Adapting to climate change in the compact city: the suburban challenge

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Abstract: This paper sets out the challenges of adapting suburbs for climate change in the context of the compact city agenda. We argue that while the compact city debate does address mitigating climate change at a strategic level, it does not specifically consider adapting existing suburban areas to cope with anticipated changes. We discuss the possibilities for, and challenges of, suburban adaptation. In terms of the built environment, such challenges include: difficulties retrofitting existing housing stock, the fragmented ownership and management of land and housing, and the slow pace of change in suburban areas. In terms of mobilising social change to affect adaptation, problems of coordinating multi-actor partnerships, developing political will, generating public acceptance, and encouraging behaviour change are identified. We conclude that suburbs pose unique challenges for realising transformations, and that the 'sustainable development' and 'climate change' discourses have yet to be fully integrated in light of potential conflicts between mitigation and adaptation measures.

Keywords: climate change, compact city, adaptation, mitigation, suburbs (suburban, suburbia)

Introduction: climate change, the compact city and suburbs

This paper sets out the challenges of adapting suburbs for climate change in the context of the compact city agenda. By suburbs we mean the predominantly residential areas of cities, excluding the city centre (or core), including both inner- and outer- suburbs. The compact city idea gained traction in academic and policy-making circles in the 1990s and has subsequently dominated the sustainable urban form debate (Jenks et al. 1996; Neuman, 2005). Advocates of the compact city promote it because it addresses a raft of economic, social and environmental problems facing cities (for example, see Newman, 1992; Katz, 1994). Largely as a response to poorly planned urban sprawl (as manifested most strikingly in some North American and Australian cities), intensification policies have been adopted in many cities worldwide (see advocacy of compaction policies in American Planning Association 1999; European Environment Agency, 1998, United Nations 1992, quoted in Neuman, 2005). While these policies have been framed by 'sustainability' discourses, the more recent ascendance of the 'climate change' discourse means there is a need to revisit the compact city agenda to test its appropriateness. Although the rationale for transitioning to more compact cities has often been tied to reducing greenhouse gas emissions (Newman & Kenworthy, 1989; Breheny et al. 1998), climate change requires a focus on both slowing climate change (mitigation) and adapting to the anticipated impacts of it (adaptation), the latter of which has not received much attention until recently (Blanco & Alberti, 2009). Mitigation and adaptation may require differing responses in terms of urban form.

We argue that there has been little integration between 'climate change' and 'sustainable urban form' debates, which may have consequences for cities in the future. In particular we argue that the compact city discourse is problematic in two ways. First, it has focused on issues such as the efficient use of land and infrastructure, reducing travel by energy inefficient modes, equitable access to employment and services, the support of vibrant social and cultural life, and more recently healthy lifestyles (Neuman, 2005; Song and Knaap, 2004; Handy et al. 2002). The debate has not specifically focused on climate change and what the anticipated changes may mean for urban form. While compact city advocates have shown strategic interest in reducing CO_2 emissions and helping to slow climate change, they have not directly addressed mitigating or adapting to its impacts, particularly at the local level.

Second, the compact city debate focuses mainly on inner urban areas and omits (or vilifies) suburban areas (Breheny, 1996; Stretton 1996; Neuman, 2005). Suburbs are seen as the antithesis of the desirable 'compact core' of city regions. Suburban, or sprawling, areas have been portrayed as individualised, single-use, wasteful places, where a combination of lifestyles and the built environment compound the social and environmental problems that cities face (see Jenks et al, 1996; Williams et al 2000; and Neuman (2005) for a discussion of these issues). Some compaction advocates have suggested that suburbs could be intensified, others have re-envisaged suburbs as 'sub-cities', with mixed-use transit-oriented urban villages within them, offering a degree of self-containment from the larger city area (Newman, 1992; Calthorpe, 1993). These new directions for suburbs have predominantly been applied to new greenfield developments and the redevelopment of brownfield sites, with less attention given to how the existing suburban fabric can be reinvented and modified (for an exception, see Curtis, 2006).

These positions within the compact city discourse have serious implications for the planning and management of cities. We argue that mitigating and adapting to climate change need to be seen alongside other objectives in the sustainable urban form debate. The traditional compact city objectives are important, but the climate change agenda may mean that new concerns focused on environmental change need to be prioritised, particularly in suburban residential areas. Land may be required for use in different ways in neighbourhoods of the future. For example, rather than promoting high-density housing and urban infill, space may be needed to provide cooling, and blue and green infrastructure in suburbs (Gill *et al,* 2007). In this context, there may be tensions between mitigation and adaptation measures, which will require further investigation.

In addition, we suggest that the sustainable urban form debate cannot continue to problematise or isolate suburban (or non-central) areas. In terms of urban form, we are not faced with an 'either/or' situation. Suburbs are a major part of cities: they already exist and will continue to do so for the foreseeable future. In most developed countries, suburban areas contain the majority of urban housing, and will be the places where the domestic life of the population will be affected most acutely by climate change. Hence, compact city advocates (including policy makers) need to recognise suburbs as, potentially, part of the solution to creating sustainable urban areas, not just as part of the problem. Successfully modifying the existing built fabric of cities in the light of these multiple objectives needs to be the focus of attention.

In this paper, we argue that an integrated approach to sustainable urban form is required that considers climate change impacts across the city and its suburbs. As a contribution to this approach, we offer a conceptualisation of the challenges of adapting suburbs to mitigate, and accommodate, for what is now considered inevitable, climate change. We also highlight how these challenges 'fit' with contemporary thinking on compact cities. The paper is divided into three sections. The first sets the context for suburban adaptation in the UK. The second section identifies the key challenges of adapting suburbs, and the final section offers some concluding thoughts on the future of the suburbs in the context of the compact city agenda.

Suburban adaptation in the UK: the context

The nature of the UK's suburbs: Suburban areas in the UK are home to 80% of the British population. In comparison to suburbs in the USA or Australia, they are medium density, although by many European standards they are considered to be low-density. Many of these suburbs are energy- and land- rich, with built form layouts that encourage car use and discourage walking and cycling (HoC, 2008). Suburban areas are characterised by a number of different building and morphological types, largely reflecting the periods when they were constructed. Predominant types in the UK include historic inner suburbs, planned (post-war) suburbs, social housing suburbs, suburban towns, public transport suburbs, and car suburbs (URBED, 2007).

The oldest suburbs tend to be located within close proximity to inner cities. They tend to be characterised by medium to high-density properties, often terrace housing, with small amounts of outdoor space (English Heritage 2007). The outer suburbs have a wider range of housing types. Most UK cities have a large number of areas made up of semi-detached and detached properties built from about the 1920-30s onwards. These properties offer family accommodation at relatively low densities with larger amounts of outdoor space and usually room to accommodate a car. These areas traditionally have communal parks, tree lined streets and grass verges in and around the residential areas that are managed by the local authority.

The UK's suburbs have experienced significant change since the 1980s as a result of housing growth, government-led regeneration initiatives, and changes to properties by landowners. Housing growth has been accommodated largely in an increasing number of new ‘car dependant’ housing estates around the perimeters of UK cities. These suburbs reflect a move towards the Australian and American model, and are characterised by commercially developed housing estates (often with similar housing types), which are largely disconnected to existing road networks, public transport links, and commercial and leisure opportunities. Government-initiated changes have mostly taken the form of regeneration of some inner suburbs, and residential dwellings in suburban or urban fringe brownfield sites (Williams, forthcoming) whilst landowner-initiated changes have included the redevelopment of backyards for additional housing, housing extensions for single homes, and the subdivision of large Victorian family homes into smaller flats for multiple occupation (English Heritage, 2007).

The UK now has a recognised housing shortage, and 240,000 additional homes a year are planned, totalling 2 million new homes by 2016, with a further 1 million planned by 2020 (DCLG, 2007:7). The Government has identified specific growth and regeneration areas in England to accommodate a large proportion of this housing. However, it is estimated that existing suburbs will have to accommodate another 2.5 million people by 2025. Given this planned growth, there is a real danger that climate change impacts will be exacerbated: hence the imperative to both build sustainable new developments, and remodel existing suburban areas to maximise the benefits of additional dwellings.

Climate change in the UK: The UK is particularly vulnerable to climate change due to its location between the continental climate of Central Europe and the maritime climate of the Atlantic. Its climate is expected to experience complex changes in temperature, precipitation and wind patterns, cloudiness and humidity, and sea level rises (Sanders and Phillipson, 2003). In terms of impact on urban areas the magnitude of changes, the rate of change and the variability of extreme events will be significant (CURE, 2004). Predictions are for increased temperatures, changing precipitation patterns and an increase in storms (*op cit*, 2004; UKCIP09). Although these changes will impact the country as a whole, cities and towns will be more acutely affected because of population concentrations and urban micro-climates (Watkins *et al,* 2007). Within cities, suburban areas may see varying impacts due to, for example, heat island effects, localised poor air quality and increased humidity. Whilst these impacts may not be as marked as in denser central areas, their human impact may be worse because of the numbers of people exposed to them (for longer time periods) in residential areas.

The potential impacts of climate change in suburbs: Suburban lifestyles and property will be affected by these climatic changes. Suburban residents will see changes in their levels of comfort, their health, and quality of life. There will also be impacts on the built environment, the economy and property markets. Some of the key impacts are set out below:

Comfort, health and quality of life: suburban homes (indoor environments and gardens) may become overheated and less comfortable, causing people difficulty with domestic activities and sleeping. Gardens and public green space may deteriorate in drier summers, putting strain on water resources to maintain them. In extreme cases vulnerable groups, such as older people, the very young, the chronically ill and those in poor housing may suffer heat stress resulting in ill health or even death (35,000 people died in the heat waves across Europe in 2003; 2000 in the UK, Bhattacharya, 2003). The phenomenon of heat islands, caused where urban areas have little natural cooling systems such as green infrastructure, and compounded by the increased presence of air conditioning outlets, will create localised impacts of extreme temperature rises. Some predict that this may result in greater social inequalities in the form of a new ‘cool poor’ whereby those unable to afford air conditioning will be faced with extreme rises in temperature that they are unable to avoid (ARCC 2009). Air quality in homes may be reduced due to increases in humidity (and consequent mould) causing respiratory problems. Outdoor public spaces (streets, parks and suburban centres) may also become prohibitively hot or wet, lessening people's willingness to go outside to exercise, walk and cycle, and take part in activities that generate social capital.

The built environment, economy and property markets: Suburban infrastructure and homes may be damaged by excessive wind, rain and flooding. Prolonged drier spells could result in increased property subsistence and demand for air-conditioning systems. This could make investments in built stock less stable. Insurance costs could increase (or insurance may become unavailable), and many suburbs may become less desirable or marketable. Some suburbs could be abandoned by those who can afford to leave, creating an equity crisis, similar to that warned by the Australian Institute of Architects (2009). Furthermore, productivity could also be reduced in hot weather, as suburbs are now key locations for economic activity, especially associated with small businesses and home workers (employers lost £168 million per day in the heat wave of 2006) (Land Use Consultants *et al*, 2008).

Suburbs will also be significantly affected by the impact of peak oil. Although there is some contention over the specific time when this will occur, it is now largely accepted that the world’s oil resource will deplete significantly in the coming decades. This will impact most profoundly on those that are dependant on petrol and diesel motorised vehicles, making car-dependant suburbs particularly vulnerable (see Dodson and Sipe, 2008).

As a result of these predicted impacts, there is now a general acceptance that suburbs will need to adapt to reduce further impacts of climate change and also to withstand ongoing changes, but very little attention has been paid to how this can be done in the UK. Neither is there much anticipatory adaptation activity in suburbs 'on the ground' (ODPM, 2004). This situation has led to polarised views about the future of suburbs. Some commentators have predicted a ‘renaissance’, where suburbs revitalise themselves, through built form adaptations to respond to climatic impacts. Others have warned of the 'death of the suburbs’, resulting from their residents' denial of environmental change, reluctance to adapt the built environment, and rising energy and transport costs (Building Futures, 2004).

Key challenges in adapting suburbs

One of the key challenges faced in dealing with climate change in suburbs is a lack of understanding or conceptualisation of the challenge. Despite the urgency of problems facing these areas, suburban adaptation is largely absent from both research and policy agendas in the UK, where the focus has been on:

- Either urban areas or rural locations, with little attention to what is 'in between'. This is particularly true of planning policy, which has policy fields for 'urban' and 'rural' areas (URBED, 2007, Johar e*t al*, 2007);

- Climate change adaptation in new-build developments, with a lack of attention to existing housing stock. Many commentators have identified the disproportionate interest in low energy new build and new sustainable settlements, to the detriment of analysis of the adaptation of existing stock (CABE, 2007; House of Commons, 2008; Land Use Consultants *et al*, 2006);
- Adaptation of individual buildings (mainly, residential and offices), but not groups of building, or mixes of building types in different settings (SKCC, 2008);
- Purely technical adaptations to buildings, which are usually treated in isolation from each other, and do not consider feasibility (Sanders and Phillipson, 2003, CABE, 2007); and
- Top-down approaches to change in the built environment, concentrating on what industry or governments can or should do, in isolation from any consideration of practical or acceptable measures, or any account of 'bottom-up' changes from communities (Kochan, 2007).

Very recently, there have been several reports on the urgency of suburban adaptation (URBED, 2007, Shaw *et al*, 2007, Johar *et al*, 2007). These call for a better knowledge base, but have not yet been matched by a research or policy response. As a contribution to this knowledge base, we set out below the unique contextual factors associated with change in suburban areas.

The nature of change and potential adaptations in suburbs: Although built environments change relatively slowly (about a 1% change per year), incremental adaptations take place continually in suburbs (Williams, 2007). Small scale changes in suburban environments can add up to significant modifications in built forms over periods of 20-30 years (McManus and Ethington, 2007). The trend for building extensions and conservatories and paving over front gardens, for example, has had a major impact on the amount of green space available in the UK's suburbs, to the extent that there is now legislation to protect some areas from such change. In addition, many suburbs may be the location for large scale housing development over the coming decades.

In terms of adaptations to climate change in suburban areas, these can be quite small adaptations like planting trees to increase shading, installing ponds and domestic rain-water systems, improving passive ventilation and insulation, ensuring additions and extensions to homes include resilient ducting, cabling and drainage. Alternatively adaptation measures could be larger, and focused on the public realm. These could include providing additional public open space and 'green and blue' infrastructure, installing sustainable urban drainage systems, and greening of public spaces.

Table 1 below presents some examples of adaptation strategies possible at the individual building and outdoor (garden or neighbourhood) scales, and the associated climate change adaptation objectives. The examples are appropriate at the suburban level and can potentially be retrofitted for existing suburbs as well as incorporated into new build developments. Some of the strategies require relatively minor changes to the built environment, whereas others signify large scale capital and physical investments. As yet, in the UK there is no mechanism for identifying the nature and scale of adaptation appropriate in any given suburb, and no means of devising an action plan, or resources to affect change. There is little knowledge about appropriate adaptation scenarios, in particular about the feasibility of implementing many of these actions.

[Table 1]

The agents and institutions of change in suburbs: In addition to a complex pattern of adaptation options, a disparate and potentially incompatible range of actors are required to implement suburban adaptation. Suburbs, far more than urban centres, are 'co-produced' over time by homeowners, public bodies, and private companies, through the dual processes of *autonomous* adaptations (i.e. those done by private householders, or companies, for their individual benefits) and *planned* adaptations (undertaken by public bodies, usually local authorities, for the public good). In addition, suburbs may also, on occasion, be partially adapted through *communal* actions by residents (Sanders et al, 2003). Hence, there are a number of important change agents in suburban areas, which could contribute to adaptations.

Yet, there are significant gaps in our knowledge around processes of the social or institutional capacities for change, the nature and extent of 'public' adaptation behaviours of the built environment, and how people and institutions behave given different drivers, such as climatic conditions, costs, or the visual impacts of change. Understanding these issues is necessary to identify the most appropriate governance processes for implementing change in the suburbs. While it has been recognised that stakeholder involvement is important (Burton *et al*, 2002; Metz *et.al*, 2007), there is less clarity on what form this involvement should take, e.g. public-private partnerships, stakeholder advisory groups, community consultation, etc. There is also a lack of knowledge of the overall governance processes required to implement adaptations in the suburban context, which may require a combination of top-down social change mechanisms such as government regulation, incentives/disincentives, education (Vago, 1999) and social marketing (McKenzie-Mohr, 2000), grass-roots action by local communities (Mander and Goldsmith, 1996) and/or collaborative approaches (Healey, 1997).

The anticipatory and long term nature of change required: Confounding the complexity surrounding the agents of change is the fact that suburban adaptation needs to be anticipatory, rather than reactive (Mendelsohn, 2000). However, it is well established that there are serious problems in getting people to act in anticipation of predicted climate change. This is the case for both autonomous and planned adaptations, and is a particular problem in 'capital intensive' sectors, such as the built environment (Few *et al*, 2006). People and institutions find it difficult to allocate resources to problems they believe either may not materialise, or are so far in the future that they cannot envisage the consequences. In addition, suburban areas tend to be poorly equipped in terms of management, ownership and institutional capacity for long term thinking about planned or communal changes. Existing political cycles do not sit easily with the farsighted perspectives required to make anticipatory changes. Currently, municipal leaders tend to be required by their electorate to concentrate on immediate issues, rather than commit time and resources to future changes.

Conclusions: suburban adaptation and the compact city

In transitioning towards more compact cities we argue that suburban areas will be a site of major change, and it is important to ensure that these changes are considered alongside the climate change concerns of mitigation and adaptation. Although the compact city is positioned within the sustainable urban form debate, the sustainable development and climate change discourses have not yet been integrated fully and there may well be conflicts inherent within these discourses.

The compact city agenda concentrates on a strategic argument for change in urban form. While this agenda is seemingly compatible with the climate change agenda because it seeks to reduce CO_2 emissions some of its policies for achieving more compact city forms may limit the capacity for built environments to be adapted to cope with anticipated changes in climate. Adapting built environments to respond to such changes, ranging from sea level rises and temperature and precipitation changes to extreme climate events, requires a new focus at the local and regional levels (Blanco & Alberti, 2009). We argue that the different geographical scales of interest in the 'climate change' and the 'compact city' discourses means that there could be conflicts between mitigation measures undertaken at the city level and adaptation measures implemented at the local level, particularly in the suburbs.

Aside from the important issues surrounding the integration of sustainable development and climate change discourses, many of the challenges for adapting suburbs lie in the 'how' of achieving change both in the built environment and in the actions of social change agents. In terms of the built environment, these challenges include: difficulties retrofitting existing housing stock, the fragmented ownership and management of land and housing, and the slow pace of change in suburban areas. Mobilising social change presents its own challenges, including coordinating multi-actor partnerships, developing political will, generating public acceptance, and encouraging behaviour change. Advances in all these areas will be required to enable suburbs adapt to and mitigate climate change.

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Table 1: Key examples of adaptation methods for buildings and outdoor spaces to reduce the impacts of climate change in suburban areas

Adaptations to buildings	**Adaptations to outdoor space (garden and neighbourhood scale)**
Elevation of properties – to protect them from alluvial and fluvial flooding, and to provide cool covered outdoor space	*Planting of drought resistant and moisture retaining tree & shrub species* – to provide shading, cooling, evapotranspiration, a reduction in rainwater run-off, increases in bio-diversity, soil moisture retention, and decreased soil nutrient erosion, and reduce building subsidence
Demolition of properties - to remove flood risk on flood plains, to release productive land, to create land for run off, *to* remove car dependant areas, to create opportunity for green infrastructure, and to increase biodiversity	*Construction of ponds and reservoirs* – to increase-evapotranspiration, CO_2 absorption, drought prevention, increase bio-diversity and establish localised cooling
Construction of conservatory extensions - to create the opportunity to capture and utilise passive solar gain, to provide indoor growing areas with potential for food production and to improve indoor air quality	*Installation of reed beds* - to reduce the impact on sewerage systems, to decrease the life cycle energy cost for water treatment, to provide wetland habitats and increase biodiversity, they also have the potential to be implemented adjacent to existing infrastructure
Installation of canopies - to increase shading and cooling both within properties and externally	*Construction of SUDS* - to enhance water containment, reduce alluvial flooding and increase bio-diversity
Installation of 'green roofs' – to improve biodiversity, to reduce rainwater run-off, to increase CO_2 absorption and evapotranspiration and to reduce UHI effects *Installation of 'white roofs'* - to increase albedo, and create conditions for localised cooling	*Increase sewerage capacity* –to enable the service of increasing numbers of properties, and to withstand more frequent and intense weather impacts, which in turn would prevent contamination of the surrounding environment and properties
Installation of passive ventilation - to aid cooling, improve air quality, reduce air-conditioning use and associated UHI[1], and improve internal temperature control	*Construction and reinforcement of flood defences – (Hard) - embankments, walls, weirs, sluices and pumping stations (Soft) mudflats and saltmarshes* - to reduce rainwater run-off, increase bio-diversity, and protect key infrastructure to enable the maintenance of normal services during extreme weather events
Installation of grey water and rain water capture systems – to decrease the life cycle energy cost for water treatment, and decrease demand and cost.	*Removal of non-porous driveways and hard standing* – to reduce rainwater run-off, and slow down ground saturation and flash flooding
Installation of solar panels (photovoltaic and thermal) - to reduce fossil fuel use, increase energy security, to provide a financial payback from grid, and decrease national grid demand, and decrease household boiler use	*Development and conservation of green space (parks & woods)* - to improve soil moisture, biodiversity, reduce rainwater run-off, increase CO_2 absorption, and evapotranspiration and share cultivable land and to reduce UHI by cooling and shading
Installation of insulation - to reduce the number of cooling degree days and heating degree days by stabilising internal temperature, to improve energy efficiency, and increase cost savings	*Restoration of green front gardens* – to reduce rainwater run-off, alluvial flooding prevention, increased bio-diversity and provide an opportunity for home grown food
Installation of wind turbines - to reduce fossil fuel use, increase energy security, to provide a financial payback from grid, and decrease national grid demand, and decrease household boiler use	*Development of allotments & garden plots* - to encourage local 'organic' food production, reduce food miles and encourage health benefits such as healthy eating and physical exercise, protection from food price rises associated with higher climate taxes and peak oil
Installation of ground source heat pumps - to reduce fossil fuel dependence and increase energy efficiency	*Integration of composting facilities into public and private outdoor space* - to reduce waste, encourage local food production and associated economic and health benefits
Installation of bio fuel powered boiler system - to reduce fossil fuel use, increase energy security, and decrease national grid demand, and decrease household boiler use and utilise waste products	*Installation of waste to energy plants* - to produce useful energy bi-products from waste, reduce landfill and harness methane for energy and reduce the build up of methane in landfill sites
Provision of property flood gates & sand bags - to provide a fast flood defence which can be installed on demand by property occupants	*Installation of local/ district heating (e.g. CHP2 units*) - to improve energy efficiency, decrease fossil fuel dependence and centralise and therefore maintain and protect heating facilities from extremes weather events and decrease costs and fuel poverty
Provision of resilient ducting, water resistant sealants, pump and sump systems, flood skirts/barriers, one-way valves improved storm proofing and increased maintenance – to minimise flood and excessive wind damage and ensure rapid repair of properties following extreme weather events	

[1] UHI - Urban Heat Island effect
[2] CHP - Combined Heat and Power units