The relative importance of the significant attributes ROOF and WATER are fairly balanced with ROOF representing 53 % and WATER 47 %. Average monthly WTPs for options range on average from 145 DKK to 500 DKK, depending on the characteristics of the scenario.

4 Conclusions and Perspectives

In this study, we looked at prospects and conflicts in relation to systematically introducing ecosystem services in dense urban areas for the benefits of inhabitants. For simplicity, we choose to focus on green roofs as an urban habitat that provides a number of ecosystem services and where competition for space is lower than on ground level. We investigated attitudes, experiences and views of city planners as well as views and preferences of citizens, using a novel mixed method approach – deliberative valuation workshop. In addition to this method being relatively new, it is also to our knowledge the first time it has been applied to green roofs. The following four sections summarise and discuss our findings.

4.1 Planning Aspects for Ecosystem based Approaches to Climate Adaptation

The Technical and Environmental Department of Copenhagen Municipality increasingly recognizes the multiple advantages related to inclusion of green and blue infrastructures in urban designs and spaces. This recognition is reflected in the focus of the urban vision the Eco-Metropolis and the Municipal Plan, and in sector specific documents. These documents stress both instrumental and cultural-symbolic benefits related to green and blue infrastructures and articulate a general 'greening' of the city as a motor of growth, through reducing environmental hazards, enhancing urban spaces and place-based identity, thus making the city more attractive to businesses and residents. In specifying the benefits of green and blue infrastructures in the city, the municipal documents and planners have begun specifying and acknowledging the services offered to human settlements by urban nature.

Green roofs are part of this growing acknowledgement which has initiated that the municipality developed a policy of green roofs. Green roofs are often included as examples, and expectations connected with the use of extensive green roofs in relation to climate adaptation are more specific, i.e. the municipality does not expect green roofs to have a great role in situations of cloudbursts while they as a local greening measure are presented as one of several sustainable urban drainage measures, since the introduction of green roofs in municipal planning documents in the late 2000s.

The key roles of green roofs in plans and policy documents related to Copenhagen's climate adaptation strategy are to provide local retention of water from intensified rains and to reduce urban heat; the latter is however stressed as a future asset (when increasing temperatures combined with the built environment give rise to urban heat waves and local heat islands). Furthermore, green roofs are greatly anticipated to make the city more attractive and city spaces more liveable while e.g. the potential for enhancing biodiversity is absent. Key actors to implement more green roofs are seen to be the municipality, assisted by private developers and house-owners.

4.2 Citizen Preferences for Private Green Space

As a group, the residents clearly consider climate adaptation in combination with cultural services, including recreation, contemplation, social coherence and place-making for their housing unit. Results of the quantitative analysis underpin our qualitative observations that this group of citizens hold distinct positive preferences for more green urban surroundings, integrated in buildings, streets and squares. This preference is not impaired by the prospects of having to pay (at least partly) for the environmental improvements (in this case tested on their own building). This is in line with the unanimous decision to work towards a green roof and local management of rainwater, taken during a board meeting 2 years previously. As such, this is not a surprising result. In fact, only 2 % and 6 % of participants chose status quo at some point during session one and two respectively.

On average, participants were willing to pay a monthly rent increase of between 145 DKK and 500 DKK. The most preferred option appears to be a sedum-moss green roof combined with solar cells and recycling of excess rain water not absorbed by the green roof. These results are by no means representative of households in Copenhagen. Rather they show for a specific case the motivations and willingness to pay for greening their own residential building.

Øbrohus must be considered a special case compared to other apartment blocks in Copenhagen by having a fairly new and very large roof terrace (ca. 300 m^2) on the 11th floor and a strong place-based community feeling sustained by a very active estate board. As there are no other buildings nearby of this height, the view from the terrace is truly stunning. Installing a green roof on the part of the roof outside the current roof terrace (ca. 1,570 m^2) would allow inhabitants to enjoy the aesthetics of green vegetation and contribute to creating a special sense of identity. The option to install a garden on the roof terrace, for instance with hedges around the fence and garden beds for flowers or vegetables would further enhance the use values of the site. In addition to the evident potential use values, the creation of at least 1,570 m^2 habitats on the edges of the current roof terrace would provide public goods in terms of habitats for biodiversity – both plants species but also for insects, invertebrates and birds. The combination with solar cells and/or recycling of excess rain water clearly represent a private good, but would also contribute to wider sustainable targets of the municipality (decoupling 30 % of rainwater in the neighbourhood from the combined sewage system and moving towards a CO_2 neutral city). The specificities of the site and the prior process and raising awareness in the housing block evidently (and should) influence our results. A similar exercise in a building block of a similar size but with no prior process or no prior access or experience with roof access would likely generate a higher level of preference for the current situation and possibly also for protests.

We also sought to test the feasibility of conducting a deliberative valuation using choice experiments on preferences for greening residential buildings and parcels. The deliberative setting compared to more standard procedures in non-market valuation studies, which use individual face-to-face interviews, postal or internet surveys, clearly helped in clarifying any questions on the survey format (a fair amount of questions were posed and clarified during the CE sessions), produced a record-low level of protest answers and allowed for a strong and expressed collective experience around the wider theme of liveable urban spaces, with sustainable solutions and greening urban areas in particular. In addition, the discussions during Part I (warming-up) and Part II (General information and discussion) allowed us to understand far better the context and motivations of individuals as these were debated and discussed during the workshop. We experienced no sequential non-participation, i.e. no participant chose the current situation in all choice situations. This is very rare and must be attributed to the general interest in the housing block for a green roof, and also the joint discussions and deliberative processes at the workshop, and moreover a fair amount of self-selection we must expect that people more interested in the topic would choose to participate compared to people not so interested in the topic. However, by offering a delightful three-course dinner, it was evident from the discussions that we managed to obtain participation from residents not particularly interested in nature, sustainability or green roofs.

4.3 Enablers and Barriers for ecosystem based approaches

Among both citizens at Øbrohus and urban policies, the potential for multiple benefits of green roofs proved to be essential. The multifunctionality of green roofs as an eco-system service provider was explicitly recognized in policy documents and at the workshop. Public and private actors had the perception that green roofs have both an instrumental role to play for retention of water, insulation, roof protection, reduction of future heat islands, and a cultural and symbolic role to play in enhancing the aesthetic of the urban built environment, in providing amiable spaces for dwelling and social encounter, as well as boosting a particular place-identity or social coherence of the housing estate and the city, respectively.

Through the multi-functionality of green spaces, both municipality and residents are able to benefit from more than one ecosystem service at the same time and at different scales. This fits like a glove with the urban strategy and vision for a future Copenhagen: green roofs should be established not just for the sake of the environment/nature but equally to enhance urban space, economy and well-being. In connection with this, it is significant that green roofs are established with a potential to deliver in relation to all three dimensions of urban sustainability, which for example also includes biodiversity.

The lack of national standards and guidelines constitute a barrier, while the competition for funding at housing project level may give rise to conflicts concerning the use of limited funds. In addition, awareness of the economic and other benefits of implementing green roofs as a measure to enhance urban ecosystem services is still rather limited at the environmental departments and centres. This is likely to slow down the process of increasing the use of green roofs in the city.

4.4 Perspectives: Future potential developments of ecosystem based approaches

Green roofs represent one example of using Nature's capacity to help people adapt to the adverse effects of climate change, while potentially also providing a whole range of other benefits that enhance quality of life and urban sustainability. Other examples of ecosystem based approaches to climate adaptation involves limiting and reversing soil sealing by creating permeable surfaces that improve water drainage capacity. Permeable surfaces can depending on usages of the space be extended by different types of habitats such as trees, bushes, temporary water holes, flower meadows or soil- and stone walls. This is also called green infrastructures. Permeable surfaces and green infrastructures in dense urban areas will inevitably entail a *range* of ecosystem services (and to some extent also disservices) as opposed to human-made technical solutions to e.g. increasing temperatures or increasing water run-off, which only provide the *one service*. Therefore, comparing options that use ecosystem based approaches to climate adaptation with human made 'grey' infrastructures ought to take into account the wider benefits and disbenefits of ecosystem services delivered by green infrastructures and permeable surfaces.

Reverting to the case of green roofs, these have the potential to deliver multiple benefits and if implemented systematically at large scale, they may contribute significantly towards urban sustainability. If, however, we look at individual benefits of green roofs, such as run-off management alone, they may not prove to be economically sound investments. This assessment may very well change when including considerations of enhanced aesthetical values, increased property value, recreation opportunities and habitats for biodiversity. Deciding upon systematically implementing green roofs in urban areas (and not uniquely on new buildings) will therefore need to comprise many aspects and involve trans-disciplinary cooperation (Berndtsson, 2010). Some benefits will accrue to private building owners (e.g. increased private property value or extended longevity of roofs), whereas other benefits may go to different beneficiaries: the neighbourhood and local authority (e.g. reduced risk of flooding and reduced pressure on urban drainage system) and yet other benefits may accrue to the wider society (e.g. establishment of new habitats for biodiversity).

Given the multi-functionality of green roofs and diversity in both ecosystem service benefits and beneficiaries, there is good reason for public authorities to introduce mandates for the installation of green roofs as well as direct and indirect incentives of various forms. Experience shows from other cities, that green roofs will not ‘take off’ unless public authorities offer either a carrot or a stick (or a mixture).

Copenhagen Municipality has mandated green roofs on new buildings meeting certain requirements since 2010 but does not apply performance or technology standards nor do they currently have any policy or direct incentives in place for existing buildings. The Municipality expects about 200.000 m^2 of new buildings to be covered by green roofs within the coming years, representing some 1,5 % of current roof area. There is therefore a huge untapped potential for habitats on the roofs of Copenhagen and good indications that many citizens are interested in establishing green roofs. The deliberative workshop, albeit hosting few respondents, provides compelling evidence towards the willingness to pay for at least part of the installation costs.

Various policy instruments are available to be combined at varying degrees or not (Carter and Fowler, 2008). These can be categorised as:

i) Direct financial incentives;

ii) Indirect financial incentives;

iii) Technology standards; and

iv) Performance standards.

4.4.1 Direct Financial Incentives

Direct financial incentives for retrofitting roofs with green roofs would serve two main purposes:

- **Green roof technology is still in its infancy in Denmark** with currently little research, few providers, few certified installation companies and no national technology and performance standards or guidelines. This obviously points towards a barrier in adopting new technology, where the immaturity of the industry likely leads to higher installation costs. Direct financial incentives would support the beginnings of an industry delivering socially desirable outcomes.

- **Green roofs are capable of providing a wide range of public goods** through a fair number of regulating and cultural ecosystem services. Public goods cannot be provided at the socially desirable level by the market on its own but necessitates regulation and/or economic incentives to ensure the desired level of services. Current regulation on green roofs does not cover existing buildings and the delivery of ecosystem services from green roofs is therefore not optimal.

Direct financial incentives for the installation of green roofs represent a widespread policy tool with evident results. In Germany, which is leading worldwide in the deployment of modern green roofs, approximately 14 % of total roof area is vegetated and about 6 % of all towns larger than 10.000 inhabitants have direct subsidies in place in 2012 compared to 18 % of all towns larger than 10.000 inhabitants in 2000 (FBB, 2012). Typical subsidy levels range from 112-224 DKK/m^2, or max 50 % of costs with a specified ceiling (FBB, 2012). Direct financial incentives are also found in numerous local communities in Austria and some state governments (http://www.gruendach.at); the Flemish Government stimulates municipalities to offer grant subsidies for green roofs since 2002 at a minimum of 231 DKK per m^2 (Claus and Rousseau, 2010) and in North American cities of Toronto, Chicago, Portland, and Washington D.C. (http://www.myplantconnection.com) provide grants or subsidies for a limited budget or limited number of years.

4.4.2 Indirect Financial Incentives

Indirect financial incentives appear to be the most prevalent instrument for supporting the installations of green roofs across the world (Carter and Fowler, 2008). Copenhagen Municipality through the municipal utility company allows in theory a 100 % refund of the rainwater connection fee if it can be documented that all rainwater is not led to the sewage system. There is currently no possibility of a part refund equalling a percentage reduction of rainwater led to the sewage. Also, it appears that the utility company does not find sufficient Danish documentation of green roof performance for the utility company to accept green roofs as a part solution to sustainable urban drainage (personal communication, city planner).

In cities outside Denmark, green roofs are frequently given credits towards a portion of the storm water utility fee, e.g. Portland, U.S., and in many German cities[10]. Density bonuses are other indirect incentives used in Portland and Chicago, where developers are allowed to construct more densely in specific areas or plots according to the amount of green roof areas (planned) installed.

[10] Close to 50 % of cities responding to the FBB (2012) survey have percentage reductions in storm water utility fees when green roofs are installed, representing 276 towns and cities out of a total of 564 cities responding. There are 1488 cities in Germany with more than 10,000 inhabitants (FBB, 2012).

4.4.3 Technology Standards

In addition to direct financial incentives for the retrofit of existing buildings, Copenhagen Municipality could consider introducing technology standards in the building code, for instance that all buildings of a certain type must green all or part of their roof such as public buildings, large commercial buildings with flat roofs or underground structures. The mandate could be placed for all new buildings as well as existing buildings when roofs are due to be replaced (Carter and Fowler, 2008). The building code could specify the depth of the growing media, amount of plant coverage compared to the building ground plan and water retention capacity. This type of regulation exists already in Tokyo (Japan), city of Linz (Austria), city of Toronto (Canada), and Portland (USA) (Carter and Fowler, 2008).

4.4.4 Performance Standards

Performance standards could be introduced to ensure that green roofs and other types of green infrastructures meet certain environmental, ecological and/or social criteria. Performance standards could be based on e.g. rainwater retention capacity, biodiversity, aesthetics, recreation or other services that are considered particularly desirable in an area or across the whole city. A municipality could specify specific performance standards for different neighbourhoods, for instance stressing water retention capacity in an area where this makes a difference and stressing biodiversity standards in another area where this would make particular sense.

An example of the operationalization of a performance standard is the use of the **Biotope Area Factor** (BAF) in dense urban settings like in Berlin to improve and promote high quality urban development with respect to the ecosystem's functionality, habitat creation, protection of biotopes and species and recreation. It formulates ecological minimum standards (targets) for structural changes and new developments in residential areas, commercial usages and infrastructure in dense urban areas and is calculated as the ratio of ecologically effective surface area to total land area (http://www.stadtentwicklung.berlin.de). Individual parts of a parcel are weighted according to their ecological value. Ecological values of different surface types range from 0,0 for sealed surfaces such as asphalt, roofs and concrete to 1,0 for surfaces with vegetation, connected to the soil layer below. In between, green roofs have a value of 0,7, green walls obtain 0,5, surfaces with vegetation with at least 80cm soil but no connection to the soil layer 0,7, partially sealed surfaces 0,3, rainwater infiltration per m^2 of roof area 0,2 and so forth.

Green roofs are also used in a **legal habitat loss compensatory mechanism** in numerous German municipalities as an ex-ante habitat creation measure that can be used as a compensation for later losses of habitats elsewhere within a municipality. Green roofs can through this regulation be used for offsets and thereby receive Eco-points [Ökopunkte][11] according to the performance and size of the vegetated roof (FBB, 2012).

[11] The German Nature Protection Act [BundesNaturSchutzgesetz] forbids in general any degradation of nature and landscapes also outside designated areas without compensation (§§ 13 - 18 BNatSchG). An instrument under this Act is the Ökokonto-verordnung that allows ex ante compensatory measures for habitat losses to be carried out, managed and documented before they are used as off-sets on specific land developments (http://www.lubw.baden-wuerttemberg.de/servlet/is/12697/).

In the US, green roof performance standards are applied to **green building standards** such as the Leadership in Energy and Environmental Design LEED system or the U.S. ETA's energy star labelling system for roofing materials that reduce urban heat island effects. Green roof systems can earn credits under the LEED standard for contributing to sustainable cities (including storm water management and heat island effects), water efficiency, energy and optimisation, and materials and resources to varying degrees depending on the individual green roof. But overall, green roofs installed on 50% or more of the roof surface virtually guarantees 2 LEED points and can contribute to an additional 7+ points toward LEED-certification which represents almost 20% of the total needed points for a building to be LEED-certified (http://www.greenrooftechnology.com/leed/leed_Greenroofs & USGBC).

Mandating green roofs through the building code or local plans represent the most secure way of getting more green roofs installed. In Copenhagen Municipality this is the case for new buildings. However, in order to tap into the large potential of existing buildings and to ensure a certain minimum level of ecosystem services, the municipality could consider i) introducing a mandate for green roofs on existing buildings under 30 degree slopes when a new roof is needed or large investments are made; *and* ii) introduce minimum performance standards and ratio green roof to building ground plan, possibly diversifying the standards to different neighbourhoods, optimising for different ecosystem services. Extending the current mandate is however a more difficult political step to take and would need strong political leadership and commitment. Direct financial incentives are also very secure ways of ensuring a wider coverage of green roofs, and could be made time limited. It's evidently a more popular policy than mandates as it is voluntary and provides for compensation for some of the initial and non-negligible installation costs and supports an immature industry. It would however necessitate adequate funding and priority-setting. Indirect financial incentives and performance standards also have the advantage of being voluntary. The current indirect financial incentive in Copenhagen Municipality could, however, be made more flexible by allowing for a partial refund of the sewage connection fee as found in many other places outside Denmark instead of an 'all or nothing' refund. The Municipality could also take inspiration from the different types of performance standards already in place elsewhere for green roofs in particular and green infrastructures in general. Finally, Copenhagen Municipality could choose to mix these policy instruments to create the basis for a truly systematic ecosystem based approach to not only climate adaptation but also to the wider variety of ecosystem services that permeable surfaces and habitat creation can offer in dense urban areas.

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6 ANNEX1 – Visualisations used during stakeholder workshop (in Danish)

6 ANNEX1 – Visualisations used during stakeholder workshop (in Danish)

Hvordan kunne et grønt tag se ud på Øbrohus?

Vi har illustreret fire forskellige muligheder og kombinationer

Standard sedum-mos

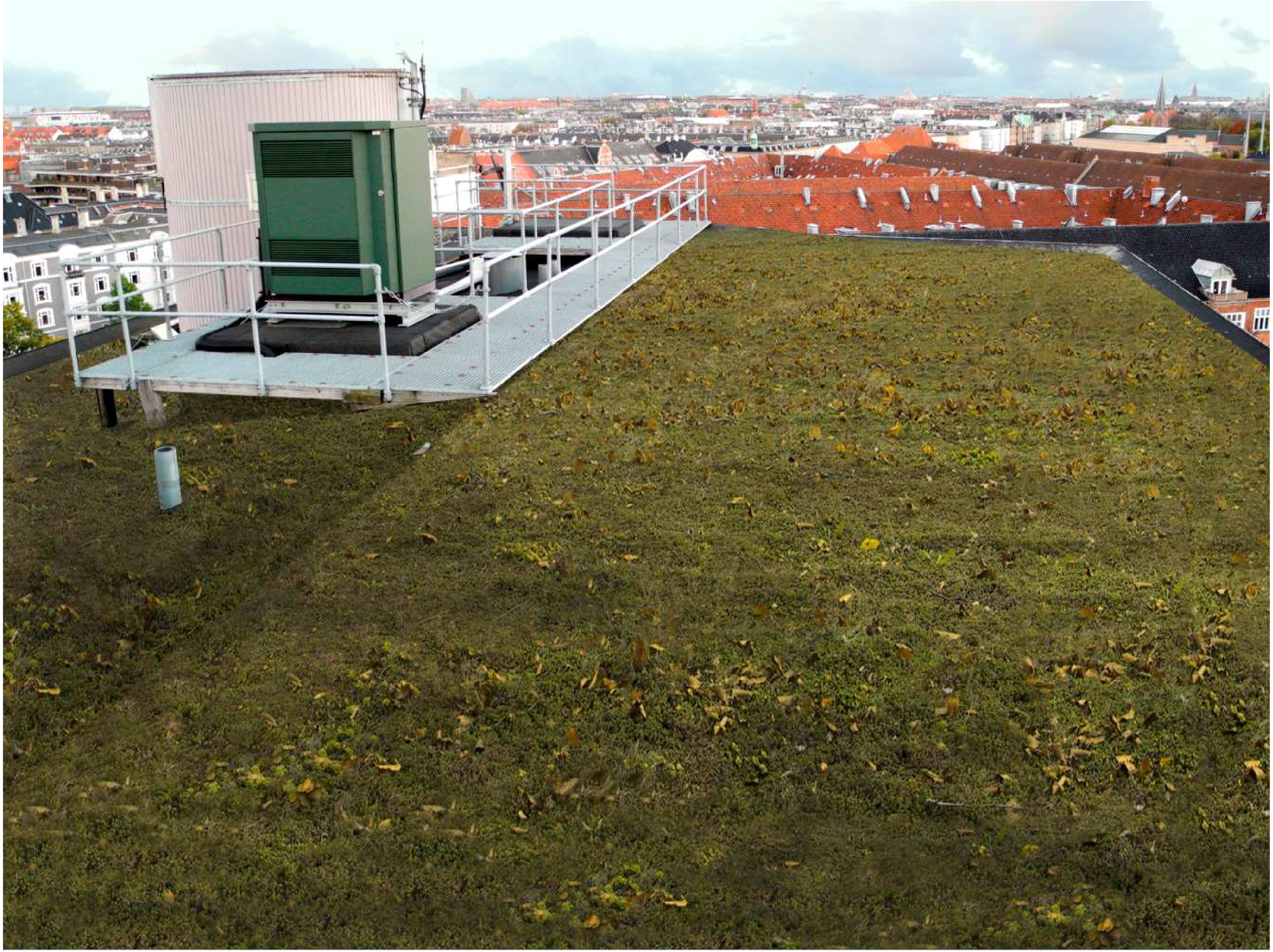
Sedum-mos-græs

Standard sedum-mos m. solceller

Sedum-mos-græs + pryd/nyttehave

Standard sedum-mos

VISUALISERING AF STANDARD SEDUM-MOS GRØNT TAG



Standard sedum-mos m. solceller

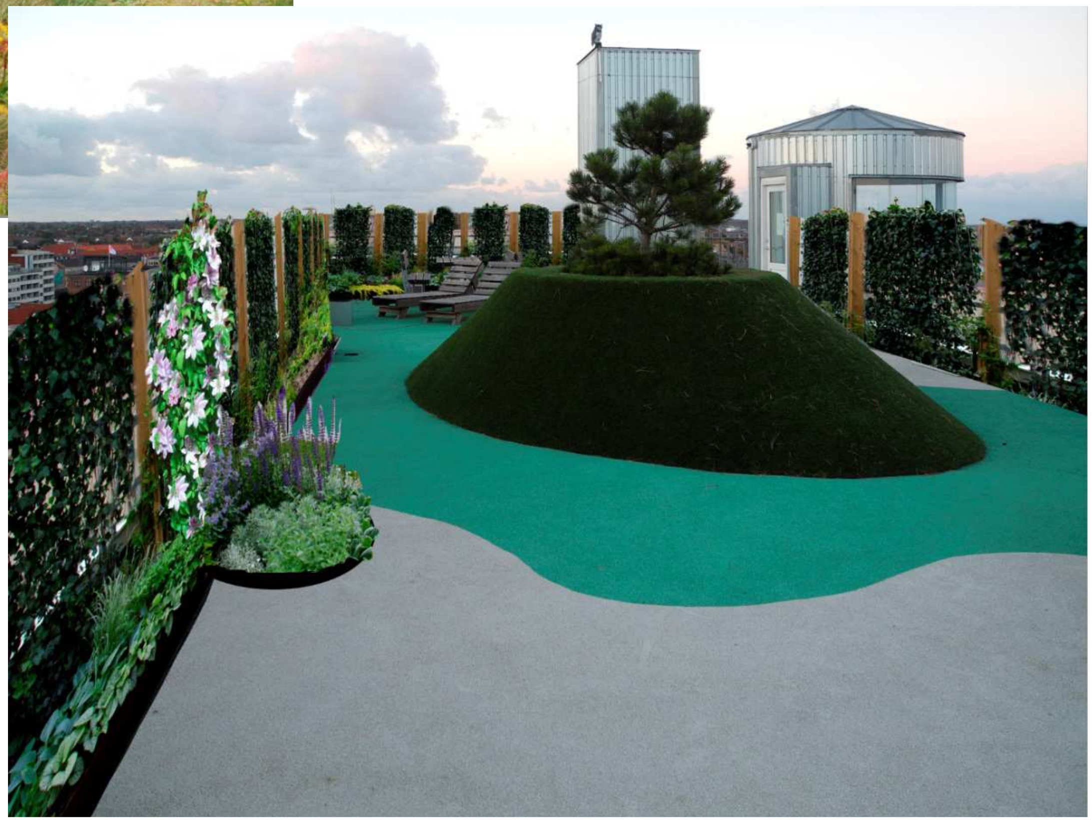
VISUALISERING AF STANDARD GRØNT TAG MED SOLCELLER

Sedum-mos-græs

VISUALISERING AF SEMI-INTENSIVT GRØNT TAG (SEDUM-MOS-GRÆS)

+

VISUALISERING AF SEMI-INTENSIVT GRØNT TAG MED TAGHAVE

ECOSYSTEM BASED APPROACHES TO CLIMATE ADAPTATION – URBAN PROSPECTS AND BARRIERS

This report analyses the prospects and barriers of applying ecosystem based approaches systematically to climate adaptation in urban areas, taking the case of green roofs in Copenhagen Municipality. It looks at planning aspects of green roofs in Copenhagen as well as citizen views and preferences regarding green roofs using policy document analysis, interviews with city planners and deliberative valuation methods.

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