

Climate Change Adaptation in Urban Systems: Strategies for Planning Regimes

Tony Matthews



Urban Research Program

**Research Paper 32
February 2011**

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ISBN 978-1-921760-31-0

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Executive summary

Adaptation is increasingly being viewed as a necessary response in respect of climate change. Though the subject of significant scholarly and professional attention, adaptation still continues to lag behind mitigation in the climate change discourse. However, this situation looks likely to change in the coming years due to increasing scientific acceptance that certain climate change effects are now inevitable.

The purpose of this research is to illustrate, consider and demonstrate how urban planning regimes can use some of their professional tools to develop adaptation strategies and interventions in urban systems. These tools include plan-making, development management, urban design and place-making. Urban systems contribute disproportionately to climate change and will also likely suffer considerably from the resulting effects. Moreover, the majority of the world's population is now urbanised, suggesting that adaptation will be crucial in order to develop urban systems that are resilient to climate change effects.

Informed by a reflexive, qualitative method, this paper offers an informed understanding and illustration of adaptation as a climate change response, its use in urban systems and some of the roles and strategies that planning may take in developing and implementing urban adaptation. It concludes that urban planning regimes have key roles in adapting urban systems to many climate change effects.

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Introduction

Climate change is often described as the greatest challenge facing humanity. Climate change, it is predicted, may potentially damage every natural and human system on the planet (Garnaut, 2008; IPCC, 2007). It is clear that urgent action is needed and that the scale and scope of such action will be hugely varied. At present, the main worldwide response to the threat of climate change is mitigation; especially the lowering of greenhouse gas (GHG) emissions across a variety of scales. The preponderance of scientific evidence suggests that climate change is caused and exacerbated by anthropogenic greenhouse gas emissions and that lowering the amount of gas being emitted will limit climate change effects (IPCC, 2007; Lovelock, 2006; Stern, 2006). Unfortunately, effective and collective planetary action is lacking and the successes of countries who lower GHGs are often offset by the failures of others. The net result is a general scientific acceptance that some climate change effects are now inevitable and unavoidable (IPCC, 2007; Schipper, 2007; Steffen, 2009). The impact of these will likely be felt to an increasing degree over the coming decades and potentially for long beyond.

An increasing amount of climate research now points to adaptation as a necessary means of addressing unavoidable climate change impacts (Garnaut, 2008; IPCC, 2007; Stern, 2006). Adaptation to climate change refers to efforts to develop resilience to predicted or potential climate impacts and effects before and as they happen (Adger, Arnell and Tompkins, 2005, IPCC, 2007). Given the broad range of potential climate effects and the ways in which these may impact on human and natural systems, strategies that work across a variety of systems and address climate impacts in locally-appropriate ways must be developed and implemented. The focus of this paper is to illustrate and consider ways in which urban planning regimes may utilise professional tools to deliver appropriate adaptive strategies in urban systems. These tools, which include plan-making, development management, urban design and place-making, are widely used by urban planning regimes, particularly in the Anglophone world. As such, the adaptive strategies and interventions considered by this paper could be applied in many urban systems, using existing and common planning tools.

This paper begins with an overview of the causes and predicted effects of climate change and the relationships between climate change and urban systems. It details the emergence of adaptation as a climate change response strategy. The emergence of adaptation is considered, both generally and in terms of its connection to urban planning. Adaptation is framed as a vital response for urban systems to build resilience to predicted climate change impacts. The paper goes on to consider the need for top-down planning policy to support adaptation as a planning issue. The ways in which urban planning regimes may forge a role in adapting urban systems through plan-making are then examined. As plan-making is traditionally a process which invites wider participation, the necessity for stakeholder engagement is also considered, as are several relevant issues including implementation strategies and requirements for Strategic Environmental Assessment (SEA). The ways in which urban planning may facilitate the adaptation of urban systems through infrastructure and design standards and interventions are subject to detailed explication. Particular attention is paid to porous surfacing and green roofing. The

role for urban planning regimes in developing, directing and implementing these kinds of adaptive infrastructure is critically examined. The final part of this paper offers conclusions in respect of the role of planning in developing urban adaptation as means of building resilience to climate change effects in urban systems.

The issues and analyses presented in this paper are informed by a wide array of literature including scholarship, official planning documents, policy documents, cross-sectoral research and reports from research institutes and think-tanks. They are further informed by findings generated from seven semi-structured interviews undertaken as part of the research process. Participants were from Ireland, England and Australia and included public and private sector planners, climate change and sustainability policy-makers, urban designers and urban planning scholars. Each interview lasted approximately one hour. Where possible, interviews were conducted face to face. In some cases, this was not possible due to geographical distances. In these instances, interviews were conducted using Skype, a voice-over-IP (VOIP) software package. All interviews were digitally recorded.

Climate Change and Urban Systems

Cause and Effect

In this paper climate change is understood as an immediate threat, with early effects evident in climate shifts now occurring on a variety of scales across the planet (Garnaut, 2008; IPCC 2007; Steffen, 2009; Stern, 2006). In spite of recent controversies, the weight of scientific evidence suggests that ongoing changes in climates across global, regional, local, micro scales are primarily caused by human actions and that the effects of this phenomenon will be widespread and extremely harmful to both people and places (IPCC, 2007; Stern, 2006). The majority of the world's population now lives and works within urban systems and the trend is increasing (Davis, 2006; UN, 2009). Urban systems are understood as 'the constantly evolving spatial product of the flow of social, economic, infrastructural and ecological systems which grow and develop around an urban area' (Gleeson, 2008, p. 2656). This settlement model tends to be extremely resource intensive and contribute hugely to increases in greenhouse gas emissions and consequently, climate change. In quantitative terms, the impact of urban systems on climate change is illustrated by the fact that 75% of all greenhouse gas emissions are generated in the world's urban areas (UN, 2007); while only approximately half of the planet's population live in closer settlements. In other words, urban systems are a principal source of emerging climate threats (Gleeson, 2008).

The very nature of urban systems contributes to climate change, as their functions require the burning of fossil fuels. Within urban systems, spatial functions include building structures to house people and commerce and the provision of space for social and economic interactions. Transport functions include the movement of people, goods and materials to, from and around cities. Supply functions include the provision of food, sanitation and clean water, as well as electricity, light and heat. These functions and others ensure that urban systems contribute hugely to the demand for fossil fuels, which, in turn, contribute to climate change. Thus, there is a

direct causal relationship between the function of urban systems and climate change.

The specific effects of climate change on urban systems will vary depending on location, but may include reductions in potable water, more regular and severe weather events such as heavy rain-falls and cyclones, increased incidences of flooding, inland storm surges and an increase in extreme heat events. The nature and scope of these potential climate change threats means that the vast majority of urban systems and their residents are vulnerable to some degree. The extent of urban vulnerability can be increased by the concentration of people and commercial activity in small spaces and the demands this places on urban functions and infrastructure (Condon, Cavens and Miller, 2008). Consequently, even minor climate change effects can affect large numbers of people and can have serious consequences for wider urban systems. All urban systems will face some vulnerability to climate change effects. These effects may disrupt or even destroy a wide variety of urban functions. Such direct effects do not exhaust the potential impacts climate change may have on urban systems. It is possible and indeed probable that urban features may exacerbate these impacts and the vulnerability of urban spaces. Such features include:

- Asphalt, tarmac, concrete and other hard surfacing absorb heat from the sun, causing an 'urban heat island' effect, which adds to increased urban temperatures
 - Hard surfacing also reduces the absorption of rain water, which can overwhelm stormwater systems and increase flood risks
 - Population densities in urban areas can reduce or put pressure on green spaces that could reduce heat, water runoff and air pollution
 - Population densities can also put pressure on water supplies, leading to an increased potential for shortages
- (Clean Air Partnership, 2007; Shaw, Colley and Connell, 2007)

As urban systems contribute significantly to climate change and stand to suffer heavily from its effects, it is posited that urban systems are currently locked in a negative feedback loop. It follows that adaptation in urban systems is necessary to reduce and manage the impacts of these effects. By implementing adaptive responses, urban vulnerability may be reduced and urban resilience improved.

Adaptation as a Climate Change Response

Adaptation to climate change is understood as taking direct action to minimize and manage the predicted or expected negative consequences of climate change before and as they happen (Adger, Arnell and Tompkins, 2005; IPCC, 2007). Promoting adaptation as a climate change management strategy represents a shift away from mitigation as the primary response tool. Mitigation strategies tend to focus on reducing greenhouse gas emissions in order to reduce the extent and severity of climate change and its potential effects. Whilst important in limiting the severity of future climate impacts, efforts towards mitigation must now occur in tandem with efforts towards adaptation and vice-versa. This is because greenhouse gases (GHG) have been collecting in the atmosphere, broadly since the Industrial

Revolution (IPCC, 2007, Stern, 2006). Scientific consensus now views these gases as 'locked in' and thus extremely likely to trigger some climate change effects (Garnaut, 2008; Stern, 2006). In other words, mitigation continues to be an important strategy for limiting future climate change impacts, whilst adaptation is necessary to manage those set in motion by historical GHG emissions. As the Intergovernmental Panel on Climate Change (IPCC) observe, 'adaptation will be necessary to address impacts resulting from the warming which is already unavoidable due to past emissions' (IPCC, 2007, p. 18). A further concern is evidence demonstrated in recent climate change science, which suggests that climate change appears to be occurring at a faster pace than previously thought. This indicates that efforts towards adaptation must be urgently developed and implemented (see for example, IPCC, 2007; Steffen, 2009; Schipper, 2007). On this point, a climate change and risk policy advisor with the UK Environment Agency stated during interview:

We can't influence the climate change effects we are going to see up to 2050 or 2060 because we have already emitted the carbon that will cause these. We're locked in between then and now. We need to adapt significantly to that point at least. We need to adapt because it [climate change] could get an awful lot worse and there's nothing really that we can do between now and 2050 in terms of [halting already established] climate change effects.

Many urban scholars, including, Bulkeley (2006); Byrne and Jinjun (2009); Gleeson, (2008); Newman, Beatley and Boyer (2009); Smith et al (2010) and Wilson and Piper (2010) argue an urgent necessity for climate change adaptation in urban systems. Gleeson, for example, argues that, 'the imminence, scale and speed of climate change threats seem to overwhelm the principal mitigation strategies on offer' (2008, p.2653). This suggests a clear and immediate need for urban adaptation, irrespective of whatever mitigation strategies may be employed. Gleeson further advocates the need for adaptation, stating that, 'the climate emergency is the greatest environmental imperative facing cities and human societies. Urban studies and policy must assist human settlements to adapt to the climate dislocations ahead, including finding ways to minimise the risks to human well-being, even life, as the changes unfold' (2008, p. 2667).

Many governments, research groups, think-tanks, professional institutes and political institutions advocate a view of adaptation that reflect the opinions of expressed in scholarship. For example, The UK Institute of Mechanical Engineers (IME) express similar perspectives in a recent report and suggest that the world's climate is changing and that urban adaptation is vital in order to cope with future climate effects. The IME suggest that adaptation of urban systems and infrastructure will be vital in tackling climate effects and minimizing risks to people. Clean Air Partnership (2007, p. vii), a Canadian applied research group, also advocates the necessity of urban adaptation:

The benefits of adaptation fall largely where the costs are expended. If a city protects itself from storms, floods, droughts and heat waves, it is the people of the city that benefit. Their environment is better, their health is more protected, and their economic activities are less liable to damage and disruption.

This indicates that adaptation of urban systems can create scenarios where outputs generally reflect inputs. This is important for two reasons. First, it indicates a positive correlation between levels of adaptation and levels of resilience, suggesting that the best adapted cities will likely be the most resilient and least vulnerable. This is a compelling argument in favour of immediate efforts in respect of urban adaptation. Second, this view highlights the fact that adaptation can produce direct, local results, reflecting the extent of effort invested (Wilson, 2006). This is opposite to the outcomes of mitigation efforts, where even the most concerted local effort may produce only limited local gain. The immediacy of adaptation efforts and the need for them to be locally directed was noted during interview with an internationally established urban scholar, who stated:

Through better comprehension of climate issues we now know that there is an important role for adaptation in climate change management. Adaptation is a compelling climate issue and the task is here now as regional climate regimes are already shifting.

Planners interviewed as part of the research supporting this paper also noted the need for urban adaptation. The following comments reflect the views of two planners, the first a public sector planner, the second a private sector planner:

The effects of climate change may be more or less extreme depending on issues facing particular cities, but all cities are likely to suffer in some ways from climate change effects.

Climate change will affect urban areas...adaptation will be a necessary response.

Urban Planning as an Agent of Adaptation

Developing adaptation strategies in urban systems is an extremely complex and challenging process. Many actors are required to work collaboratively, as well as independently. In many ways, urban planning regimes are well suited to meeting challenges generated by the adaptation process (Condon, Cavens and Miller, 2009; Gleeson, 2008; Wilson, 2006). Planning is internationally utilised, multi-disciplinary, collaborative and forward-thinking (Forrester, 1989; Healey, 1996). Urban planning regimes are societal tools charged with creating order among activities in urban spaces and reducing conflicts between them. In fulfilling this role, urban planners play a key role in guiding and shaping the function and structure of urban systems (Sanchez-Rodriguez, 2009). Moreover, the tools employed by planning regimes, such as plan-making, development management, urban design, etc, tend to be universal. Planning regimes also tend to function primarily on a local level. It is posited therefore that urban planning regimes are well placed to positively contribute to urban adaptation efforts, especially when adaptation actions are locally directed. Moreover, as Wilson (2006) notes, whilst there may be financial costs associated with building climate change considerations into planning processes and systems, the cost of taking early action should be much less than responding to climate change impacts as they happen or retrospectively. This need for early planning-led action towards adaptation was addressed throughout the interviews conducted for this paper. One respondent saw this issue as particularly critical, suggesting:

The most compelling role for planning is adaptation...it is a burning imperative. Planning needs to wake up to adaptation immediately.

Another respondent stated that:

Climate change should be an immediate concern for planning. The balance of evidence indicates that climate change will affect how we plan cities. Adaptation may require extreme planning action.

The European Spatial Planning Adapting to Climate Events Project (ESPACE) offers perspective on the role of urban planning as an agent for adaptation in its recent guidance document entitled, *Climate Change Impacts and Spatial Planning Decision Support Guidance* (2008). ESPACE assert that while adaptation presents a variety of new issues for planning, it can be an opportunity for good planning to thrive. It is further argued that good planning can positively contribute to adaptive efforts if it works within its means and correctly uses the tools available to it. The ESPACE report (2008) also emphasizes the many advantages for planning if it prioritizes stakeholder collaboration when formulating and developing adaptation strategies. These arguments are also central in much of the other policy and guidance literature concerned with key issues faced by planning when attempting to formulate and deliver urban adaptation (see, for example, Clean Air Partnership, 2007; ODPM, 2005 and The Heinz Center, 2008).

Adequate and appropriate 'top-down' planning policy will improve the potential for success rate for urban planning regimes seeking to develop and implement adaptation responses within their own functional areas (Wolf, 2009). For the purposes of this paper, 'top-down' policy guidance refers to policy guidance issued to local planning authorities by national, state or regional government. Well formulated, top-down policy guidance can define parameters, set clear agendas and offer support to individual urban planning regimes as they try to develop and implement localised adaptation policies and strategies (Burton et al, 2002; Wilson, 2006). High-level policy support for adaptation, instituted by government, can allow local planning regimes to implement locally appropriate adaptive responses through plan-making, codifying development standards, establishing design criteria, setting implementation strategies and defining targets. Addressing this point during interview, a policy maker from the UK noted:

We [the UK public sector] have realised that nothing gets done without the policy backing to help it happen and no more so than in the planning sector. If you don't have the policy, you're stuffed from the get-go.

A senior policy planner working in local government noted during interview that:

[Adaptation policy for urban planning] ideally needs to be built in at the upper legislative levels...general national guidance would be useful.

England offers a good example of national policy guidance being effectively used in order to support planning's role in delivering urban adaptation. Planning policy guidance is established through *Planning Policy Statement (PPS) 1: Delivering Sustainable Development* (ODPM, 2005), as well through *Supplement to Planning*

Policy Statement (PPS) 1: Planning and Climate Change (ODPM, 2007). More specifically directed policy is established through *Planning Policy Statement 25: Development and Flood Risk Practice Guide* (ODPM, 2008). These documents offer significant advantages to local planning authorities in England. Most importantly, they establish a national, top-down policy basis for adaptive action and provide local planning regimes with a basis for developing plans and establishing implementation strategies. In this case, the fact that national planning policy guidance is established by *PPS 1* means that planning authorities have a clear and important remit in respect of formulating adaptation strategies. The policy basis established in these documents also establishes adaptation as an issue of national importance. All of this adds significantly to the scope and remit of urban planning regimes to develop appropriate adaptive responses in urban systems by providing local planning authorities in England with a solid foundation for formulating, developing and implementing locally-appropriate adaptation strategies.

Adaptation through Plan-making

Plan-making is a central planning tool that is used at various levels by urban planning regimes worldwide (Healey, 1998). Written plans are vital to the planning profession as they can facilitate proper planning and sustainable development in a number of ways. These include:

- Providing clear strategic framework for the proper planning and sustainable development of the area over the duration of the plan, consistent with longer-term planning and sustainable development aims;
 - Setting out an over-arching vision for the development of the area to which the plan relates;
 - Giving spatial expression to the planning aims of an area;
 - Providing clear guidance to developers in framing development proposals and to the planning authority in assessing such proposals through the development control process;
 - Protecting and enhancing the amenities of an area.
- (DOEHLG, 2007)

With adequate policy guidance on adaptation, planning authorities can systematically use plan-making to establish a framework for delivering appropriate action (Gleeson, 2008). This important point is noted by a variety of advocates, including the IPCC (2007), who assert that proper plan-making can increase adaptive capacities in urban systems by including adaptation measures in land-use planning and infrastructure design and by including other measures for reducing vulnerability. Dixon (2009) offers a similar assessment, stating that as a strategy, adaptation needs clear plan backing if it is to succeed, whilst Bulkeley (2006) and Wilson (2006) state that it is imperative for adaptive responses to be integrated into local development frameworks.

There are important issues to be considered in respect of creating a plan-basis for adaptation in urban systems. Chief amongst these is where the issue of adaptation can be best addressed through plan-making. Specific questions arise as to (a) whether adaptation is solely a development plan issue, (b) whether separate

adaptation plans may be needed or, (c) whether adaptation may be best addressed through both types of plan. Clean Air Partnership (2007), for example, suggest that there may be a need for both levels of plan development in order to introduce climate concerns and adaptation into planning decisions. Within this approach, adaptation plans serve to establish general priorities in respect of adaptation, whilst development plans distil these priorities into specific areas such as design, land-use, urban form, infrastructure and so forth. Burton et al (2002, p. 157) suggest that effective climate adaptation policy cannot be made on a 'stand alone' basis and must instead be incorporated and integrated into other policies. Within this context, an adaptation plan in itself is unlikely to adequately direct the efforts of an urban planning regime as the policies contained therein may not link to specific areas of planning attention and activity. In other words, an adaptation plan may have some use on its own, but will be more effective if it provides a generalised policy basis for operationalising adaptation through specific urban development plans. It is contended, therefore, that the integration of adaptation strategies into urban development plans can be particularly useful as development plans are central to a plan-led system and are inherently local in scope. Considering the fact that adaptation strategies tend to be best employed as localised initiatives (Willbanks et al, 2003), urban development plans seem to be a particularly useful vehicle for delivering locally-appropriate adaptive action. However, integrating adaptation into development plans may only offer a limited scope for success unless the policies established are underpinned by implementation and monitoring strategies.

Urban planning regimes are most likely to succeed in efforts towards adaptation when the two-plan approach is used. This involves integrating adaptation strategies into urban development plans, whilst also preparing dedicated adaptation plans. Advantages of this approach include the potential for developing specific adaptation objectives based on the particular climate change effects facing the urban system to which the plan applies through dedicated adaptation plans. In tandem with this process, development and design standards can be codified through policies and standards in urban development plans, which are designed to ensure that urban development and redevelopment initiatives possess adaptive capacity. Moreover, by creating dedicated adaptation plans, urban planning regimes can situate adaptation as a separate concern that does not fit with a 'business as usual' approach. This can create the potential for increased stakeholder support and political interest, as well as the potential for securing increased budgetary support that may be ring-fenced to ensure the delivery and implementation of adaptation strategies set out by both types of plan. On these matters, a director of planning policy with an Irish urban council stated during interview that:

The principle of adaptation would need to be part of the development plan. But when it comes to detailed implementation, you might well have to have a separate adaptation action plan that would cross over and take in a number of other disciplines as well.

The nature of climate adaptation as an issue demanding urban responses means that considerable expertise is required in drafting plans and developing implementation strategies. This expertise may go beyond that which is available to planners (Wilson, 2006). The potential for formulating successful plans may be greatly increased when planning authorities invite other professional stakeholders to

become involved and to contribute their expertise to the plan-making process. The matter of who the professional stakeholders might be was raised in all interviews undertaken for this paper. Those most commonly mentioned were engineers, transport consultants, architects, businesses and the emergency services. In terms of a specific approach, it is posited that professional stakeholders can offer most value when plans are being drafted, whilst both the public and professional stakeholders can add value at the review stage. Stakeholder engagement, if properly managed and co-ordinated, may greatly enhance the success of planning's efforts to deliver adaptation through plan-making. However, one interview participant was more reticent about the value of extensive stakeholder engagement:

I get concerned with the language of stakeholders because its too often used as a cover for the lobbies that have taken control of the planning process and in a sense re-situated [sic] it away away a more participatory or democratic process. Too much of planning at the stakeholder level is a problem – it ends up being about business as usual. What is needed now is to mobilise a much more participatory project around planning's response to climate change because [adaptation] is not going to happen without it.

A further matter to be noted is the requirement (in jurisdictions where it is present) that any policies or plans which address adaptation be subjected to strategic environmental assessment (SEA). The purpose of SEA is to 'provide the competent authority with a tool which enables it to be fully aware of the environmental/sustainability issues associated with a particular policy, program or plan (PPP) while the PPP is still being formulated, or at the very least, evaluated before it is implemented' (Therivel and Brown, 1999, p. 441). Strategic environmental assessment should be required for discrete adaptation plans, as well as any other level of plan which addresses adaptation, including development plans. This requirement will ensure that planning authorities endeavour to develop adaptation policies and objectives which do not contribute to further environmental damage.

Finally, it must be noted that plan-based objectives are not always guaranteed success. Many issues may obstruct or interfere with the ability of planning to oversee the transition of plan objectives into any sort of reality (Climate Impacts Group, 2007; Wolf, 2009). Political influence, budgetary constraints and competing needs may impede the ability of a planning system to co-ordinate expertise and develop methodologies for translating plan-based objectives into working adaptation strategies. Additionally, discrete adaptation and development plans may potentially lead to dilution of responsibilities and difficulties with co-ordination and implementation.

Adaptation through Infrastructure and Design

Planning is particularly important in developing and implementing infrastructure and design standards. Infrastructure and design can play an important role in adapting urban systems and improving their resilience to climate change effects (IPCC, 2007; Mueller and Rynne, 2009). Accordingly, planning regimes can have a useful and strategic role in developing urban resilience in respect of climate change effects by promoting certain infrastructure and design standards that have adaptive

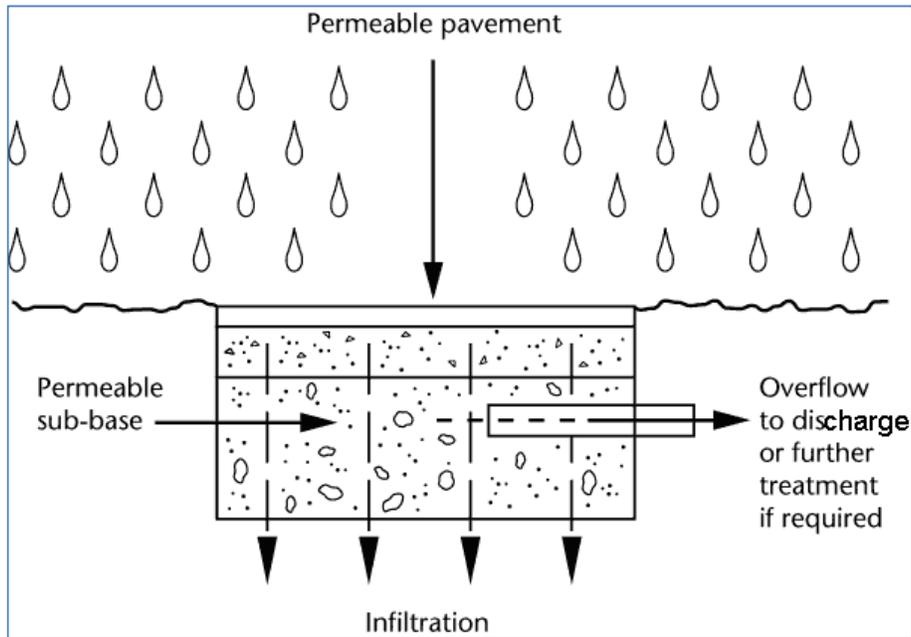
qualities. This section examines some of the ways in which urban planning can achieve this aim. It focuses on the role of planning in promoting porous surfacing and green roofing as adaptive design interventions. These technologies offer a wide degree of adaptive potential for urban systems, including the management of excess surface water and urban heat island effects. As such, they offer significant potential for urban planning regimes seeking to improve resilience through adaptation.

Porous Surfacing

Conventional hard surfacing found in urban areas, such as concrete, asphalt and paving slabs is impervious, preventing surface water from being absorbed into the ground. Many urban systems instead rely on piped systems to rapidly carry away excess surface water. As water gathers on impervious surfaces, it tends to move laterally until it enters a sewer system. Piped systems usually concentrate peak surface water flow into small spaces, leaving the system vulnerable. The systems are designed to capture and 'bottle' surface water run-off to carry it away from affected areas through a system of pipes. When they reach peak capacity, problems can occur. The most severe of these is increased flooding in urban systems as surface water backs up in conventional piped systems. This can overwhelm the system and increase both flood risk and frequency (DEFRA, 2008). Conventional piped systems are becoming increasingly vulnerable as the number of extreme weather events producing rainfall in excess of piped system capacity increases. More frequent storm surges and heavy rainfalls can be particularly problematic, especially when heavy rainfall patterns are characterized by short, intense bursts or result from increased storm activity. These events are becoming more common and look set to be a near universal climate change effect (IPCC, 2007; Lovelock, 2006).

Porous surfacing refers to paving and other surfacing materials that are permeable and so allow the passage of water through the surfacing material and into the ground beneath. Different types of available materials include porous asphalt, pervious concrete, porous turf and open-jointed blocks. These technologies offer a slower conveyance of excess surface water and reductions in water carriage volumes. This can lead to improved flood risk management and better protection of groundwater resources, whilst also benefiting bio-diversity and increasing urban amenity. Porous surfacing can also increase groundwater supplies (DEFRA, 2008). A further advantage is that porous surfacing can potentially be used in a diversity of urban systems. Indeed, efforts to enhance urban adaptation by making porous surfacing an infrastructural and design standard are underway in a variety of cities worldwide. Of particular note is the Chicago Pilot Program, a planning-led strategy that was launched in 2006, with the intention of retro-fitting many of the city's alleyways with porous surfacing in order to increase urban adaptation by reducing the threats brought about by more severe rainfall events (Berg, 2009). Porous surfacing – particularly porous turf – can also reduce urban heat island effects by absorbing and cooling atmospheric heat (DEFRA, 2008).

Figure 1: Porous surfacing technical design



Source: <http://www.netregs.gov.uk/static/images/NetRegs/pavementAKP.gif>, accessed 11.1.2011

The value of porous surfacing technologies was noted during several interviews. A sustainable communities policy advisor stated that:

You'll always need hard surfacing so porous paving and such is the way forward. For more green and nicer looking developments, you can use grass surfaces like swale strips and filter strips. A whole suite of porous surfaces is best. The planning system should be charged with delivering the technology whenever possible.

A climate change and risk policy advisor with the UK Environment Agency argued that:

If you design and implement porous surfacing, you can generate huge positives in urban adaptation and resilience. It's vital that the planning system gets its house in order in this way.

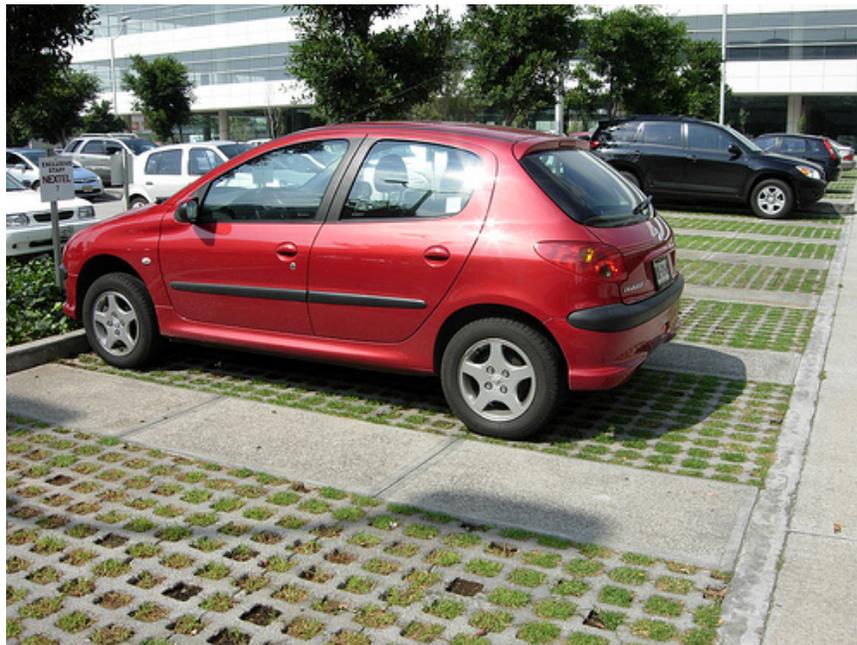
Urban planning regimes may forge a role in increasing urban adaptation by establishing infrastructure and design standards that prioritise porous surfacing. Adapting any urban system to climate change effects requires a variety of responses. Porous surfacing enjoys the advantage of being potentially integrated into most urban systems. Useful locations for installing this technology include outdoor car parks, residential streets and urban plazas. By switching surfacing materials from impervious to porous, large surface areas in urban systems can facilitate increased soakage. With responsibilities for managing, designing, developing and co-ordinating urban built environments, planning regimes are well positioned to oversee the successful delivery of porous surfacing, both in new developments and in redesigning existing urban spaces. Such interventions will

likely improve adaptive capacity, especially in respect of high levels of rain-fall and flood events.

The most important step that planning can take in this regard is the introduction of infrastructural and design standards relating to porous surfacing into development plans and adaptation plans. If urban planning authorities establish a suitable plan-basis for porous surfacing, the development management and urban design process can become central in ensuring a proper roll-out of the technology in new and in redevelopment schemes. Pre-planning consultations can be used to determine in advance the technical and cost issues that porous surfacing can bring to bear on developments. This may be particularly useful in the case of medium to large developments, as it can ensure that adaptation becomes an early concern. In the case of smaller developments, development control may be able to impose relevant requirements in terms of porous paving, for example in driveways and car parks. However, changes in design standards can often encounter resistance from the public and developers. To counter this, planning authorities should take steps to demonstrate the practical, economic and visual benefits of porous surfacing. In doing so, planning can actively try to build support for the technology. This can help ensure a more fluid and effective roll-out of porous surfacing in urban systems, which will, in turn, improve urban adaptation and lead to increased urban resilience. These matters were addressed during interview an urban designer, who argued that:

Changes in design philosophy can be hard to sell to people. If planning can demonstrate that porous surfacing has practical and visual benefits, you can build support for it. Then planning will find it easier to insist on certain technical standards.

Figure 2: Porous surfacing in a car park



Source: <http://www.flickr.com/photos/lisastown/3466645845/sizes/m/in/pool-431210@N20/>, accessed 11.1.2011

Green Roofs

Green roofs are specially engineered roofing systems which are designed to have plants and vegetation growing on their surface. They can potentially be used on many types of building, including residential, commercial and industrial. Traditional roofing materials such as slate, tile and lead are designed to allow rainwater to run off the roof and into sewer systems. This tends to add further stress to water management systems, particularly during intense rain-fall or storm events. With green roofing, rainwater flow is slowed and some is absorbed by the roof itself. This then decreases storm water runoff and pollution into drainage systems as the vegetated surfaces provide a degree of retention, attenuation and treatment of rainwater (Buckwalter Berkooz, 2007). Whilst improved water management is a significant advantage of green roofing, it is not the only way that the technology can be useful. Green roofing has other benefits. These include urban cooling and a reduction of urban heat island effects, as roof-based vegetation lowers the absorption and release of solar radiation, whilst water trapped in foliage increases local humidity and allows cooling via evapotranspiration. Additionally, green roofs can contribute to local biodiversity by providing habitats and food sources for insects and birds. Green roofs can also offer aesthetic value. These points were discussed during interview and one respondent asserted that:

Green roofs have some really big benefits. Biodiversity is one, as well as water management. They are good for attenuating the run-off from storm events and locking up some of it so it doesn't get to the sewerage system. Anything that slows down rainfall from reached piped systems has got to be good, especially in terms of the effects climate change might have on rainfall patterns.

A number of cities have grasped the adaptive advantages of green roofs and have implemented standards which allow local planning regimes to ensure that urban development includes this technology. For example, due to new development standards recently introduced in Toronto (Alter, 2009), the planning system can now utilise the development control process to ensure that new buildings have between 25 and 50 per cent green roof cover, depending on type and use. The planning regimes of Chicago, Boston and Minneapolis have also implemented similar standards (Buckwalter Berkooz, 2007). These examples demonstrate that urban planning regimes can play an important role in delivering urban adaptation through the establishment of infrastructure and design standards relating to green roofs. As is the case with porous paving, these standards will likely work best if integrated into objectives and strategies contained within development plans and adaptation plans. If urban planning regimes undertake this task, they may be better able to regulate and impose green roof standards through the development control and urban design processes. An interview participant noted that:

There has been a trend towards green roofing in some parts of the world. If it has an advantage in terms of absorbing water and thermal regulation, there would be a case for planning in promoting it.

Figure 3: Green roof, City Hall, Chicago



Source: http://www.explorechicago.org/city/en/about_the_city/green_chicago/Green_Roofs_.html, accessed 11.1.2011

It should be noted that based on present expertise and technology, green roofs are best suited to new developments. Retrofitting the technology is less straightforward, mainly due to the extra weight that they place on buildings. This is unfortunate, as planning-led urban adaptation should ideally apply to existing urban development also. However, it is submitted that the many advantages offered by green roofs are enough to offset current limitations around their use. It is also important to note that technologies generally improve and become more applicable as they develop. If urban planning regimes seek to promote green roofs as an adaptive measure, it may increase the potential for innovation and thus, improve the potential for successful retrofitting in future.

Figure 4: Residential green roofing, EVA Lanxmeer eco-village, Holland



Source: Author's own collection

Conclusions

Climate change presents a significant challenge for urban systems worldwide. Its effects will likely intensify over the coming decades. Whilst humanity may be able to take collective action to limit the intensity of these effects, scientific evidence indicates that some are already happening and will continue to occur, irrespective of any ongoing mitigation. Climate change impacts such as increased rainfall intensity, storm surges, flooding and urban heat island effects are likely to effect many urban systems worldwide. These will impact severely on urban systems and the populations and services they support. Adaptation will almost certainly be required in order to cope with these effects. In this regard, it is positive to note that urban planning has the potential to become a key actor in developing and implementing adaptive responses in urban systems. A particular advantage of urban planning is the universality of the profession and the tools available to it. Tools such as plan-making, stakeholder engagement, development management and design standards are available to and used by urban planning regimes worldwide. All of these are important for developing and delivering urban adaptation across a variety of scales.

Urban planning regimes can perhaps best establish an evolving role in adapting urban systems to climate change effects by utilising planning tools in locally-appropriate ways. Plan-making can be an important means of setting out general objectives and strategies for urban adaptation. This can be achieved through development plans and through independent adaptation action plans. These plans may then be used to establish specific, locally-appropriate infrastructure and design standards to ensure that new developments have adaptive capacity and that existing developments can be adequately retrofitted. In doing so, planning regimes can

establish a basis for integrating urban adaptation into the development management process and into planning-led urban design schemes. This can establish a firm basis for adaptation and can ensure that it is delivered as part of both public and private development. The fact that a number of planning jurisdictions are already engaged in this process further demonstrates the important and evolving role that urban planning has in building climate resilience through adaptation.

It must be noted that whilst planning can have a key role in developing and delivering urban adaptation, it may struggle in the absence of adequate political, policy, financial and professional support. It is important that central and local government, developers, the public and other professions recognise the need for urban adaptation and endeavour to engage with the planning profession on a variety of levels in order to contribute to successful adaptation efforts. Without this support, planning may well struggle to develop and implement meaningful adaptive measures. Often, support for new approaches and strategies can be absent until there is a clear need for them. In respect of the need for adaptation, it is submitted that early action can lead to better results and that a 'wait and see' approach may ultimately prove damaging and costly. In short, planning will likely deliver most advantage in urban systems where it benefits from clear, early and wide-ranging support for the development and implementation of adaptation.

In conclusion, preparing for and attempting to manage climate change effects is becoming a key urban planning challenge for the 21st century and potentially beyond. As the world's population becomes more urbanised, planning efforts in respect of managing climate change effects will require a particular urban focus. In this regard, adaptation is likely to feature prominently and the development of adaptive responses will become a central urban planning concern. This will have profound impacts on the planning profession, as well as on infrastructure and development standards and technologies. In order to generate best-case results in terms of urban adaptation, urban planning itself may need to adapt to new requirements, boundaries and limitations. This much is certain: climate change and its effects will present many new challenges for urban systems and for urban planning. The ways in which planning reacts to these challenges will condition the form, function and perhaps, survival, of urban systems worldwide.

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