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The absorbent city: urban form and flood risk management

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Cities have always been built in hostile and harsh environments. Technological advances have helped increase the safety and security of their inhabitants and, to a large extent, have divorced the urban area from local environmental constraints. However, the dominance of economic issues in the development of urban form has created a legacy of exposure and vulnerability to flood risk, and a growing recognition of the limitations of this methodology has led to a desire to manage flooding in a way more in harmony with nature. This paper contends that, with regard to flood risk management, there has been a transition from self-protection to engineered defence to the current ideology of natural management, which provides a driver for consideration of the nature of an idealised urban form that is more resilient to flood risk, designed to absorb water and minimise damage. The paper identifies reflexivity, knowledge and adaptation as the three underlying principles of a theoretical 'absorbent city' and aims to stimulate debate by describing the potential urban form of a flood-resilient urban area, according to geographical and climatic constraints. Adaptive measures needed to help increase resilience are also discussed.

1. INTRODUCTION

And on the pedestal these words appear:
'My name is Ozymandias, king of kings:
Look on my works, ye Mighty, and despair!'

Ozymandias (Shelly, 1818)

The overriding message of Shelley's Ozymandias is hubris, designed to emphasise the transience of civilisation when compared with time and the power of nature. This central theme further argues that the built environment and human activity are limited and constrained by external factors, most notably local environmental risks. The nature of specific threats and the available technology and knowledge may alter mitigation strategies and successful settlements have attempted to adapt to risks by altering urban form and function. For example, after the Great Fire of London in 1666, an increased awareness of the vulnerability of the city to this hazard resulted in the first bylaws introduced to regulate building design to inhibit the spread of fire. The desire to examine urban form and function with a view to working towards a more advantageously designed city also has a long and well-defined history. Aristotle's *Politics* discusses the nature of an ideal city with regard to aspects such as its site and construction, while more contemporary movements, such as new urbanism and smart growth, have questioned the current development paradigm and highlighted the need to think more strategically and long term.

Although contemporary hazards may differ from those of antiquity, history demonstrates that the development of design-led solutions and intervention strategies to manage risks have always had a symbiotic relationship with urban living. However, we need to ask ourselves why, in an age of unparalleled knowledge and expertise, do we arguably have the highest ever exposure and vulnerability to hazards, especially those of an environmental nature?[1] The factors that have influenced the nature of current urban forms and functions have been predominately economic in origin, and in developed cities environmental risks have been addressed from a technocratic perspective or underwritten by economic tools, such as the availability of state or private insurance. The perception that risk can be effectively managed and that engineering can remove environmental constraints is now being questioned in the face of a rising incidence of 'natural' disasters.[2]

The rising trend towards urban living and the escalating costs of hazardous events has resulted in a growing awareness of the need for modern cities to adapt to their local conditions to manage environmental risks more effectively in the face of a changing climate.[3] Where urban areas were once seen as a place of safety, cities are now the hub of modern risks and there is a recognition that urban development patterns have profound implications for managing hazards. This paper argues that the current vulnerability to flooding is the result of historical development paths, and that our exposure and vulnerability to flood risk during the 21st century will depend on how we act now and in the near future. This work aims to stimulate debate in this area by investigating the potential for spatial planning to assist in the development of more resilient cities, with particular regard to the ability to manage flood risk more effectively. It investigates the principles underlying an idealised urban form and function of an 'absorbent city' and discusses the ability of spatial planning to move towards this goal.

2. FLOODING AND THE CITY

Historically, floodplains have been attractive places for settlements. They have inherent advantages in terms of defence, food, transport, power and water supply, while silt deposits make agricultural land very fertile. However, the location of developments in these areas brings the risk of flooding, as periods of intense precipitation can cause watercourses to follow their natural processes and utilise floodplains. Flooding therefore has always been one of the most frequent natural risks; the UK's River Severn, for example, was first recorded as flooded in 1258 and there is a clear history of inundation ever since.[4] Prior to the 17th century, historical records indicate that lowland settlements were wisely located above areas subject to episodic flooding. However, the impact of the first drainage engineers altered long-held perceptions and the view that technology could tame nature started to become more widespread.[5]

The geographer Gilbert White is commonly referred to as the father of floodplain management.[6] In his influential 1945 dissertation,[7] White argued that 'floods are an act of God, but flood losses are largely an act of man' and provided the first real academic critique of lack of foresight in this field, setting the foundation for a more resilient city. At the time, there was essentially a process of self-protection with regard to flooding, with no mechanism for large-scale central management aimed at increasing resilience and reducing risk. Two years later, the formation of the land use planning system marked a step change in the ability to influence flood risk in the UK. Potentially, the negative impacts of precipitation could now be regulated, but it would take some time for effective and sophisticated flood risk orientated planning to emerge.

Although small-scale periodic flooding had been a possibility for many towns and cities, it was the impact of more significant flood events that was the catalyst for a stronger policy interface between planning and flooding.[8] For example, in 1947 a major flood occurred in the River Thames, affecting 2000 properties in Maidenhead, Windsor and Eton. The flood was estimated to have been the worst to affect the country for many centuries and was certainly the first significant flood since the Industrial Revolution and the onset of widespread urbanisation.[9] The severity of this flood resulted in public pressure on government to take measures; the Thames Conservancy Board received recommendations that new development in certain areas along the floodplain should be prevented and when current houses came up for sale they should be bought and demolished. However, despite this planning-orientated measure, during this period the response could be generally categorised as a phase of incrementally increasing engineered defence, centred on engineering solutions rather than planning measures.

The natural advantages of the floodplain and the trend towards densification and urban extensions ensured that floodplain development continued apace, regardless of the potential of the planning system to control these factors. In fact, despite the UK government's release of flood risk guidance circulars in 1947, 1962, 1969, 1982 and 1992, by today's standards the level of planning control over flooding issues was small scale, if not practically non-existent, until the rising consequence of flood events towards the end of the 20th century began to challenge current practices. A review of significant widespread UK flood events in 1998 and 2000[10,11] led to a growing awareness that the impacts of climate change, coupled with escalating housing demand, would require tighter planning controls. This realisation heralded a change in approach, with flood defence becoming flood risk management and a new narrative that society needed to 'learn to live with rivers'[12] and 'make space for water'[13] as a more complete understanding of flood risks and the capacity of society to manage nature effectively emerged. The sustainability agenda was also given increased prominence and there was a general 'greening' of flood risk policies from the European scale downwards, although the actual impact of this agenda on practice is still in doubt.[14]

In retrospect, the management of flooding can be understood as following a three-stage process

(*a*) *self-protection*, mainly characterised by individual response
(*b*) then, the mid 20th century witnessed a period of increasing *engineered defence* in which, although the location of development was loosely controlled, there was systematic construction of hard defences
(*c*) to the current process of emerging *natural management*—as the limitations of the technocentric approach are recognised, land is given back for floodplain restoration and more room is made for rivers.

This current direction creates an interesting challenge for flood defence provision. It argues that we need to work with nature rather than control it, and is accompanied by a scaling back of the traditional emphasis on hard engineering solutions and a more interventionist approach in influencing the form and function of land.

The need to consider an idealised vision of the city—one designed to minimise risk from flooding—seems to gain in importance each year as new flood events (see Figs 1 to 6) and increasing knowledge of the threats of climate change become more apparent. Interestingly the ability of the planning system to think long term and incrementally influence factors such as urban morphology, greenspace provision and building design provides an opportunity to travel towards a strategic, long-term vision of the city region— one with flood risk management at its heart, and urban form and function being in an appropriate location according to hydrologically sensitive principles rather than being driven in a purely socio-economic fashion. From a flood risk management perspective, during the recent past we simply attempted to manage the results of historical unsustainable development patterns by applying mainly technologically driven solutions. But what if we took the problem back to its fundamental principles of geography, climate, land use, urban form and function? The most sustainable way to manage risk is simply to avoid it. Therefore this paper presents a positive view in setting out principles for a long-term vision of the city based on the growing need to build in strategic resilience to flood risk by way of spatial planning and move towards a reflexive, absorbent city.

3. PRINCIPLES OF THE ABSORBENT CITY

The sheer complexity of the city as a place where technological, natural and social components interact provides a multi-faceted foundation of the intricate and integrated character of the absorbent city. Moreover, the sophisticated and potent nature of large urban systems provides inherent advantages to achieving resilience. Cities can access enormous

Fig. 1. Aerial photograph of Tewkesbury, UK, during the summer 2007, floods

Fig. 2. Aerial shot of Gloucestershire, UK, in floods of summer 2007

Fig. 3. The impact of the summer 2007 floods on people and property in the UK

Fig. 4. A view of a UK street in summer 2007

Fig. 5. An attempt to build in temporary resilience during summer 2007

Fig. 6. Temporary resilience to the summer 2007 floods

internal and external resources (e.g. finance, knowledge, networks) to better manage hazards in comparison with other scales of development,[15] all of which increase the potential capacity of a city to respond to threats and be more resilient. Another clear advantage of the absorbent city as an aim for spatial planning is that resilience does not have any specific agenda beyond the pursuit of reduced hazard, vulnerability or exposure. Different patterns of urbanism or growth therefore remain a viable option, provided they meet caveats related to risk, sustainability or uncertainty. This provides a refreshing degree of flexibility and an onus on creative responses for differing settlement patterns, geographical constraints and development requirements. Although this elasticity is a clear advantage, it also provides a daunting level of complexity—at this stage, a concentration on the principles designed to influence flooding resilience can provide a much clearer focus.

Contemporary understanding of flooding and the city links with the concepts of resilience and water management as cities are becoming increasingly at risk and our ability to control flooding is challenged owing to the way in which the built environment is constraining our responses. In short, floods will occur and a key part of the planning system therefore should be aimed at providing sustainable, adaptive responses that increase the resilience of cities and citizens. The paradigm shift towards the natural management of flood risk also logically leads to a discussion of the nature of an absorbent city, and the ability of spatial planning to shape this idealised urban form and function. Moreover, the individualised nature of flood risk affecting various urban areas necessitates the need for a focus on principles, rather than a prescriptive strategy. The following sections outline and unpack each of the main concepts of this synoptic urban environment and begin to highlight a framework and agenda for spatial planning to operationalise change following three main principles: reflexivity, knowledge and adaptation.

3.1. The reflexive city

Reflexivity is essentially connected with the verb 'to reflect' and is therefore concerned with a need to have respect for the past, learn from mistakes and through this process of self-enquiry create knowledge to enable adaptation to current and emerging threats. The reflexive city is therefore aware of cause and effect and has a constant remit for critical reflection, while being proactive in developing positive feedback loops to ensure its future wellbeing. We are living in an age of more visible risk, where individuals and governments have ever more knowledge about the possibility of a seemingly growing number of undesirable events occurring, such as flu pandemics, terrorism or flood risk.[16] Agents who have the ability to act on behalf of cities are numerous, but the foremost are designers and planners as they hold the main power over future development within urban areas. Other key stakeholders include developers, the construction industry, governments and, of course, the public.

The view that areas that suffer repeated flood events are subject to man-made rather than natural disasters has been growing in currency for over 50 years. The present focus on natural management reflects this view and presents the foundation of the reflexive city with regard to flood risk management. Urban areas are not normally designed with flooding in mind. Their urban form is a result of historical evolution informed by political, social and economic factors, which present many challenges for a coherent and reflexive strategy. The absorbent city from this perspective should not be seen purely from a structural standpoint, but should encompass the internal operation of our institutions and their ability to influence resilience elsewhere. A key area here is spatial planning, which is a very effective mechanism to influence the market and instigate a more interventionist approach. Continuation of the current strategy—and a society experiencing frequent flooding—in effect represents a market failure, as insurance is unobtainable in many areas and the state is forced to intervene financially. In addition, the development of a different urban form would not necessarily harm investment and growth; it simply shapes development down an alternative future pattern. Although there is considerable inertia in the built environment, with the lifetime of a typical building estimated to be between 20 and 100 years,[17] any paradigm shift away from engineered protection towards natural management would need to recognise that current patterns of urban form pay little attention towards flood risk and reflexivity is at the heart of this process.

A long-term view would be gradually to adapt the urban form and function within any city to be more sensitive to its geography and move towards a more sustainable pattern of development; not solely determined by socio-economic factors, but also its local geographical, climatic and environmental constraints. Thus far, the focus has been on structural resilience measures to protect against flood risk. This, however, repeats the technocratic mistakes of historic approaches to flood defence and essentially commits future generations to potentially unsustainable defence measures. Resilience to flood risk should be systematically built into the planning process, with a break away from the ad hoc treatment of the past and a move towards sustainable, strategic city-wide solutions based on prevention rather than protection. Furthermore, the seeds of cultural change contained in the natural management approach argue that a paradigm shift away from defence towards proactive action and management should occur and therefore spatial planning needs to adapt to manage the environmental threats of the 21st century.

The ability of the planning system to influence land use and future development patterns over the medium to longer term is vital in any move towards a more absorbent city. Although the overall effects of a change in planning policies and guidance may take decades to be seen, knowledge regarding the potential future impacts of flooding upon cites has been quantified on a much longer timescale and the predicted economic damages for the long term are frighteningly large.[2,18] However, the natural management approach, if followed to its logical conclusion, provides a degree of focus and the conceptual framework of the characteristics of a reflexive, geographically sensitive, flood-resilient city starts to emerge. An ability to understand the nature of the threat to each urban area is a critical foundation of any adaptive strategy. The process of reflexivity provides the awareness of current gaps in knowledge and an understanding of the need to accumulate knowledge to act effectively.

3.2. The knowledgeable city

The foundation of any flood-resilient city is knowledge, both in terms of its generation and effective dissemination. Even though this aspect may be largely outside the remit of spatial planning, there is a clear need for this knowledge to feed into planning and land use decisions, especially over the long term. Knowledge produced by, or contained within, agencies such as the Met Office, the Environment Agency, geological organisations, and water and sewerage providers are all key to assessing risk accurately and informing urban form and function. The main driver within this approach would be to link geographical features more tightly with the nature of development within a city so that the layout and functioning of urban areas can adapt to current risks and predicted future changes in rainfall patterns. However, before we consider how the city might look we first need to outline the necessary information requirements.

Within the UK, there is an ever improving understanding of the areas that flood, as a result of Environment Agency flood risk maps, and the requirement for local authorities to produce strategic flood risk assessments is advancing this knowledge further. As an initial layer of information for an idealised city, a map of areas at risk from flooding provides a good start, but we can go much further. A second layer of information would be connected with mapping green infrastructure, defined as the interconnected network of green spaces that conserve natural ecosystem values and functions and also benefit human populations.[19] Within urban areas there has been a gradual erosion of greenspace as its overall contribution to the wellbeing of a city is often difficult to quantify and therefore undervalued,[20] yet greenspaces can provide vital functions for flood risk management. Although geographical features such as floodplains are currently influencing development decisions, related areas such as greenspace have no real impact on flood risk management despite their significant influence on aspects fundamental to flooding, such as infiltration, evaporation, runoff and storage.[21]

Closely linked to these data is information concerning the underlying ground composition within a selected area. With regard to flood risk, the difference in infiltration potential between sandy and clay soils can be significant and the runoff generation of clay soils can be comparable with that of a highly built-up area,[22] yet this information does not permeate into decisions concerning urban form and function. This means that areas that may currently be designated and protected as greenspace, and therefore perceived to operate as mechanisms to manage flood risk, naturally many actually provide very little benefit in practice. Further, areas of low-density development with significant greenspaces may bring added benefits in water storage and infiltration if sited upon sandy soils, and could therefore be protected from densification.

Although not strictly a geographical feature, a further relevant layer of knowledge is connected with the provision to manage surface water. In the UK, the Foresight report on future flooding stated that there are currently almost two million properties at risk from flooding from rivers, estuaries and coasts,[2] but the events of summer 2007 demonstrated that many people who fall outside these categories are also at risk from flooding owing to inadequate drainage,[23] making the true figure much higher and more unsure. Moreover, while the location and connectivity of the majority of the below ground surface water management infrastructure is well mapped, in some areas there is evidence that the existence of hidden watercourses and inaccurate mapping records make the true drainage capacity much more uncertain.[24] Therefore, accurate modelling information would be needed on all the flow routes of water, from the sources of flooding from watercourses high in the catchment, to the flow paths taken by surface water runoff and the below ground sewer infrastructure. Planners could use this information to consider a variety of aspects, from the need to build in increased storage, redirecting the flow of surface water away from areas at risk or the selection of areas with restricted new development.

A final layer of information would be concerned with the nature of the existing urban fabric. This is, of course, already in existence and it would need to be examined with regard to the presence of both critical infrastructure and vulnerable communities. The absorbent city would be resilient and able to manage flood events with a minimum of impact; the need to protect critical infrastructure, such as power stations and water treatment works, would therefore be paramount. In developing countries, it is commonplace for the most vulnerable to live in areas at risk from flooding, but within developed cities the nature or function of developments has had no real impact on location. Therefore, vulnerable buildings such as hospitals, retirement homes, etc. that may have the least ability to cope with a flood event may be sited in relatively high-risk locations. Utilising this knowledge effectively could considerably affect the impact of any flood event.

The unclear nature of true flood risk, as powerfully demonstrated by the largely unpredicted and extensive intra-urban flooding in 2007, provides a compelling argument for 'built-in resilience' to these hazards and a new responsibility for spatial planning. A society resilient to flooding would also be analogous with a more adaptive, sustainable city that ensures that the location, design and function of future development do not increase future vulnerability. Presently, not all the information covered in this section exists, but the drive to provide planners with increased data, through flood risk assessments or surface water management plans for example, demonstrates that it may not be too far over the horizon. The real challenge will be to link the knowledge with spatial planning so that it can influence urban form and function in a tangible manner. Fig. 7 summarises the theoretical layers of information needed to provide the reflexive city with the tools to adapt to the risk of flooding.

3.3. The adaptive city

3.3.1. Blue infrastructure. Currently, only one of the seven geographical layers of information influences the management of urban form by way of the planning system, yet this is the most high profile and effective. The ability to map the extent of floodplain inundation presents us with our first predictable opportunity to further the absorbent city: a need to tightly manage new development in functioning floodplains. An idealised view of the city would go further, however, and consider the possibility of abandoning areas currently at risk and restoring the natural floodplain in order to create extra storage for flood waters. These newly created areas could be

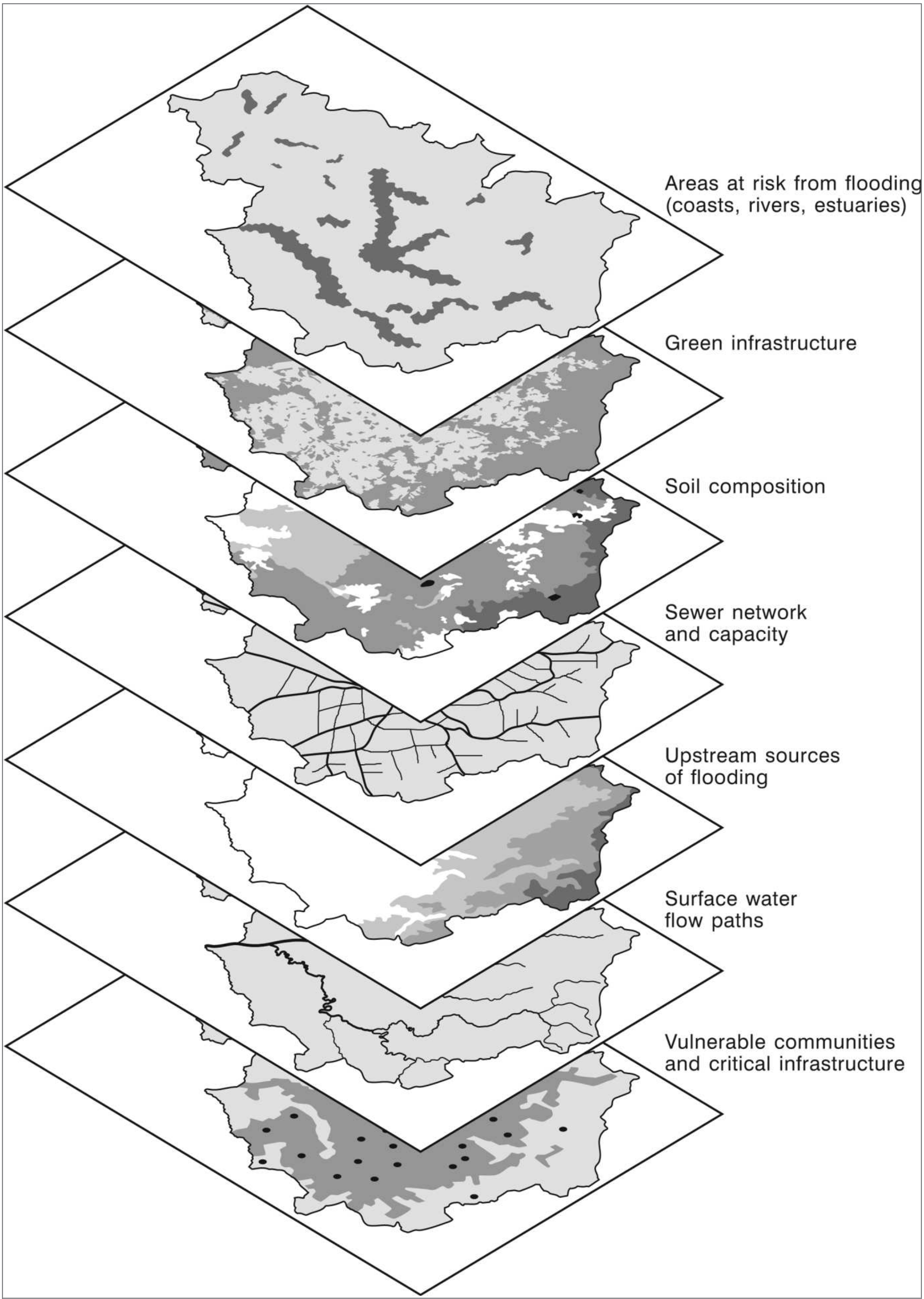

Fig. 7. The differing layers of knowledge needed to move towards an 'absorbent city'

multi-functional green and bluespace, combining flood storage capabilities with recreational and ecological uses. In short, these would function as environmental corridors, or blue belts, to complement existing green belts that are predominately socio-economic constructs effective at controlling urban sprawl, but may not contain a high ecological or amenity value.[25]

Where areas at risk from flooding are impossible or inappropriate for floodplain restoration, perhaps owing to being the core of the city, measures can be taken to develop resilience. New development in these areas could be subject to tighter building controls advocating design features such as habitable spaces starting on the first floor above parking provision, while existing buildings could be altered either by owners themselves as a preventative measure or by insurers after any flood event. Retrofitting design features can reduce the vulnerability of people and places to flood risk impacts by protecting properties from inundation by way of the erection of temporary defences or the covering of air bricks. If inundation is unavoidable there are a number of existing methods that can reduce damage and lessen the time for repairs to take place. Examples include wet proofing, the siting of electrical networks at a higher level and the use of differing material for floors and cupboards.[26] Therefore, spatial planning can positively influence human resilience by minimising the impact and increasing the ability to cope.

3.3.2. Green infrastructure. With regard to greenspace provision, an initial planning aim would be to ascertain which areas are both currently designated as greenspace and sited on sandy soils. These locations are actually operating as a natural drain, absorbing water at a relatively high rate and where their value is high in this respect they should receive added protection within spatial planning. Furthermore, areas that have sandy soils could be considered as appropriate locales to create new greenspace when determining the shape of the urban form over the medium to long term, and new development in these areas could be prohibited once the lifespan of existing buildings comes to an end. Presently, there is an almost automatic assumption that brownfield sites should be regenerated. However, if they are performing valuable roles in managing water owing to their underlying soil structure, consideration should be given towards integrating them into the greenspace network of a city.

In order to best maximise the ability of the green infrastructure to manage flood risk, we should also plan the network to operate in a strategic fashion. For example, in addition to infiltration, evaporation or storage functions, greenspace should be designed to operate as both temporary flood storage and as a safe flood pathway to transport water into areas with little or no consequences. Its ability to bring substantial wider sustainability benefits, such as with regard to the environment or the amenity, should also not be underestimated. Greenspace of various functions can be designed to store flood water if sited and designed correctly, and information on upstream sources and runoff models can assist with this aim. An example is in Greater Manchester, where Sale golf course and an adjoining nature reserve alongside the River Mersey are utilised for water storage in times of high precipitation, providing a good example of the multi-functional use of land and an insight into the ideal land use of an absorbent city.

Densification is usually a problematical subject for sustainable flood risk management. While policies to increase urban density may deter the release of new building land elsewhere, development also increases the volume of runoff in general. The reflexive, knowledgeable city would recognise this apparent contradiction and ensure that existing urban areas could be adapted to better manage precipitation. Where sandy soils underlie the city, we could usefully promote the unsealing of hard surfaces in order to promote infiltration and limit runoff. There are many possible areas for this, such as car parks, urban squares or locations with low public usage.
A further measure would involve improving the multi-functionality of our existing infrastructure. Transport networks such as motorways, railways and ring roads could be designed to be at a lower level and operate as sacrificial storage areas in times of excessive precipitation, as the damage would be at a much lower level as long as adequate warning systems were in place.[2] Figs 8 and 9 demonstrate the impact of severe flooding on transport infrastructure.

3.3.3. The built environment. While there is simply no need to develop specifically on a floodplain as there may have been over preceding centuries, there is still a need to provide safe and sustainable land for new development. Utilising the principle of siting the most appropriate land use in the best location, undeveloped land that is presently not fulfilling a role in flood risk management or does not have high ecological value could be considered for development. For example, areas

Fig. 8. The impact of the 2007 floods on rail infrastructure

Fig. 9. Road infrastructure affected by the flood of summer 2007

of greenspace on clay soils may be released for development, dependent upon their having no significant ecological functions that could not be replicated and compensated by newly created greenspace within blue belts. This land may include areas within the existing green belt, which are attractive for development and in many cases offer very little recreational, amenity or ecological value but operate simply as an artificial barrier to urban sprawl. This low value, however, conflicts with one of the main premises of the space conscious absorbent city: the requirement for land to be multi-functional where possible. Although this view is controversial within the current development paradigm, the idealised flood-resilient absorbent city would allocate land according to its most sustainable use and aim to make new safe land available to compensate for losses elsewhere.

Densification could also be encouraged in areas that are inappropriate for surface unsealing. Essential development and its associated infrastructure could be directed towards areas that fulfil little or no flood management role, freeing up valuable land elsewhere. Where new development does take place, planners and architects could adopt a number of measures to ensure that the impact of development on flood risk elsewhere is minimised or even reduced. Design features could include the installation of green roofs and other temporary storage devices, or a policy of promoting pre-development or better runoff levels, especially if data on surface water flow routes present a risk downstream. Where development occurs, the planning system should also promote more resilient building methods and materials, so if flooding does occur the impact on citizens is reduced and buildings are made habitable much more quickly. Above ground space would be at a premium in highly urbanised areas, but it is possible for water storage to be provided below ground in order to better protect areas of high importance.

'Urban creep' or the gradual incremental urbanisation of a city has historically not been tackled by the planning system, yet its cumulative impact can increase the risk of surface water flooding both in the immediate area and elsewhere. For example, the paving over of gardens with hard surfaces can increase runoff and place strain on drains, and driveway and parking areas can be provided equally well using permeable technology.[27] Research by the Royal Horticultural Society revealed that in some parts of London over 75% of front gardens have been paved over (the majority to provide parking spaces),[28] placing extra demands on the sewerage infrastructure. In an absorbent city, opportunities to minimise runoff would be pursued and there would be a revision of the current permitted development rights for householders to limit practices that may exacerbate flood risk but do not require planning permission. It should be noted that this discussion is currently taking place in England as the risks of surface water runoff are becoming increasingly understood.[27] Thus far, the strategy may appear to be relatively negative, focusing on areas that should be protected, taking land out of the

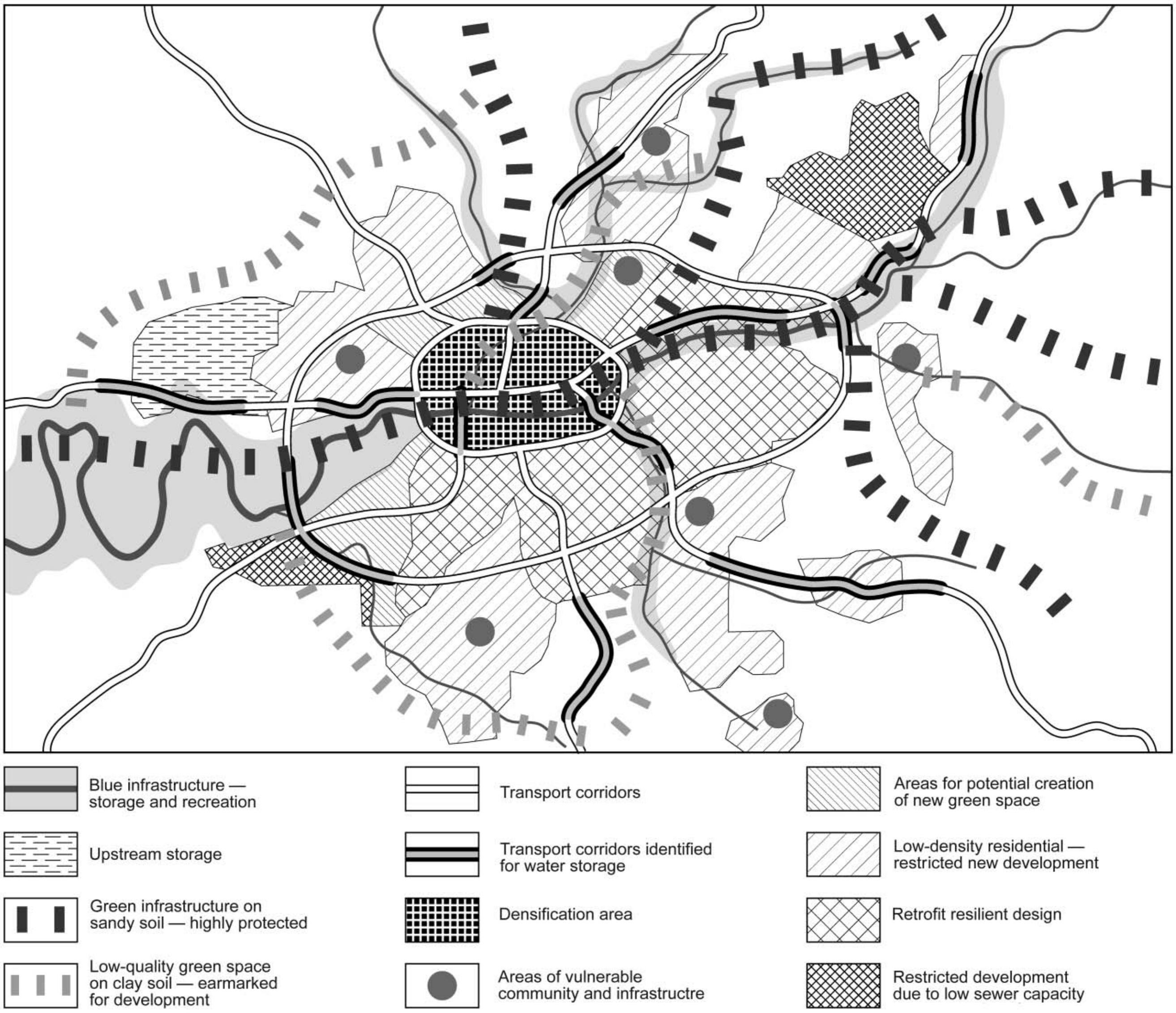

Fig. 10. Representation of the potential urban form of an 'absorbent city'

development process and restricting the supply of land. We should recognise, however, that there is a pressing need for new development and successful cities will not only be protected from flooding, but should be able to grow and regenerate.

3.3.4. The wider catchment. Although storage is one of the most effective methods of managing flood risk, it is difficult to find an appropriate area to accept a large amount of water at short notice within the urban core. This is where the boundaries between the resilient city and its surrounding hinterland become blurred. Any consideration of flood risk should recognise that the catchment level is the key scale. The absorbent city must therefore make use of land outside its administrative borders; information on flood source areas and flow pathways can be of great use in this respect. Upstream storage options should be exploited where appropriate and low-value greenspace or agricultural land could be transformed into flood storage basins, intercepting flow from the upper catchment and releasing pressure on the city core.[21] This may be difficult if the land is controlled by a neighbouring authority or agency, but this idealised view of a reflexive resilient city would have land use situated and managed according to its most appropriate function. Fig. 10 provides a strategic overview of how an absorbent city may be structured and the differing measures designed to re-engage the city with its local environment and manage water most effectively.

4. CONCLUSION

On 28 October 1944, during the rebuilding of the House of Commons, Winston Churchill stated 'first we shape our structures; thereafter they shape us'. Embedded in this observation is the truism that synergies exist between people and places—not just in the architectural stage, but in the way these buildings subsequently influence our behaviour and decision making. The dominance of economic issues in the development of urban form has created a legacy of exposure and vulnerability to flood risk, and a growing recognition of the limitations of this methodology has led to a desire to manage flooding in a way more harmonious with nature.

This paper contends that there has been a transition from self-protection to engineered defence to the current ideology of natural management with regard to flood risk management. This has provided a driver for the consideration of the nature of an idealised urban form that is more resilient to flood risk and is designed to absorb water and minimise damage.

Escalating urbanisation and increasing reliance on the economic value of cities associated with modernity has created an urgent need for effective protection measures. The gradual movement towards an idealised urban form for a flood-resilient city that reflects its individual geographical constraints could be a long-term sustainable goal designed to reduce risk to the population and the subsequent social, environmental and economic costs of flooding. The initial principle underlying the absorbent city is one of reflexivity—where spatial planners and other relevant stakeholders acknowledge that the future success of urban areas and their inhabitants is dependent upon proactive management and critical reflection. This process of self-enquiry creates an awareness of knowledge requirements and the need for effective dissemination strategies to provide a foundation of data to influence future urban form and development patterns. Adaptive strategies can then be led by a long-term strategic spatial planning approach, and responses could be different for each city according to local geography, climatic conditions and growth plans. Moreover, the uncertainty associated with differing management strategies suggests that a portfolio approach based on reducing exposure and vulnerability, and creating space for the urban area to absorb water safely would be the most desirable method.

The measures suggested reflect the aim of this paper as being of an idealised nature, and there is recognition that some suggestions (e.g. greenbelt functions, sacrificial areas, etc.) are controversial and that related issues such as ecology and biodiversity would need to be considered. However, this article is intended to stimulate debate and raise awareness that, theoretically, the absorbent city is possible using tools and information that may be available in the near future. As the main mechanism to control urban form, a more interventionist-oriented spatial planning approach could seek to develop resilient cities capable of withstanding and quickly recovering from hazards. Key considerations here are sustainable development and utilisation of the precautionary principle—both core facets of planning. However, the complexities involved in predicting the movement of water throughout catchments, especially when interacting with the built environment, are very difficult to define. In the face of uncertainty, a move towards developing enhanced resilience and appropriate land use allocation within cities is an eminently rational strategy. Indeed, there are many long-term benefits of this strategic approach and, as the true impacts of flooding on people and places are becoming more established, an incremental and measured move towards an absorbent city may be the most sustainable option.

Cities have always been built in hostile and harsh environments and technological advances have helped increase the safety and security of inhabitants and, to a large extent, divorced urban areas from local environmental constraints. The increasing incidence and impacts of flooding have challenged this paradigm, however, and the vital importance of cities means that urban designers and planners need to take steps to re-engage urban areas with their local environment. The concept of the absorbent city explored in this paper is boldly idealised, but the principles underlying its production may be of value when considering the strategic, long-term protection of cities from flooding.

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