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Urban resilience: a theoretical and empirical investigation

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Urban resilience: a theoretical and empirical investigation

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Preface

This thesis argues for the significance of urban resilience in sustainable urban development as well as for the necessity for practitioners to engage with this new emerging concept. It does so with a theoretical contribution to the definition of urban resilience, and with case studies analysis that help develop practical pathways to its attainment. For this purpose, the author has used a particular existing method (the Urban Futures method) developed within the EPSRC-funded four-year Urban Futures research programme. The author, as a member of the inter-disciplinary research team and of the sub-team of the 'Surface Built Environment and Open Spaces' work package, was instrumental to the development of that method, particularly for those aspects that pertain specifically to urban design and planning. In the section 5.3.3 the personal contribution of the author is described in detail. Moreover, interviews with practitioners presented in the chapter four, which constitute an essential part of the thesis, were conducted together with Dr. Maria Caserio, another team member of the work package mentioned above. She contributed to select interviewees, carry out the interviews, draft the transcripts, and discuss findings. However, the principal input in all these phases of the research comes exclusively from the author.

The case studies presented in chapter six were also developed by the author throughout the course of the research programme. The chapter is based on papers that have been published or accepted for publication in peer-reviewed journals (Caputo et al, 2012; Caputo et al (forthcoming)), and on conference papers accepted for oral presentation (Caputo and Gaterell, 2011; Caputo and Gaterell, 2012) in two important international conferences: the *Sustainable buildings conference* - Helsinki, 2011; and the *1st International Conference on Urban Sustainability and Resilience* - London, 2012. Likewise, chapter five introducing the Urban Futures method as well as the process of selection and modification of the future scenarios that are at its heart, is based on papers published in peer-reviewed journals, and on a book dedicated to the Urban Futures method printed by the Building Research Establishment, which the author has co-authored (Hunt et al, 2012; Boyko et al, 2012; Lombardi et al, 2012). Finally, chapter three and four presenting the literature review and the interviews to practitioners are based on an article submitted to a peer-reviewed journal, which the author has revised in response to reviewers' comments and that is in the course of resubmission (Caputo, et al - Designing a resilient urban system. Submitted to *Journal of Urbanism*).

Abstract

As a concept, resilience is relatively new to the urban debate although highly relevant. Cities are faced with major challenges. For example, climate change and issues related to food and energy security pose serious threats to the urban environment. In this context, the metaphor of an urban organism that adapts to maintain its functionality helps conceptualise an urban model (the resilient city) fit for this time. Urban resilience has been recently much investigated in disaster studies, as well as in relationship to all the manifestations of climate change. However, these are not the only destabilising factors cities will have to tackle. The post-industrial age is characterised by an unprecedented pace of change resulting in geopolitical and economic instability and uncertainty progressively entrenched in society. This makes the task of delivering sustainable urban environments all the more complicated. On the one hand, in order to optimise the use of financial and material resources, sustainable buildings and infrastructure designed today must be retained for their potential physical lifetime. On the other hand, economic and socio-political future pressures can accelerate obsolescence regardless of their sustainable performance. Cities must be resilient to climate change as well as to societal shifts.

This thesis contributes to the debate on urban resilience and to its understanding both from a theoretical and from a practitioner's standpoint. The aim of the thesis is twofold: to contribute to the urban design debate by bringing clarity on the concept of urban resilience that has been extensively used and interpreted in different fashions over the last decade; and to develop and trial professional approaches to embed resilience within design processes. The initial literature review is structured in five strands of urban resilience: resilience to natural hazards; resilience to man-made hazards; community resilience; resilience to climate change; and resilience through urban adaptability. Differences and intersections are highlighted and debated, and an argument for a more integrated interpretation of this concept is made. The review is subsequently complemented with eleven interviews to practitioners, intended to probe their perception of the relevance of this issue within the urban design practice, and to canvass opinions that can help define effective and practical approaches to eliciting conditions for urban resilience. Findings from this initial stage of the thesis enable the definition of the characteristics and the identification of a methodology for this purpose. The methodology is trialled here on three urban development cases in the UK. Results provide important insights on the planning and design strategies for resilience as well as an indication of the physical configuration of resilient urban forms. The thesis is concluded with a discussion on the importance of new professional tools for facilitating the delivery of resilient places and with the conclusions of the investigation.

Chapter one - Introduction

1.1 – Background

Post industrial societies are characterised by an unprecedented dynamism and a fast pace of change (see Auge, 1995). This trait can be in itself challenging and bear some important consequences. Over the last decade the world has experienced a condition of geopolitical and economic crisis which seems to become progressively entrenched in the cycles of society, making the task of policy-making and governance more difficult, especially with a view to sustainability. Legislation is stipulated and decisions are taken in order to govern development and respond to current demographic, social, and economic pressures. How can this be done effectively if such pressures are mutating so fast? Moreover, the velocity of transformation can generate instability since it is difficult to foresee and plan in a permanent condition of uncertainty. Projections of current trends are contradictory and do not point towards a clear future outcome (Carpenter et al., 2006; Bezold, 1999). This condition can be particularly problematic in an urban context. With the urban population growing (UNFPA, 2011), and the energy demand rising (DTI, 2007), cities are relentlessly transforming and expanding to accommodate new infrastructure in the endeavour of reducing the high environmental impact related to building construction and operations. Buildings and infrastructure require long term planning and therefore clarity of vision in order to effectively meet future targets (DECC, 2011). However, since the future is uncertain, how can urban development be designed today and still perform well under circumstances that may radically change?

In this perspective, the challenge of sustainable development is further magnified and requires continuous efforts to redefine strategies for its attainment. More than twenty five years have passed since the World Commission on Environment and Development hosted in Rio and chaired by G. H. Bruntland, the then former prime minister of Norway, officially recognised the significance of the sustainable development of society, and attempted the definition that is now used as a reference in almost every debate on sustainability. In the Commission's final report, this definition is formulated on the assumption that societal development and the environment are not two separated spheres, and only the protection of the environment can enable society to thrive (WCED, 1987). Concerns about the environment and the excessive use of resources were already voiced much earlier, with the 'Limits to growth' report commissioned by the Club of Rome (Meadows et al., 1979), and before then with Carson's pioneering studies on soil and water contamination (1962). However, only the official, global recognition of these issues bestowed by the UN commission in Rio seemed to constitute a sufficiently powerful call to action. Since then, governments and environmental organisations worldwide have been incessantly formulating policies and undertaking actions that can reconcile the need and want to expand each country's economy and urbanisation, with the necessity of protecting the environment that supports and feeds such a growth. Today, debate is still on-going as to how a desirable, sustainable state of the world can be achieved, although there is a shift in emphasis with respect to the many uncertainties related to climate change and the geopolitical instabilities that this could generate.

For this purpose, the concept of resilience is emerging to the extent of 'becoming a pervasive idiom of global governance' (Walker and Cooper, 2011). It connotes the capability of a system to continue functioning in the face of adverse conditions. If the future is uncertain, the ability of the vital global and local systems (e.g. food systems; energy systems, etc.) to continue function and provide services becomes crucial. Likewise, applied to the domain of the built environment, resilience conveys the vision of cities that perform sustainably under unpredictable adverse conditions, no matter what the future holds, thus constituting a worthy legacy to future generation. Mediated from ecological studies (Holling, 1973) the concept of an urban organism that adapts so as to maintain its functioning helps conceptualise an urban model (the resilient city) that is fit for this age of rapid change. In literature and in practice urban resilience has been largely associated with climate change and man-made hazards and as such regarded as 'an increasing policy priority for the UK and other countries' (HM Government, 2010a). It must be noted, however, that economic and socio-political pressures can accelerate obsolescence of elements of cities such as buildings and spaces regardless of their sustainable performance. A case in point is the recent dramatic population contraction of Detroit due to economic downturn resulting in a staggering one-third of its residential lots and houses becoming empty, with significant new problems with urban areas having excessively low population density, the reconversion of abandoned neighbourhoods, the resizing of infrastructure, etc. (Hollander et al., 2010). Cities must be resilient both to climatic changes and to societal shifts.

It is widely acknowledged that in a world where more than half of the population is urban, cities have a major impact on the environment (Girardet, 2004). The latest UN Habitat report 'Cities and Climate Change 2011' (UN HABITAT, 2011) states that currently cities are responsible for 40 to 70 percent of total anthropogenic green house gases emissions. This is mainly a consequence of fossil fuel consumption, much of which is due to electricity use and space heating in buildings. In the UK, for example, buildings are responsible for almost half of carbon emissions, with residential buildings accounting for 29 percent, and non-residential for 19 percent (Hinnells, 2008). Cities, however, are also engines for opportunities. With 80 percent of the national population being urban (Denham and White, 1998), and with 89% of the total jobs offered in urbanised areas (Urban Task Force, 1999), they constitute vital nodes of cultural and technological innovation and are therefore central to the progress of society. In the UK there is an ambitious statutory commitment to reduce carbon emissions by 80 percent by 2050 (HM Government, 2008). The sustainable development of cities is therefore crucial to deliver such a target. In the Planning Policy Statement 1, sustainable development is defined as a process that delivers 'a better quality of life now and for future generations' (ODPM, 2005; see also Cabinet of the Prime Minister, 1999). In particular, urban and rural regeneration can be used 'to improve the well being of communities, improve facilities, promote high quality and safe development and create new opportunities for the people living in those communities' (ODPM, 2005).

The pressing issues outlined above form the context for this research. Cities are a key factor for society, and their sustainable re/development is essential for a transition to a low carbon future (HM Government, 2009). Nevertheless the acceleration of change in society imposes new approaches to implement strategies for sustainability. In particular, it can no longer be comfortably assumed that buildings and cities designed to be environmentally efficient will retain over their life time that same efficiency. Today, sustainable design needs to be complemented with a view to long-term changes that can potentially undermine its performance. The resilience of urban systems is therefore taking centre stage within the sustainability debate. This thesis offers a theoretical and practical contribution to the elucidation of a concept which is still relatively young to urban studies and therefore not yet sufficiently investigated.

1.2 - Rationale for the research

Today, the debate on urban sustainability is very active. Strategies to deliver sustainable urban development are in constant evolution with a focus both at building scale (e.g. new resource and energy efficient technologies, integration of green roofs and green walls, new low embodied energy building materials, etc.) and at city scale (i.e. efficient urban forms, the emerging importance of ecosystems services and green infrastructure, etc.). For this purpose, much guidance has been provided at a national level by attempting to define sustainable urban development and embed it in the UK former planning policies. Practitioner-oriented research in this field is also continuously undertaken by organisations such as the Building Research Establishment (www.bre.co.uk) and the UK Green Building Council (www.ukgbc.org*)*. These provide information and tools for professionals working in this field, which are much needed in order to promote and foster sustainable approaches in design and construction. Conversely, the concept of resilience applied to the built environment cannot yet rely on such a body of work. Although this concept was introduced almost forty years ago in ecology studies (Holling, 1973), only approximately ten years ago, as the literature review shows (see chapter three), it started to consistently surface, and to be interpreted and applied to the urban context. Whilst even before the Bruntland report was formulated, urban sustainability has been continuously investigated both in theory and practice and experimented in many applications, research on urban resilience is still at a relatively early stage. Moreover, since resilience specifically relates to shocks, only the exacerbation of economic, social and environmental tensions culminated with the credit crunch in 2008 has given new significance to the term (Raco and Street, 2012). However, if sustainability theory seems ill-equipped to offer conceptual frameworks that can specifically address this new condition of society, the studies on ecological systems that can respond to disturbances offer particularly well-suited analogies.

Studies on urban resilience are one of the latest attempts to evolve the concept of sustainability and the related strategies so as to address sudden crises or, better still, a new emerging state of society characterised by the relentless manifestation of crises (Raco and Street, 2012). Over the last decade, a substantial body of work has been produced, some of which will be reviewed here (see chapter three). Much of this, however, addresses specific issues, mostly in isolation. These include climate change, security (i.e. terrorism), or social adaptive capacity in the aftermath of disasters. Some provide practical advice. For example, summarising the impact of climate change on the built environment, the Technology Strategy Board report 'Design for Future Climate' (Gething, 2010) identifies some specific categories that will contribute to the resilience of buildings and cities, which require more research and experimentation. These are:

- Thermal comfort and energy performance (warmer winters may reduce the need for heating but will increase energy consumption for cooling and related carbon emissions);
- Building structures, envelopes, and materials that may need to resist extreme weather conditions;
- Excess of water (flooding) or shortage of water (soil movement) that may affect buildings and infrastructure.

Interpretations available on urban resilience are not only focusing on specific sectors of the built environment, such as those mentioned above on building structure and envelope. Some organisations such as the Stockholm Resilience Centre and the Resilience Alliance broaden the focus of investigation, thus encompassing natural systems, socio-ecological systems, and the urban system. Their approach is holistic, focusing on the connection amongst the built environment, its metabolic flows, governance networks, and social dynamics (Resilience Alliance, 2007). The concept of resilience constitutes a powerful metaphor, encompassing many disciplines, and as such can be used for interdisciplinary collaboration (Folke, 2006). Yet in spite of so much on-going research, the wide variety of interpretations available to those who seek guidance is confusing. There are many integrated frameworks for sustainable urban design available in design guides that attempt to aggregate the diverse aspects of sustainability and the built environment (see Roberts et al., 2009; Barton et al., 2005; Llewelyn – Davies, 2000; DETR/CABE, 2000), although to date no comprehensive literature on urban resilience can offer similar professional aid. Regardless of some attempts in this direction (see Roaf et al., 2005 for urban resilience to climate change; see Watson and Adams, 2010 for urban resilience to flooding; see also Coaffee, 2009 for urban resilience to terrorism) guidance remains predominantly fragmented into the many streams in which urban resilience has been so far divided.

This context offers the rationale for the thesis, which addresses two specific issues: the absence of an in depth study analysing all specific literature available on urban resilience so as to learn from (and transcend) the individual interpretations of this topic; and the absence of practical tools/approaches to facilitate the design of resilient cities. Arguably the latter is dependent on the former, since a clear understanding of the nature of urban resilience is instrumental to its pursuit. The former necessitates a thorough analysis of the concept as initially formulated in the ecology studies domain, in order to glean those features that can be of use for urban studies, confront them with studies and guidance available on urban resilience, and reach some general conclusions. In parallel, the relationship between sustainability and resilience must also be clarified. The latter requires the transposition of theoretical findings into practical applications that can be of use for practitioners. Hence, a further contribution of this study is to trial a structured approach for identifying conditions for resilience from case studies. In turn, this will help understand how these conditions reinforce or conflict with current professional approaches to sustainability. Ultimately, the objective of the thesis is to promote a new mindset in urban design practice, one that has a view to the long-term while taking crucial decision that will determine the shape and functionality of projects over their lifetime. Indeed, it is the full understanding of the long-term consequences of design decisions that can contribute to a shift in the professional attitude.

In testing structured approaches to investigate urban resilience, this study will initially focus on energy and the built environment since these are inextricably interconnected (Ritchie and Thomas, 2009}. Planning Policy Statement 1 specifically promotes the adaptation of cities to (and mitigation of the effects of) climatic changes by means of ‘policies which reduce energy use, reduce emissions (for example, by encouraging patterns of development which reduce the need to travel by private car, or reduce the impact of moving freight), and facilitate the development of renewable energy resources’ (ODPM, 2005). The Energy White Paper (DTI, 2007) discussing pathways to build energy security, summarises as the three essential measures: to save energy; to develop clean energy supply; and to secure reliable energy supply. While the latter involves a wide and varied supply chain of energy sources, solutions advocated for the first two include zero carbon homes and buildings, the energy efficient refurbishments of the existing building stock, and the expansion of decentralised renewable energy production sources. Planning plays an important role in the implementation of such measures. It can promote the adoption of on-site energy production in new developments (Keirstead, 2008), which is recommended in planning policies (ODPM, 2004a); it can also encourage locally the adoption of energy efficiency building standards, and more importantly can promote energy efficient urban patterns, in which appropriate densities (Littlefair et al., 2000) and the adoption of principles for maximised sun access and daylighting can yield energy savings (ODPM, 2004b). Energy efficiency is therefore at the core of environmental strategies and of sustainable urban development. With such a reliance on energy efficiency to curtail the urban environmental impact it is important to test its resilience in the face of uncertainty and change. Many argue that environmental efficiency is only a facet of urban sustainability, and that it would be a mistake to consider it in isolation, separated by those other factors from which sustainability depends (see HM Government, 2010a; Foresight, 2008).The expectation of this thesis is to further validate such an assumption. If the environmental efficiency of the building stock is strictly dependent on social, cultural, and economic factors, an investigation on its long-term performance (i.e. resilience) should elicit these relationships and make more compelling the case for an integrated design approach. As this thesis will demonstrate, an analytical view to outline resilient strategies to energy efficiency will inevitably touch on other facets of sustainability. Hence, energy serves only as a starting point to analyse and appraise the built environment in its multi-dimensionality.

1.3 - Aims and objectives

The aim of this research is to develop an understanding of the conditions enabling the long-term resilience of sustainable built environments. It does so from a theoretical and an empirical standpoint. Thus its aim is twofold: to contribute to the urban design debate by bringing clarity to this concept that over the last decade has been extensively used, albeit interpreted in different ways; and to develop and trial professional approaches to embed resilience within design processes. In the thesis, this second aim takes its cue from, but it is not limited to, energy efficiency. By examining in a holistic fashion the energy efficiency strategies of three urban development case studies with a view to resilience, social and economic factors impinging on energy efficiency are elicited, thus broadening the scope of investigation to all urban dimensions.

Within this overall aim the specific objectives of the research are:

- To conduct a literature review on the concept and significance of urban resilience;
- To research and document how the notion of resilience is interpreted and perceived by professionals working in architecture and urban design;
- To research in literature and identify a conceptual approach suitable for the appraisal of urban resilience, and to identify an existing assessment framework accordingly;
- To adapt the assessment framework for the analysis of buildings and open spaces;
- To test on case studies the efficacy of the assessment framework for the purpose of identifying conditions for resilience;
- To establish advantages and shortfalls of the assessment framework as well as its potential to surpass current assessment tools with regard to long-term planning.

1.4 - Structure of the thesis

Following this initial chapter introducing the context, rationale, and aim and objectives of the thesis, and the second chapter presenting the methodology of the research, the two following chapters focus on the theoretical investigation on urban resilience. In particular, the third chapter reviews relevant literature from varied and diverse sources. These include reports and studies by governmental department and professional associations, which are generally consulted for guidance by professionals working in the field of the built environment, and relevant academic studies.

The fourth chapter presents a series of interviews with practitioners probing their understanding of urban resilience and their perception of its relevance. Because of the practitioner-focused objectives of this study, the opinions of the relevant professional categories are central to the identification of effective approaches and tools that can aid in designing resilient places.

The following two chapters focus on the empirical facet of the thesis. The fifth chapter includes a brief overview of current approaches to urban planning, highlighting aspects deemed not fit to cope with long-term changes and disturbances. Subsequently, alternative approaches are reviewed, which are specifically addressing uncertainty in planning. This review leads to the selection of an existing method suitable to identify long-term vulnerabilities of plans for urban re/development. This method is presented and the contribution of the author to adapt it in order to analyse buildings and open spaces illustrated. Findings of the literature review and of the interviews point at features that any analysis on urban resilience would necessitate to be approachable and effective from a professional standpoint. As a consequence the method is adjusted to meet such requirements.

The sixth chapter presents the analysis of three case studies developed using the method to appraise urban resilience introduced in the previous chapter. In each one, the energy efficiency strategy is examined in detail and the long term risks of failure (with related causes) ascertained. Each case study commences with the description of the context, of the development's scheme characteristics, and of its environmental strategy. Subsequently the analysis to resilience is developed. Finally, a discussion section elaborates on the analytical process as well as on a range of different and diverse issues surfaced during its unravelling, which show the interplay between energy efficiency and diverse socio-economic factors.

The seventh chapter brings together the key findings of the thesis to subsequently elaborate on the advantages and disadvantages of using the analysis method trialled here as a professional design tool. The measuring and appraisal of sustainable design solutions with current assessment tools provides essential understanding about their actual environmental impact. Similarly the appraisal of resilience can provide important design and planning guidance on this matter, although in very different ways. The chapter evaluates the modalities for 'measuring' resilience and what they entail, and compares them with those used to measure sustainable building performance.

The main conclusions of the research are presented in chapter eight, in which issues that remain unanswered and new ones arising are highlighted.

Chapter two – Methodology

The chapter illustrating the general methodology for the thesis begins with a caveat. This investigation has the ambition of being inter-disciplinary since it draws from diverse discipline-specific sources and methodologies. In particular it reviews and learns from literature on ecology and urban studies, and uses qualitative and quantitative analysis, the latter by applying methodologies used in social sciences. Clearly, such an attempt comes with the inherent difficulties of pulling together diverse methods of investigation in a coherent fashion, and interpreting and understanding knowledge that does not strictly belong to urban studies, the field of studies to which this thesis pertains. It is therefore important to note that since this attempt is to an extent experimental, methodologies are possibly utilised in an unorthodox fashion, or even hybridised. Nonetheless, results attained lead to conclusions that the author believes internally consistent and that are supported by evidence and validated through triangulation of methodologies. What follows is an account of the whole methodological process.

The involvement of the author with the Urban Futures (UF) research programme led to the decision to use the UF methodology for developing an investigation on urban resilience, and on the design approaches necessary for professionals to design resilient urban environments,. Since such a methodology is designed to facilitate the delivery of resilient cities, its trialling can generate knowledge on this topic. Consequently the initial research question was formulated as follows: does the approach to plan and design resilient cities differ from those currently used for urban environments, and in particular for sustainable cities? From this research question stemmed the aim and objectives stated in the previous chapter. The empirical attempt to gain insights on urban resilience, however, required circumstantiation. For this purpose the trialling of the methodology needed to be preceded by a literature review on urban resilience (and resilience in general). In particular, it was necessary to provide answers to the questions: is the topic relevant? Is the UF methodology fit for purpose? Moreover, since the initial intention was to produce research of interest for the professional domain, it was decided to review and analyse primary and secondary sources, namely relevant literature and interviews with professionals. The interviews have two purposes: first, to validate through triangulation finding from the literature review. Since this review means to elucidate the actual concept of urban resilience especially from a professional standpoint, interviews can confirm ensuing results. Second, to gain some expert's knowledge on the necessary features that a method to design resilient cities requires.

The overall methodological approach to the research is therefore constructed following a non-linear sequence. In a circular fashion, the empirical investigation is grounded in the literature review, and at the same time the findings from the literature review require validation through the analysis of findings of the case studies. These two phases, however, overlap in time. Whilst most of the literature review is developed prior to the finalisation of the UF methodology and its trialling on the first case study presented here (see section 6.1), thus contributing to its theoretical underpinning, the interviews are conducted alongside the development of the first case study. Thus they help shape the modalities with which the UF method is applied from then onwards. It could be said that the experts interviewed to an extent co-design the methodology. Had the interviews been conducted at a later stage so as to assess the effectiveness of the UF methodology in its application on case studies, their contribution would have been different (i.e. contribution to assess the validity of the method and fine-tune it as opposed to co-designing it).

It must be also noted that whilst the UF team (composed by eight sub-teams from different fields of knowledge) developed the methodology collectively, its application differs for each sub-team reflecting a particular discipline domain. The first case study presented in this thesis is part of a collective effort of analysing an urban regeneration from different discipline perspectives. Each sub-team applies the UF method on different aspects of the regeneration site's planning strategy. These aspects include: biodiversity, air quality, social needs, etc. Each aspect is analysed using the discipline's lens and corresponding professional attitude. For example, the analysis on water focuses on the water consumption scenarios of residential and commercial spaces through the use of water saving technologies such as greywater recycling and rainwater harvesting. The one on biodiversity, focuses on green corridors and the likelihood that these can be effective for birds' movements. The one developed by the author, whilst focusing on energy efficiency, attempts to encompass the spatial, social, and environmental qualities of the place, thus reflecting a professional attitude of architects and urban designers to coordinate in their work many diverse urban dimensions. Thus the research effort of the author is, from the incipit of the research, directed to give a distinct contribution to the research topic.

An attempt to visualise the methodological process is shown in Figure 1, in which the overlapping of the research phases, and correspondent methodologies, are captured in a flow chart. What follows is a detailed account of each research phase and methodology.

Literature review – The theoretical investigation uses collection and review of primary and secondary sources. Secondary sources are selected following two criteria: to review literature on the origins of the concept of resilience, and to review literature specifically focused on urban resilience and on urban adaptability. The literature review focuses initially on resilience as defined in ecology studies, since therein this concept was initially investigated. There are ulterior motives to commence with the review of that literature, namely the evident connection between urbanisation and natural environment, and the attempt, over the past century, to learn from nature and the self-organisational properties of natural systems when designing urban systems (see section 3.1). The analogy between these two system models has a long tradition in urban studies. It is therefore possible to trace similarities, learn from the behaviour of natural systems, and try to capture those connotations of resilience that, when applied to an urban context, can strengthen current urban strategies for sustainability. The review enables the identification of such connotations, which are subsequently compared against the characteristics for urban resilience outlined in dedicated guidance. In other words, a template for assessing natural resilience is used to produce a comparative analysis of the current interpretation/s of urban resilience. Findings from this comparative analysis are outlined at the end of each section in Chapter two (i.e. literature review), capturing the merits and drawbacks of each interpretation of urban resilience.

This methodological approach, and the ensuing results, is validated through informal consultation with experts However, it must be once again stressed that debate on urban studies has a tradition of connecting with ecology studies. The analogy of the city as living organisms (with what this entails in terms of constructing models of urban development informed by logics of nature) is well established. The assessment of urban resilience through a set of principles mediated from ecology studies is thus rooted in the tradition of this discipline. Moreover, findings from literature review are subsequently validated with the empirical part of the thesis. Although the author recognises that a more robust validation would be necessary, given the timeframe and the scope of this investigation, it was decided that this procedure is sufficiently adequate.

The review on resilience in ecology studies is particularly important also because it allows a sharper understanding of the necessity for a systemic approach to resilience and its links with complex systems theory. Consequently, complex systems theory is subsequently discussed within the same section. Literature on this theory, however, is not thoroughly reviewed since this is not within the scope of the investigation. Its basic elements are briefly discussed, with the aid of limited but eminent texts on the topic, in relationship to natural systems and urban systems.

The selection of the relevant sources on urban resilience is operated on the basis of their direct and indirect connection with this concept. In other words, reports and studies that explicitly claim to investigate aspects of urban resilience are included as well as those focusing on the physical adaptive capacity of cities to new uses and users. As mentioned before (see section 1.1), urban resilience is intended here in its broader meaning, thus not only in relationship to disasters and emergencies, but also to shifting societal conditions that require different uses of the cities in function of the changing demographic composition of the population, the evolving business landscape, etc. Consequently, although texts consulted do not explicitly link this issue to the debate on urban resilience, a literature review on this particular aspect (defined here as urban adaptability) is nonetheless included in the investigation.

The review on urban resilience is divided into sections, each one for a specific category of urban resilience as identified in literature. These are: resilience to natural hazards, resilience to man-made hazards, community resilience, resilience to climate change, and resilience through urban adaptability. These categories present significant overlaps. For example, resilience to climate change can evidently include the category of resilience to natural hazards. Nevertheless, since there is literature that addresses individually natural hazards such as flooding, and other that refers to climate change, the decision of keeping these categories distinct reflects the situation on the ground. Overlaps and intersections are highlighted at the end of each section, since these offer the opportunity to find synergies and interrelations between categories. Other resilience categories that are to an extent relevant to this study are not included in order to narrow the scope of research specifically to buildings and open spaces. For example, literature on resilient infrastructure (see HM Government, 2011) is not reviewed. In a paper reviewing resilience studies on critical local infrastructure, Rogers et al (2012) focus also on governance resilience and economy resilience since these are categories relevant to its functioning. Whilst all these categories are equally relevant to the urban context, it is felt that their inclusion would broaden the review much beyond the scope of the thesis.

Interviews – In addition to the literature review, the interviews with practitioners working in the field of the built environment is reputed a necessary component of this study for two main reasons:

- To gain further understanding as to how long term resilience is interpreted in current practice so as to validate or question findings from the literature review;
- To gain some understanding from a practitioner's standpoint on practical issues concerning the assessment of resilience such as the modalities for its measurement, spatial scales for effective appraisal, etc.

Since this study has the twofold ambition to contribute to the theoretical debate on urban resilience *and* to produce insights for its implementation that can be of use to practice, it is felt that canvassing the opinions of the target audience (i.e. professionals working in the built environment sector) can provide important elements to both purposes.

The sampling of professionals for interviews is based on the following criteria:

- Experts with many years of experience in the sector of architecture and urban design;
- Practitioners directing renown architectural and urban design practices, and actively involved in research activities with professional organisations;
- Central figures in prominent architectural organisations.

These criteria ensure that interviewees selected are exposed to (and in a position to be informed of) current professional debate. However, since the number of interviewees is limited, opinions canvassed and their subsequent analysis are by no means statistically relevant. Although the stated objective of this phase of the investigation is to analyse interviews, it must be noted that ultimately interviewees are experts within their professional domain. As such their opinion helps consolidate findings from the literature review and, in a sort of co-design process, shape the modalities of application of the UF methodology. This ambiguity (i.e. interviews used to probe views on a topic *and* acquire experts' views) is reflected in the imperfect use of the content analysis methodology which is illustrated below.

Opinions collected are examined through content analysis, which is a form of qualitative analysis. Qualitative research is intended here as one that involves 'an interpretative approach to the world', and that offers an analysis model for studying and interpreting 'phenomena in terms of the meanings people bring to them' (Denzin and Lincoln, 1994). In this case this thesis is concerned with understanding how the issues emerging from the literature review are perceived by a sample of practitioners, constituting the intended audience of that material. Content analysis is therefore used here to develop insights on the following core issues:

- To ascertain the relevance of an investigation on this topic;
- To ascertain the view of practitioners on this topic;
- To canvass practitioners' opinions on the most effective approach to assess urban resilience.

Content analysis is a method of textual investigation in which the researcher establishes a number of categories 'sufficiently precise to enable different coders to arrive at the same result when the same body of material is examined' (Silverman, 1993). In its simplest form (as outlined in Silverman, 1993:65) it consists of the sampling of text or interviews, the identification of categories emerging from the material sampled, its coding (i.e. its interpretation and classification into groups of meaning), and the establishing of a code system that can enable independent coders to reach the same analytical conclusions. In this investigation such a procedure was only partially developed. After sampling the group of interviewees, the analysis of the interviews led to the emergence of some views (or understanding, or meanings) on urban resilience and the professional attitude/propensity to embed it into practice. Such views were sufficiently clear and did not need to be interpreted and classified under codes. In its simplicity, the process delivered what it was initially intended: a set of meanings that could confirm or contradict the original evaluation on urban resilience through literature review. Ultimately the analytical process resembles more that which is termed as thematic analysis (see Braun and Clarke, 2006): 'a method for identifying, analysing, and reporting patterns (themes) within data'. This is a simple methodology to track surfacing patterns of meanings in text or interviews. Clearly, the questions posed in the course of the interview play a crucial role in this process, since they are instrumental to direct interviewees towards the research focus.

The list of questions was compiled reflecting the aim of the thesis, which is twofold. Thus two initial categories were defined. These are:

- The concept of urban resilience and its interpretation (theoretical strand of the research);
- The application of such a concept in practice (empirical strand of research).

From this initial categorisation, following the literature review, stem four categories that elaborate on the first two. The literature review shows that the concept of urban resilience is interpreted in different ways and with an ambiguous relationship with sustainability. It also shows the importance of accounting for spatial and temporal scales when considering resilience. These are all essential issues for an investigation, the objective of which is to bring clarity to the concept of urban resilience. Moreover, the issue of how to apply this concept in practice leads directly to questions around its measurability. Finally, as a result of discussions about these four categories between the author, Dr. Maria Caserio, and some members of the UF sub-team 'Surface Built Environment and Open Space', eleven questions are identified that form the final questionnaire. The process is captured in Table 1. Further details of the process leading to the interviews are in section 4.1.

Strands of research	**Categories derived from literature research**	**Final list of questions developed from the four categories after discussion with peers**
Theoretical strand of the research	Interpretation of urban resilience in practice	Is this a familiar concept within the professional domain?
		Is it associated with the longevity of buildings?
		Is urban resilience achievable?
		How is it dealt with?
	Sustainability and urban resilience	Are these concepts related?
	Scale	Does the application of urban resilience change with the urban scale considered? Is it applicable at all scales?
Empirical strand of research	Applicability/measurability of urban resilience	Is urban resilience measurable?
		Can it be measured qualitatively?
		Can it be measured quantitatively?
		Can its measurement be integrated within current rating codes?

Table 1 – Phases of definition of the list of question for the interviews to practitioners (see chapter 4)

The list of questions is subsequently forwarded to the interviewees prior to each interview. Interviews are recorded and transcripts written. The counting of the answers given to each individual question, and the ascertaining of the predominance of a certain response, gives the measure of the likely attitude of the professional category towards the specific issue. For example, responses to the question: 'are resilience and sustainability related?' gives a clue as to whether urban designers deem the two concepts related or not, which in itself is information of use to the debate on urban resilience. Since many answers given are ambiguous, or dubitative, or even not pertinent to the question itself, and since the sample of interviewees selected for this exercise is relatively small, clear patterns of answers do not always emerge. Still, in the opinion of the author, ambiguity of reply can offer an insight that is relevant to the purpose of this investigation. For example, it can reflect an actual situation on the ground for which the issue debated is not understood within the professional category. Following the analysis of the opinions canvassed, some of the most relevant topics emerged are elaborated in a discussion section. For reasons of anonymity interviewees and their quotes are referred to by a number. In the table that summarises responses (see chapter four) each number corresponds to a brief exposition of each interviewee's professional profile and area of expertise.

Identification of the methodology to test resilience/Adaptation of the methodology –Before the development of the empirical part of the research, a brief review on current planning approaches with regard to their capability to cope with uncertainties enables the identification of a particular technique (i.e. scenario analysis) fit for purpose. Subsequently, a specific scenario-based methodology designed to appraise urban re/development (Urban Futures method) is identified, which is compatible with the findings of the review. For example, the scenario-based methodology is capable of examining urban development in a systemic fashion, which as the review demonstrates is one of the features necessary to identify conditions for resilience. It must be noted that it is not within the scope of this research to develop a new analytical method, which would probably be an aim too ambitious given its nature and timeframe. Instead, the intention of the author is to focus on the investigation of the analysis results and on the discussion of their relevance for the professional domain.

In order to proceed with the testing of this method on some case study analysis so as to verify its effectiveness, modifications of its structure are necessary to make it fit for purpose. In chapter five these modifications are explained. The author has therefore contributed to adapt the scenario-based Urban Futures method to allow a resilience analysis of the built environment that can reflect the professional necessities emerged in the course of the interviews. These modifications mainly consist of:

- The adaptation of a methodology designed to analyse single, discrete issues related to the built environment to one capable of multiple analysis. This is recognised as a necessary precondition to examine urban development. For this purpose, an initial attempt to apply the UF methodology simultaneously on several issues is undertaken in section 5.3.3.2, in order to demonstrate that a multiple analysis is possible. Some of the most commonly used strategies for energy efficiency in buildings are evaluated to ascertain the long-term implications of implementing low, or medium, or high levels of performance. Thus, a range of performances for each one of those strategies is identified through literature review (e.g. range of building fabric performance suggested in rating codes such as Code for Sustainable Homes and BREEAM). Whenever such ranges are not available, these are surmised by the author simply through the selection of modest, common practice, and ambitious performance targets. Although arbitrary, this approach serves the purpose of trialling a multiple analysis of the UF methodology that reflects the decision-making process normally followed by practitioners when setting the sustainability ambition of a project (i.e. evaluating the economic and technical consequences of designing at varying levels of performance before deciding the environmental profile of a design scheme).
- The detailing of the scenarios so as to capture urban aspects (therefore indicators) which are missing and that are envisaged as essential in any design and planning process. The selection and the definition of these new indicators is based on literature reviewed on urban design such as urban design guides or guidance on urban planning

and design from RIBA and CABE. A detailed account of the process is provided in the section 5.3.3.

Case study analysis – The number of case studies (i.e. three) is considered sufficient, given the timeframe of the research, to evaluate and compare findings so as to ascertain communalities and divergences as well as the general validity and efficacy of the analysis method. Clearly, a larger number of case studies can provide a stronger evidence base for drawing conclusions. Nevertheless the convergence of findings of the three cases constitutes sufficient proof of robustness. Case studies are selected amongst UK regeneration or development projects with sustainability claims (a full account of the process of selection is given in the initial paragraphs of chapter 6). The focus of the analysis is therefore on ascertaining conditions for resilience of their sustainable performance as originally planned, or more in general of the development performing sustainably over its lifetime. The preliminary phase of analysis consists in the collection of relevant documentation. In particular:

- Reports describing the social, economic, environmental and spatial conditions of the site prior the development;
- City plans, planning guidance, design statements, and all design documents outlining the vision for the development of the place, the design ambitions, and the consequent strategies for their accomplishment specifically with a view to sustainability.

This documentation, when necessary, is integrated with a visit to the site and with informal conversations with stakeholders such as city planners or developers. These conversations help interpret correctly the socio-economic context and the aspirations of stakeholders as outlined in the documents consulted. The collection of the material offers a robust basis for developing each case study with the Urban Futures methodology. Finally, as a further assessment methodology in this investigation, IES (Integrated Environmental Solutions) is used to measure the expected environmental performance on a digital model constructed with the software. This is because, given the advanced design stage of one of the case studies presented here (see section 6.2) sufficient materials is available.

The development of case studies is functional to: a) validate findings from the literature. Such findings highlight the systemic nature of urban resilience, the necessity to consider resilience within a sufficiently large temporal and spatial scale, and more. The identification of a methodology (the UF methodology) based on these features, its application on case studies, and the development of findings that can lead to a design strategy for resilience constitute a sufficient validation. In other words, since the UF methodology has the power to elicit the systemic nature of the built environment, and to capitalise on such evidence to suggest approaches to ensure long-term sustainability, the assumption that was originally developed through the literature review is correct (i.e. the systemic nature of urban resilience, etc.). A list of initial findings validated through case study analysis is presented in Chapter seven (see 7.1); b) cross-validate findings developed through case study analysis. For example, since the analyses focuses primarily on energy efficiency, the correspondence of findings across the three case studies demonstrates the robustness of the process.

The following chapter presents the literature review on resilience of natural and urban systems.

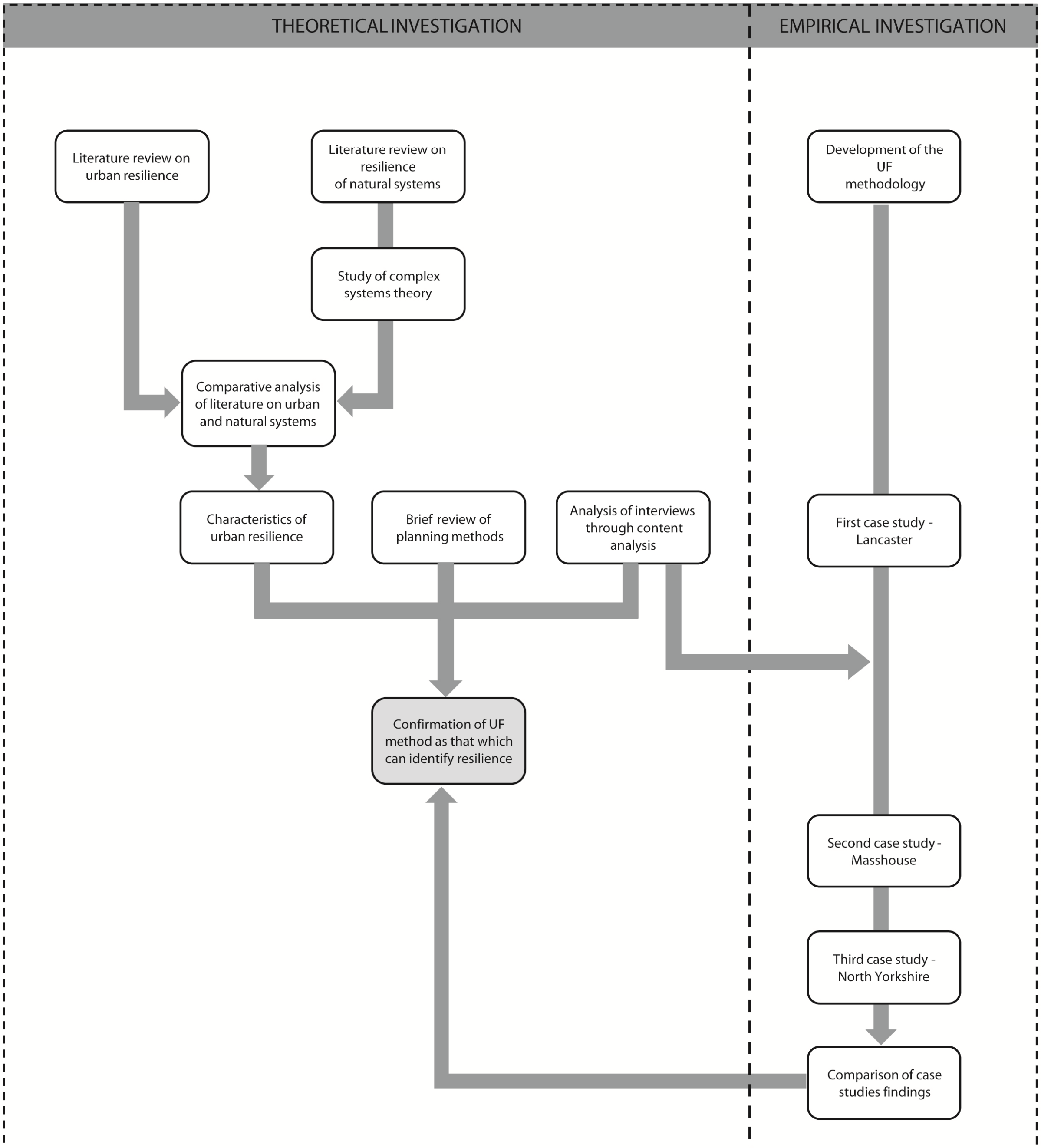


Figure 1 – Flow chart of the phases of investigation

Chapter three - Literature review

3.1 – The origin of the concept of urban resilience

As mentioned above (see section 1.1), the concept of urban resilience was mediated from the study of ecological systems. The analogy with organic structures is well suited for conveying and studying a dynamic urban model of cities as self-organising systems in evolution, with their own metabolism, feedback loops, and states of stability and instability, which reflects the present, highly complex, sophisticated, and multi-dimensional urban condition. The fascination of comparing complex human artefacts (i.e. cities) with those self-constructed by natural processes has long and ramified roots in the history of the architectural and urban debate. It builds on a long tradition probably commenced by Geddes with his studies on ‘cities in evolution’. He was proposing an ‘organic approach to human-nature interaction in urban planning’ (Mehmood, 2010), possibly also influenced by the Garden City vision of Ebenezer Howard, which percolated to more modern approaches such as those experimented by McHarg (1992 [1967]), who pioneered the concept of ecological planning. These theories constitute important endeavours to recompose the urban and the rural divide in an historical moment in which their dysfunctional relationship was spiralling out of control. The reconciliation of the two worlds was attempted through a careful observation of the natural realm so as to integrate planning strategies with natural logics. After the 1960s, however, this stream of investigation shifted the focus on the functioning of organisms within complex systems to design homeostatic and evolutionary artificial models (Hagan, 2008), namely objects (i.e. buildings) or systems of objects (i.e. cities) that could evolve in time while maintaining an internal equilibrium. In other words, the focus is on learning from the inner functioning of organic systems so as to model artificial ones, rather than on harmonising opposite dimensions through planning strategies. Christopher Alexander (see 1977; 1974 [1967]) is probably the most eminent representative of this current of studies, which utilised mathematical and computer modelling to mimic organic self-assembling growth for urban systems. Only over the last two decades, the study of natural systems and cycles has been developed in conjunction with the social ones with a view to sustainability. Perhaps, a cogent application of such an approach can be found in studies on socio-ecological systems (Alberti, 1999a; Alberti, 1999b; Alberti et al., 2003; Alberti and Marzluff, 2004; Alberti, 2005, Pickett et al., 2004; Folke, 2006; Young et al., 2006) in which urban development is examined as dependent on ecological systems, thus linking the effective functioning and resilience of both. Since society must live within the carrying capacities of the environment, and since cities are the main consumer of resources (UN Habitat, 2011), a balance of urban living must be reached, which maintains the ecosystem functioning and providing sufficient resources. This vivid image of cities as dynamic and evolutionary systems has served as a holistic and connected model, adopted by many eminent urban design guides and studies to formulate design principles for sustainability (see Ritchie and Thomas, 2009; Girardet, 2004; Urban Task Force, 1999). It has therefore been a useful metaphorical figure to mainstream complex theoretical principles into urban design and building practice. Metaphors of common use in the urban design domain such as urban metabolism, urban symbiosis, complex urban systems, are today essential to interpret the sophisticated and inter-layered construction of cities, and to merge self-sustaining cycles (i.e. natural cycles) with those that must learn to be so (i.e. artificial cycles).These metaphors have had an impact on the way urban design practitioners think and operate, since they can provide a conceptual framework in which concepts such as ‘adaptivity’ or ‘holistic approach’ can be better understood (see Mehmood, 2010).

In ecology, one of the most cited interpretations of resilience was elaborated by Holling. In his groundbreaking studies on natural ecosystems, he moved away from an equilibrium-centred view of such systems to a model characterised (if observed over a sufficiently long period of time and a sufficiently large area) by oscillations of state. He cites as an example the cycle of the spruce budworm in the spruce-fir forests of Eastern Canada (Holling, 1973). Peaks of population of this parasite can cause extensive destruction of firs, leaving the composition of the forest unbalanced, with much space given to the expansion of other tree species, namely birch and spruce. Nevertheless, if looked over decades, this particular ecosystem maintains its balance precisely because of the parasite. Firs are very strong trees with an advantage in competing for space with the other trees. Outbursts of budworms therefore give space for growth to the birch and the spruce, until firs grow back and expand again at the expenses of the other species. The growth of the fir population triggers the one of the budworms, thus restarting the cycle. There is another essential catalyst for the budworm population growth that is external to the ecosystem, namely a sequence of dry years. The impact of this external shock, however, is not damaging the long term functioning of the system, which is temporarily altered but maintains a long-term persistence. It is this persistence that Holling terms resilience. Resilience is thus ‘the amount of change the system can undergo and still retain the same controls on function and structure’ (Holling and Walker, 2003). This capacity to keep functioning through the self-balancing of the system is particularly attractive if transported to the urban environment. Likewise ecosystems, cities are composed by a multitude of interconnected elements, each one with its own function, interfering with others. If this system, in spite of its short to medium term oscillations of state, is still capable to keep functioning, human, financial, and material resources that contributed to its implementation are well allocated. In other words, ‘the longer a building lasts, the longer the period of time over which the environmental impacts of buildings can be spread’ (Symes and Pauwels, 1999).

Still, the long term equilibrium (i.e. resilience) that a system can attain may be unwanted. ‘Resilience, per se, is not necessarily a good thing. Undesirable system configurations (e.g. Stalin’s regime, collapsed fish stocks, etc.) can be very resilient, and they can have high adaptive capacity in the sense of re-configuring to retain the same controls on function. Building resilience of a desired system configuration requires increasing the adaptive capacity of structures and processes (social, ecological, economic) that help maintain this configuration. It also requires reducing the adaptive capacity of those that tend to undermine it.’ (Holling and Walker, 2003). This concept, again, is very useful to analyse reasons for negative urban situations such as the persistence of derelict areas within cities or energy inefficient urban forms that resist change (i.e. suburban sprawl, energy inefficient buildings stock, etc.). If resilience is sought after because of its potential to increase the longevity of the built environment, then it is necessary to understand that it is no guarantee of its sustainability (Derissen et al., 2011), intended here as a minimisation of the impact on the environment which does not impair economic and social needs.

Carpenter et al. (2001) too argue that whilst sustainability represents a desirable system state, resilience may not. Therefore it is necessary to ask: ‘resilience of what and to what?’ This is an important observation. Only the analysis of the system itself, of its finalities, of the likely risks of failure, and of the elements that require adaptive capacity can lead to the identification of those resilience strategies that can ensure a desirable state. Moreover, the definition of the system must be broad enough so as to enable all the necessary elements to be considered. There may be ‘a danger in becoming too focused on ‘specified resilience’, because increasing resilience of particular parts of a system to specific disturbances may cause the system to lose its 'general resilience' in other ways (Folke et al., 2010). This assumption comes together with the one that resilience in natural systems allows incremental adaptation until the system tips towards a reconfiguration, a state transformation that is better suited to cope with a new regime (Folke et al., 2010). Building adaptive capacity in an urban system requires that the system learns, evolves, and changes whilst still retaining those characteristics for which it is desirable.

In an ecosystem, it is the interplay amongst elements that determines the progressive adjustments enabling the system to adapt. Its observation and understanding requires systems thinking, which is, understandably, another discipline greatly influencing ecology studies. In general, complex systems are composed of elements, their interconnections, and their ultimate purpose (Meadows, 2009; Meadows et al., 2004). Elements can be substituted, but as long as interconnections are preserved, the system will continue functioning according to its intended purposes. Cells of the human body are constantly regenerated. Still, the body keeps functioning as long as the workings between cells deliver the intended functions. Exploring the reality through systems can be of use. 'Systems are conceptual devices that we bound with a purpose; however once bounded they become real and we can explore, and influence, how they emerge through internal restructuring and their interactions with their environment' (Charnley et al., 2011). In complex systems the identification of feedback loops can lead to the understanding of the leverages that can modify the system itself. 'A feedback loop is formed when changes in a stock affect the flows into or out of the same stock' (Meadows, 2009). An example of feedback loop is represented by the thermostat that when turned up increases the quantity of fossil fuel consumed for space heating. The analysis of the structure and composition of the loop can provide means to identify the factors that, if changed, can alter the loop to attain a planned outcome. If the objective is to reduce fossil fuel consumption, leverage points can be: the perception of thermal comfort of the user (e.g. a sweater can help improve the comfort); the efficiency of the heating system; the regulation of the space heat level (e.g. eliminate the option of rising temperature); etc. Within complex systems theory 'resilience is a measure of the system's ability to survive and persist within a variable environment'. More importantly, it 'arises from a rich structure of many feedback loops that can work in different ways to restore a system after its perturbation' (Meadows, 2009).

Feedback loops and delays are another useful analogy to transpose from ecology into urban design. They describe how changes of the state of elements affect system performance, and how delayed recognition of this change can cause disruption. Failure (and delay) in taking action on carbon emission reduction may lead to mean temperatures rising above the critical two degrees increase. Because of the delays in building new power plants (or tackling excessive energy consumption) electricity industry oscillates between cycles of overcapacity and undercapacity (Meadows, 2009). Similarly, different temporal cycles of concurring phenomena make it difficult to interpret warning signs and discrepancies, thus making it difficult to govern complex transformations (Resilience Alliance, 2007). As Batty et al.. (2004) mention, 'urban traffic jams occur over minutes, stock market crashes over days and weeks, market cycles in housing prices over months and sometimes years, while the process of urban gentrification can take decades'. Each cycle requires the identification of an appropriate temporal and spatial scale so as to interpret effectively events, feedback loops, and warning signs.

What can be learned from ecology and complex systems studies goes beyond the conceptual figure of the capacity of a system to resist external shocks. These studies show that the comprehension of its systemic nature, its purpose, its architecture, and its ‘rules of engagement’ are all elements necessary to determine a correct strategy for resilience that can lead the system, in its future states, to retain its desirable connotations. Summarising the most relevant findings:

- Resilience is desirable when it is not leading to a negative system configuration. It is therefore important to define what is regarded as negative and desirable before strategies for resilience can be formulated. In an urban context, for example, resilience could be sought after for buildings and spaces designed to a sufficiently good level of environmental performance;
- Like in ecology, urban resilience should be sought after only at a system level possibly attempting to attain general, rather than specified resilience. In an urban context this poses the problem of the definition of temporal and spatial scale, and specificity or scope: is the scale considered sufficiently broad? Is the timeline sufficiently long? Is the aspect analysed for its resilience (i.e. the scope of analysis) too specific?
- Pathways to resilience require the identification of elements of the system, feedback loops, and leverage points. By eliciting the rules of the game it will be possible to understand, say, consequences of one choice at the expenses of another (feedback loops) and target leverage points to prompt change;
- In response to external factors, systems do not maintain their initial configuration, but transform over time. Resisting change may not be a successful strategy. In order to retain the overall positive connotations of the system and, to an extent, govern change, sufficient adaptive capacity must be provided. In urban systems, such a capacity must be clearly related to all dimensions (i.e. social, cultural, economic, environmental, etc.).

Before proceeding to the review of the literature on urban resilience, it is necessary to establish its definition. Alberti et al. (2003) define it as the degree to which cities are able to tolerate alteration before reorganising around a new set of structures and processes. Similarly to the ecological model, in an environment characterised by change, urban systems must reconfigure/adapt to retain functioning. Other definitions follow a similar construct. For example Hamilton (2009) states that ‘Urban resilience is sometimes defined as an ecological concept, meaning the degree to which cities are able to tolerate alteration before reorganising around a new set of structures and processes’. O’Brien and Hope (2009) define it as ‘the ability to withstand and adjust to disruptions whilst still retaining function’. In a more articulated fashion, the Resilient City (a network of practitioners and academics that share knowledge and promote professional engagement for urban resilience) states: ‘a resilient city is one that has developed capacities to help absorb future shocks and stresses to its social, economic, and technical systems and infrastructures so as to still be able to maintain essentially the same functions, structures, systems, and identity’ (www.resilientcity.org). More broadly, urban resilience is in this thesis defined as the capacity of sustainable cities to adapt in response to unexpected change and still perform over time as initially planned, thus extending their lifecycle. However longevity is not solely dependent on building materials and technologies. An array of social, cultural and economic factors can potentially determine critical failures and undermine physical performance. Dwellings designed to substantially reduce their carbon emissions and withstand flooding require consistent user behaviour to deliver the planned carbon savings, and economic and infrastructure conditions allowing vital community services and facilities to be quickly restored in the face of flooding.

3.2 – Several interpretations of urban resilience

Over the last decade, several reports commissioned by the UK government as well as a stream of academic research have debated the subject of resilience and how it should be embedded in national systems. Reports on resilient systems have focused on energy supply (HM Government, 2010b; DECC, 2011), energy infrastructure (Foresight, 2008), food supply and production (Foresight, 2011; SDC, 2011; HM Government, 2010), transport and water infrastructure (HM Government, 2011), etc., which are all prone to minor of major failures because of local and global instability. At the same time, this concept has become 'increasingly prominent in disaster research' (Bosher and Dainty, 2011). Urban resilience has been investigated and applied in relationship to natural hazards, terrorist threats, security at large, etc. Arguably, since such shocks are increasingly recurrent and can generate considerable disruption, it is important that cities are designed to quickly recover and spring back to normality in the post-disaster recovery phase. For example, resilience has been looked at under the lens of adaptation to extreme climatic events, mostly in relationship to climate change (see Roaf et al., 2005; see also Gething, 2010). In that context, energy and resource efficiency are also recommended in the light of future fossil fuel shortage, and as necessary to curtailing carbon emissions, which in turn can cause further energy use (i.e. hotter summer months). The former UK government issued guidance for planning and delivering a built environment resistant to floods and other natural hazards (see DCLG, 2006a; DCLG, 2006b; HM Government, 2011) as well as safe from crime (ODPM, 2004a). The academic community has joined this debate developing an abundant body of work on a resilient water sector (Hamilton, 2009); resilience to flooding (Lamond and Proverbs, 2009); resilient design to counter terrorism (Coeffee et al., 2008); resilience of communities (Magis, 2010); etc., which has produced both theoretical and practical outcomes. Finally, although not specifically linked to the term of resilience, it has also been considered under the notion of flexibility of buildings' typology and interior layouts that can meet diverse needs occurring over buildings' lifetime, due to change in ownership or composition of the household (see Llewelyn and Davies, 2000; see also CABE, 2008).

The vast literature and guidance available on urban resilience demonstrates how complex is its attainment, as well as the difficulties of integrating the multitude of recommendations, let alone mainstreaming them, into urban design and planning practice. The ultimate purpose of urban resilience is longevity of buildings and their performance through adaptability. This is a finality that encompasses many urban strategies, some of them explicitly linked to the term resilience, some of them connoted with different definitions. The literature review shows that urban resilience has been used primarily to indicate an urban environment reactive to disasters, post-disaster recovery, and climate change. However, the attainment of longevity has been traditionally pursued in the architectural and urban design field through building attributes such as flexibility and adaptability. The literature review intends to bring clarity and identify all those requirements necessary for urban longevity.

3.2.1 – *Natural hazards*

Extreme damage to urban systems can happen as a consequence of natural hazards such as earthquakes or volcano eruptions. Natural hazards can also be generated by meteorological events (i.e. extreme rainfalls, floods, heatwaves, etc.) that are believed to occur with unusual frequency as a consequence of climate change (Roaf et al., 2005). In the UK, as floods can be frequent and disruptive, particular attention has been given to the design of flood resilient development. The annual average damage caused by coastal and river flooding is estimated at around £800million (POST, 2001). Floods can also be caused by ground water, sewers and man-made infrastructure (i.e. canals, reservoirs, etc.) (RIBA, 2009c). As national guidance, the Planning Policy Statement 25 and its accompanying PPS 25 Practice Guide (DCLG,

2010a; DCLG, 2009) set the determining criteria for sites in order 'to avoid inappropriate development in areas at risk of flooding'. This is done through:
Appraising risk: mapping the local flood- prone areas and their degree of risk;
Managing risk: formulating local policies consistent with the risks appraised and permitting development on high-risk areas only when those at low-risk are unavailable;
Reducing risk: undertaking works to reduce risks of flooding (e.g. conveyance and storage of flood water, and flood defences) and requiring for new development measures such as SUDs or effective site landscaping.
These efforts must be done liaising with the Environment Agency and other local operating bodies. The guide also provides the structure of a five-step sequential test to facilitate decisions on land suitable for development.

For those buildings that are designed in flood risk areas, detailed guidance is given in 'Improving the Flood Performance of New Buildings: flood resilient construction' (DCLG, 2007). The following principles are outlined:
Flood avoidance: constructing the building and surrounding areas at site level to avoid it being flooded (e.g. raising it above flood level, etc.);
Flood resistance: designing the building to prevent water entering and damaging its fabric;
Flood resilience: designing and constructing so as to limit the consequences of flooding on the building's elements;
Flood repairable: Designing and constructing so as elements damaged can be easily and affordably replaced or repaired.
In other words, the distinction is made between physically resisting the impact of the water with strong structural frames, elements that prevent access of water, and particular design strategies (resistance), and the capacity of the building to suffer limited and repairable damage (resilience).

It is important to note, as this literature shows, the interconnectedness of different scales of intervention (i.e. district, site, and building) and the necessity to address them simultaneously when planning resilient places. Before addressing building design, solutions for water management require analysis and action at a district (or wider) level. Moreover, national policy requires local authorities to assess risks, prioritise development on non flood-prone areas, and ensure that development does not impact the risk of flooding elsewhere (DCLG, 2010a). Yet, high-risk areas can be considered for development when other more suitable alternatives are unavailable, and in this case flood resistant building design strategies should be implemented. This flexible approach comes with risks. First, building design needs to focus particularly on resisting the impact of water. This entails higher structural resistance, uncommon building configurations, and possibly higher construction costs. Secondly, because of these design principles, there is a risk to deliver places that do not facilitate social interaction. This is quite efficiently explained in the RIBA publication 'Design for flood risk', which is part of their Climate Change Toolkit (RIBA, 2009c), where it says: 'Standard responses to the risk of flooding include flood defences, barriers to flood pathways and raising accommodation above the potential water level onto columns or stilts. These measures are often not well integrated with the overall architecture and landscape design, resulting in poor quality and badly functioning neighbourhoods and streetscapes'. Possible unintended effects of unthinking implementation of guidance available are further discussed. For example, with buildings raised from the flood level for *flood avoidance* and ground level destined for car parking, the public space risks to be poor, visually unattractive, and unsuitable for social gatherings. With no people using open spaces, there can also be consequent lack of passive surveillance on the street and no sense of ownership. In other words, physical resilience if implemented with little consideration of the social dimension of the place can hinder social resilience. The solution suggested in the RIBA publication is to integrate approaches for place-making, sustainable design, and flood control/mitigation. However, it could be argued that in the case of new developments the best strategy for resilience would be to avoid building on flood-risk land.

Resilience is not only determined by site configuration and building design. Communities play an important role, and developing on flood risk areas also entails a further burden for the community. This must be prepared for, and responsive to, emergencies. Lamond and Proverbs (2009) argue that, in order to reach the point of implementing mitigation measures, factors such as desire and ability to act are necessary. The former comes with awareness, perception, and ownership. Individuals must be motivated in taking action, and the sense of belonging to a place can provide a strong incentive. The latter comes with knowledge, resources, and belief. Any intervention to counter flooding can be undermined if correct information and means to counter shocks are not provided. These depend also on financial and time constraint. Similarly Hamilton (2009), in analysing resilience conditions for the water sector, distinguishes between technical factors, and social, political and institutional. He believes that resilience is usually regarded as connected to 'technical and political/social factors but, ultimately, is about the response and collective attitude of the inhabitants'.

What can be learned from this approach to resilience is that:

- Essential to the resilience of places is not only the physical response to flooding but also the social context and the character of the place. The exceptional site conditions of flood-prone areas require exceptional design solutions, thus great attention to the quality of the public realm. National guidance possibly fails to emphasise sufficiently this argument;
- The interconnectedness of scales of intervention is fundamental to the success of any resilience strategy;
- From a complex systems perspective, there are delay factors that can undermine efforts. One of these is the knowledge of how and when action must be taken within the community to avoid excessive damage to places and the community itself. Another one is the sense of ownership, which can inhibit the feeling of responsibility for taking action.

3.2.2 – *Man-made hazards*

Man-made hazards causing disruption can be generated by terrorist action or system and component failure (Hamilton, 2009). These can cause damage to infrastructure and buildings, and can induce, within the community, a collective perception of lack of safety and security. The safety of places has always been a serious concern, and urban design guides, long before the concept of resilience reached centre stage, have included principles to discourage crime (see Jacobs, 1993 [1961]; Llewis-Davies, 2000; CABE, 2002). Nevertheless the last decades have witnessed a radicalisation of social and cultural conflicts which, directly or indirectly, has resulted in a growing public concern around safety issues. Consequently places resilient to man-made hazards must be sufficiently protected against them as well as *perceived* to be safe by the general public. For this purpose 'Safer Places' (a guide delivered by the previous UK government on planning for security) addresses crime prevention through effective planning (ODPM, 2004), and gives a thorough report as to how neighbourhoods can be liveable, pleasant, and discourage crime. Seven are the necessary attributes for crime prevention. These are:

Access and movement – the movement framework should provide a network of routes that is clear and well defined. Too many connections may not be easy to control. Too few may result in an isolated area because of reduced accessibility;
Structure – the layout of the development and of buildings, the mix of uses as well as their adaptability to future transformations can deter crime;
Surveillance – passive surveillance is made possible when spatial configurations enable inhabitants to overlook open spaces at all times; active surveillance is one exerted through devices or dedicated staff. Both can act as a crime deterrent;
Ownership – communities that identify with the place in which they live tend to take responsibility for places and their security. Uncertainty of ownership can increase the likelihood of crime and anti-social behaviour;
Physical protection – physical and visible features that prevent or discourage access to entrances or open spaces;
Activity – in active streets and with active building frontages, the 'eyes of people' control streets. However, excess of activity can make crime invisible;
Management and Maintenance – neglected places tend to attract crime and anti-social behaviour. The management and maintenance of the place will keep it visually attractive to people.

Safe places are therefore those where circulation, access, and uses facilitate a passive surveillance by the people who live and work locally. In turn the place needs to possess those qualities needed for the community to develop a sense of ownership. Buildings must also be designed with security in mind. For example, the larger the glazed surface, the higher the risk in case of blast. Finally, management and maintenance are crucial to maintain over time the quality of the place. These guidelines merge passive and active spatial strategies. The former aims at fostering community cohesion to prevent the decay of the social fabric. For this purpose, places must be designed with a mix of uses, a strong identity, active frontages, etc. The latter aims at imposing security through technology (i.e. CCTV, etc.) and through spatial configurations that limit or discourage free circulation. However, there could be tensions between measures that attempt to stimulate participation and encourage people to take responsibility of their places, and measures that offer security by reducing responsible engagement.

Coaffee has produced a consistent and broad body of work on this subject (see Coaffee, 2008; Coaffee, 2010) examining from different perspectives the risks to infrastructure and buildings that may come from terrorist activities, and promoting the integration of security principles within the urban planning and design. Much of his work focuses on the attempt to go beyond the narrow specialist standpoint, and identify synergies which could lead to holistic design approaches. He argues that the disaster agenda and sustainability are not disconnected. Who would wish to live in an energy efficient but unsafe place? An integration of the two, and an identification of the conflicts between the two, is necessary to produce joined-up approaches to design (see Bosher, 2009). In the effort to integrate security strategies with those pertaining to sustainable building construction, Coaffee and Bosher (2008) analyse the opportunities for some of the safety measures to be implemented so as to deliver environmental benefits. For example, windows positioned to allow good visibility on entrances, could also provide good daylighting levels. Reduced energy consumption and a degree of self-sufficiency with on-site renewable energy generation can suffice for energy systems failure. Coaffe and Rogers (2008) argue for the necessity of augmenting institutional security strategies through community resilience. Community networks such as the Local Resilience Forums (established under the 2004 Civil Contingencies Act) 'are tasked with ensuring that there is an appropriate level of preparedness to enable an effective multiagency response to emergencies to be established at a sub regional level'. Finally, Coaffee et al. (2008; see also Coaffee and Bosher, 2008) suggest that any measure for security and terrorist action prevention, if successful, needs to be endorsed by the local community. This entails integration of aesthetic and social consideration so as to contribute to 'place-making'.

The terrorist attack in London in July 2005 magnified public concerns for safety, and exposed the fragility of critical components of the built environments (Bosher, 2009). For this purpose, other principles were introduced (see RIBA, 2010; see also Home Office, 2010). For example, a particular attention to the design and management of places likely to attract crowds was recommended, as well as a classification according to their level of risk, which could enable a proportional implementation of counter-measures. It should not be underestimated, however, the impact that the undue implementation of such measures can have on the built environment, since it can encourage a culture of diffidence and produce spaces that hinder social interaction and vitality, thus being not resilient in the long term. Security issues constitute a strong public concern and they are driving much of the decision-making processes. But are these issues going to be as influential as at present in the next decades? Is it reasonable to yield to the preoccupations of the moment in favour of a long-term strategy? Security and counter-terrorism measures contribute to shape our cities and their impact will be inherited by the future generations. Briggs (2005) argues: 'The long-term impact of counter-terrorism on the built environment will be measured in terms of the fabric of the city, but will be determined and framed by the nature of governance cultures and practices that exist at the city level. Getting the right answers to these questions will be key to preserving the vitality of our cities for generations to come.'

What can be learned from this approach to resilience is that:

- The resilience of places to man-made-hazards depends on the response of individuals and communities, which is also based on their perception of security of places. The design of building and open spaces resistant to attacks must address not only physical but also behavioural issues;
- The integration of security features within building fabric and infrastructure can be harmonised with environmental design features;
- The excess of safety and security prevention (e.g. strong artificial light allowing effective surveillance, CCTVs, barriers to easy access to cars, the limitation to meet in large numbers to prevent terrorist actions, etc.) can produce sanitised spaces that lack vitality (Pierce and Williams, 2011). In turn, this may also hinder the capacity to react to threats.
- The previous point suggests that the tendency to over-design preventive measures could be interpreted as a 'detailed resilience' (as opposed to 'general resilience') approach. By narrowing excessively the focus on the avoidance of terrorist actions, recommendations do not sufficiently consider long term threats that come with, say, 'sanitised places'. Existing guidance also mentions, but does not sufficiently emphasise, those elements that could bestow resilience to the system (i.e. leverage points) such as active surveillance. For this purpose social and cultural activities must be encouraged, which can attract people. Yet in guidance crowds are regarded as potentially dangerous and when possible discouraged.

3.2.3 – *Community or social resilience*

In literature, community or social resilience is normally regarded as the ability of communities to recover from disasters, or to resist and adapt to the consequences of climate change. It can also refer to the interaction between social and ecological systems and the environmental changes triggered by human activities. In this perspective resilience is examined at multiple scales (from local to global) with a very broad focus that encompasses all human processes and their impact on the environment. At a national level, the recently drafted 'Strategic National Framework for Community Resilience' (Cabinet Office, 2011) focuses on the ability of individuals and community to promptly respond to threats of any kind. Such response can be effective and fast if local networks are established that link third sector organisations, responsible individuals, and agencies. Awareness and information available to all is also crucial. The document sets the timeline of a governmental programme aimed at fostering individual and community reaction to emergences. The programme aims at: *raise awareness of risks and consequences*; *expand and export successful community resilience models across the country*; *eliminate barriers to participation*; *support dialogue between practitioners and the community; provide a shared framework to communities*. It is therefore the provision of professional guidance and information, and the constitution of dedicated networks and organisations, which can help the community to spring back in the aftermath of disasters. In this perspective professionals can contribute to social resilience through knowledge transfer and the facilitation of social participation. This is an approach deemed necessary for many other strategies strictly related to a sustainable built environment (e.g. correct use of energy efficient buildings, etc.). Still it is one that struggles to be integrated into common practice, possibly because of scarce individual engagement, difficulty in elaborating effective strategies, or because of reluctance of practitioners to address user behaviour within the design process.

While the focus here is on enabling the community to cope with emergencies through information and preparedness, and in building resource management, some studies presented in these section have stressed how crucial is the strength of the social fabric for the purpose of recovering community vitality after disasters. The scope (and the interpretation) of resilience is therefore extending to the social and economic vitality, and to community building. These studies maintain that social resilience strongly depends on the social composition and the particular economy of the place, which can sometimes be characterised by a fragmented social fabric with vulnerable groups. Other scholars maintain that it is in fact the value system of the community that will make it more resilient, and that 'the presence of sustainability-generating resilience attributes will be greater among urban areas featuring moralistic political cultures and will be less among individualistic cultures' (Pierce et al., 2011).

Campanella (2006) argues that, after disasters, buildings can be rebuilt. However it is the reconstruction of social and cultural networks on which cities are based that will lead to recovery. This is because disasters 'uncover underlying vulnerabilities, which have social, political, economic and environmental origins' (Reale and Handmer, 2011). The reconstruction of networks can be facilitated through a diversified economy and a built environment with quality and identity. Whether communities resilience is looked at as the organisational capacity to respond to threats, or as the net that will hold the community together in the aftermath of a shock, emergencies should not be regarded as occasional events, since disturbances will inevitably occur in urban systems because of their dynamic nature (Pierce et al., 2011). Thus the building of community resilience should be envisaged as a constant, on-going process to which institutions, local groups, and individuals must be committed. Central attributes of social resilience are *information*, intended as the ability of reading signals and designing solutions as a response to environmental change; *motivation*, intended as to how responses to change are evaluated; and *capacity*, intended as resources to implement change (Lambin, 2005).

The many streams of study on vulnerability descend from two research traditions: vulnerability to natural hazards and vulnerability as disparity of access to resources (Adger, 2006; Mustafa et al., 2011). The former can lend itself to a restricted perspective (i.e. emergencies as a consequence of calamities), whereas the latter necessarily relates to societal structure, policy, and governance. The National Framework for Community Resilience, for example, appears to be biased towards the emergency perspective, and not enough on an integration of the emergency within a three-step policy of continuous information, motivation, and capacity building. Therein, the role of professionals appears unclear, probably consigned to one of support and information provider.

Adger (2000), expanding the view from the community dimension to a wider urban social sphere, links together social and ecological resilience, since both are dependent on human activities. Political institutions governing society, economy, and cultural structures all depend on the ecosystem services supplying resources. These impact the degree of ecosystem resilience, which in turn influences social resilience. Through progressive urbanisation socio-economic and biophysical processes interact, and depending on their form cities will impact ecosystems in different ways. For example urban sprawl can be deemed as an inefficient use of land that reduces the coverage of green areas surrounding cities (Musacchio and Wu, 2002). Drawing on empirical evidence of the damages and alterations of urban forms on ecosystems (e.g. diminished connectivity for several species, environmental pollution, light pollution, etc.), it is possible to test strategies or development plans that link urban patterns, economic activities and ecological conditions (Alberti, 2005; Alberti and Marzluff, 2004; Alberti et al., 2003). Arguably, it is difficult to determine the extent to which political and cultural choices cascade on human activities and urbanisation, on the ecological systems, and finally on local communities and their ability to adapt to change. These studies, however, attempt to demonstrate that links between these distinct spheres exist and must be studied within the logic of one large and complex system.

What can be learned from this approach to resilience is that:

- Community resilience and social resilience, although predominantly viewed in relationship to disasters is strongly influenced by the local and general economic and social conditions;
- As for other guidelines for resilience, the time factor here is crucial. Measures for its attainment must not focus on the here and now. Instead they necessitate long term vision and planning;
- The exploration of social resilience in relationship to the physical conditions of the built environment is limited whereas some attempts to capture these interplays can be found in the literature reviewed on natural and man-made hazards. To what extent the quality of the urban context, its use, its environmental efficiency can support the resilience of communities?

3.2.4 – *Resilience to climate change*

This is a wide category of resilience that encompasses many specific areas such as natural hazards, resilient infrastructure, resilience to rising temperatures, etc. Climate change is the specific subject of the Supplement to the Planning Policy Statement 1: Planning and Climate Change (DCLG, 2007), in which principles for sustainable urban development are integrated with those for adaptation and mitigation. The accent is on the reduction of carbon emission, an increased degree of energy self-sufficiency, and the design of cities that can mitigate effects of rising temperatures and the expected more extreme weather events. Ensuing recommendations include: *provision of trees and vegetation as carbon sinks or as mitigation of urban heat island effects; decentralised energy production; infrastructures protected from disasters; avoidance to develop on flood-prone areas; energy and resource efficient buildings; sustainable drainage systems*. The scale of interventions recommended here requires the coordination of Regional Spatial Strategies with Local Development Frameworks and the prioritisation of environmental goals for new developments and new buildings. The climate change umbrella offers the opportunity to conflate the entire gamut of best practice approaches to environmental design, such as energy efficiency (e.g. resilient energy supply to avoid energy cuts during extreme heat events, local energy production, etc.); reduced water consumption leading to resiliency to droughts (Kamal-Chaui and Robert, 2009); passive design principles; resistance, recovery and adaptation to floods; building structures resisting higher subsidence, etc.

With its Climate Change Toolkit, RIBA offers practical advice on low carbon building design, designing for flood risk, and whole life building assessment (RIBA, 2009a; 2009b). Although the publication is of use for practitioners, it merely lists current well-known low carbon design principles reinstating their relevance for the purpose of urban resilience in the light of climate change. Design for Future Climate, the report delivered by Gething (2010) for the Technology Strategy Board, is possibly a more complete and relevant study. It is composed of three large sections: *Designing for comfort* (keeping cool; keeping warm); *Construction stability* (over ground; underground, weatherproofing); and *Managing water* (water conservation; drainage; and flooding). In each section the report highlights the tardiness of the construction industry to this challenge and the ensuing opportunities. Existing technologies and assessment design tools facilitate the design of low carbon buildings, however much more research and experimentation is necessary to face with challenges that are not yet completely known. Moreover, the construction industry needs to devise effective and innovative pathways to build affordably and effectively since costly construction solutions are generally resisted. Thus, buildings resilient to climate change require innovative methods of construction and the redesign of supply and procurement chains. More importantly, emphasis is put on the uncertainties still existing as to how and to what extent climate change will impact environment, thus building design needs to factor in a degree of ‘excess capacity’ to be able to resist that which is still unknown.

At a more strategic level the report ‘Climate Action in Megacities (Arup, 2011) identifies three categories of adaptation and resilience: *crisis planning and preparation*; *reducing flood risks*; *reducing vulnerability to climate stress*, the latter consisting in reducing ‘vulnerability to heat, water and health stressors produced by climate change’.

Although failing to satisfactorily cover social and economic factors, Roaf’s guide on climate change (2005), provides an exhaustive outlook on resiliency principles for a post peak-oil urban environment, in a ‘world where power failures will become more common’ and ecosystems adapt to mutated environmental conditions. Here too, the attempt is to draw a systematic picture of the destabilising factors impeding resilience, which can be foreseen but are still uncertain. The focus is exclusively on the environment (i.e. floods, extreme summer heat, stronger weather events, etc.), resources (i.e. water and fossil fuel) and the social tensions deriving from migration patterns and ecological changes.

A much broader picture is outlined by the Resilient City with their website in which a 'set of planning and design resources - including blog posts, web links, research references, and planning and design exemplars - that further explore the question of how to build the capacity for resilience in our cities' is made available (www.resilientcity.org). On the website climate change is depicted as only one of the (although a major) factors that can limit urban resilience, others include, for example, resource scarcity and population growth. Resilient design principles are given at a city and a building scale, and these merge those listed in other literature presented here with those provided in best practice sustainable urban design guides. For example, under the section of resilient city principles, 'Density, Diversity and Mix' and 'Placemaking' are included for their contribution to carbon reduction through a better land use, walkable neighbourhoods, concentration of activities as well as vibrant and liveable places. Under the section for resilient buildings, the principle 'Design for use of building systems that can be serviced and maintained with local materials, parts and labour' is introduced, which emphasises the importance of a local supply chain for all building components and processes in a near future where global trade is unaffordable because of the extreme depletion of fossil fuel stocks. Although guidance given here is broad and never specific, and although a theoretical framework encapsulating principles for resilience is lacking, there is nevertheless an interesting attempt to portray resilience to a practitioner's audience in all its dimensions.

The urban resilience prospectus compiled by the Resilience Alliance (2007) sets the foundation for a strong holistic research framework for urban resilience, which does not specifically address climate change although it positions itself in the context of a process of environmental change. The research agenda outlined includes: drivers of change and threats for cities; pathways to integrate the triple bottom line dimensions; the influence on resilience of the new socio-ecological urban systems emerging (i.e. city-regions, metropolises, etc.); and finally the alternatives to redirect urban growth towards sustainability objectives. The key, interconnected areas for this investigation are: *metabolic flows* (production, supply and consumption chains); *governance networks* (institutional structures and organisations); *social dynamics* (demographics, human capital, and inequality); and *built environment* (ecosystem services in urban landscapes). A vast and comprehensive system is traced here, of which the built environment is only one of the components. The prospectus anticipates future research of the Resilience Alliance team, of which no results to date are available. It effectively captures the essence of urban resilience, which is systemic, and the interplay between evolving cities and ecosystems in a process that is not fully controlled by societies. It is a bold attempt which could lead to further the theoretical understanding in this area.

These last two attempts to define resilience possess a breadth and richness that the rest of the literature reviewed under this category lacks because of its restricted scope (i.e. environmental efficiency to adapt to climate change). Unfortunately both attempts are not sufficiently developed so as to provide a fully-fledged theoretical framework for resilience and/or specific integrated guidance to climate change that can help practitioners focusing on attainable targets.

What can be learned from this approach to resilience is that:

- Urban resilience to climate change is a category that encompasses several strategies for environmental efficiency, which are already commonly used for building and energy resource efficiency;

- Climate change is a global phenomenon. Its examination in relationship to the urban environment must necessarily take into consideration different scales and different urban dimensions. Thus a complex systems approach is needed;
- Resilience to climate change is the most comprehensive of the categories reviewed here. As such is the most suited to be looked at holistically and with a complex systems approach. Still, little attention is given to the adaptive capacity of cities to future social and economic shifts, which will be also dictated by climatic changes;
- Much of the literature examined fails to provide a framework supporting the multitude of recommendations/strategies/approaches to urban resilience.

3.2.5 – Resilience through adaptability

If the ultimate purpose of resilient urban environments is to survive the test of time, then arguably physical adaptability is a key element. Although this topic features in some literature on resilience reviewed here (see Gething, 2010), and its relevance is highlighted in the latest sustainability-centred revision of RIBA's Plan of Works (RIBA, 2011), much of the studies on urban and building adaptability were developed before the concept of resilience came to prominence, therefore not directly linked to it. At an urban scale, interventions for adaptability inevitably relate to the economy and the social conditions of the place, since they impact on the future uses of buildings and their suitability to future social expectations. Debate on these issues conflates with the one on the quality of the urban environment and the role it can play in supporting the vitality of local communities (see Jacobs, 1993[1961]; see also Urban Task Force, 2000; DETR, 2000).

In discussing the transformation of cities over their lives, Childs (2001) introduces the concept of civic evolution. In his opinion 'building types and cities change over time'. Understanding the nature of change would aid designers in making adaptable and resilient built forms. Buildings resilient to changing social practices and to aesthetic appreciation, or neighbourhoods maintaining their vitality, are such because they have evolved, similarly to ecosystems. New 'species' of buildings evolve from the hybridisation of obsolete typologies. For example, the 19th century railway station 'is the result of a cross between the engineering shed and the chateau hotel'. Nevertheless this typology has been able to capture the need for representativeness, flexibility, and vast, unobstructed spaces capable of accommodating crowds and flows of people. It is also a typology that has resisted time and that to date is still suitable to public space spatial requirements. Resilient urban design and planning should therefore: *focus on the built form rather than being unduly influenced by other dynamics* (e.g. economic, political, etc.); *allow change over the lifetime of buildings*; *consider the interaction between buildings*; *consider the not pre-planned emergence of urban patterns and settlements*. This last principle connects to an urban theory tradition initiated by Jane Jacobs (1993[1961]), which promotes urban vitality through co-existence within the same neighbourhood of diversity of uses and income groups with bottom-up social participation.

Successful architectural design 'maintains a compelling coherence and meaning even as the details of its context shifts' (Childs, 2001). This needs to apply not only to aesthetics but also to changing social conditions. There are historical precedents of building stock that did not survive a perception of inadequacy, which wasn't strictly related to its spatial and mechanical qualities. Peter Hall (2002) reports on the failure of many high-rise developments built in the UK during the 50s under the influence of the architectural modernists' vogue, many of which were demolished after less than forty years. This suggests that failure may not be explained only on aesthetic and functional grounds. Instead it may be attributable to changing social condition (i.e. 'problem families' moving in as a consequence of sudden housing surplus) and ineffective management (i.e. control of disturbance, building maintenance, etc.). The ensuing removal of many of these developments seemed to reiterate the ‘clean-sweeping planning’ that replaced many slums with high-rise blocks and in doing so destroyed many communities that were integral to those places.

More broadly, the issue of adaptability can be brought back to the attitude with which cities are regenerated. Many scholars have claimed the unbalanced approach of regeneration policies which tend to be viewed as drivers for economic growth and much less as occasions for amelioration of social conditions and creation for local jobs, thus contradicting the principles of sustainable urban development (see Bromley et al., 2005; Raco and Henderson, 2006). Elaborating on this critique, it could be argued that the adaptability of any urban environment is also a function of the agenda that is behind each process of urban change. If there is political will, much of the existing building stock and of the urban spaces could possibly be adapted and retrofitted to meet environmental excellence standards, with demolition and reconstruction carried out only when strictly necessary. Jane Jacobs (1993[1961) describes vividly the case of the North End area of Boston, whose community was thriving and its street life attracted visitors, but nevertheless was earmarked for regeneration. Carmon (1999), in giving an account of the UK renewal/regeneration policies over the last three generations, shows that in the face of the best goals of social amelioration and provision of much needed dwellings, rarely large scale interventions met initial intentions. She comes to the conclusion that if economic development and social equity are the truly ultimate objectives ‘the analysis of ``who pays and who benefits" should be used as a main criterion for selecting projects for urban regeneration’.

‘Civic evolution’ is about adaptation to time, and guidance available on building adaptability can be found in the ‘Building for Life’ set of principles (CABE, 2008), or in best practice urban design guides such as By Design (DETR, 2000) and the Urban Design Compendium (Llewelyn – Davies, 2000). The Urban Design Compendium, for example, recommends urban block forms that allow accommodating over time a variety of building typologies and sizes. ‘Building for Life’ advocates adaptability ‘through development that can respond to changing social, technological and economic conditions.’ This can be attained through simple building forms that can easily adapt to a variety of purposes, and allow modifications of interior layouts. However such guidance mainly consists in practical criteria applicable to residential buildings. It refers to dwelling transformation to changing user needs and for inclusivity purposes. Instead, the notion of ‘civic evolution’ goes beyond spatial flexibility to include design principles sensitive to the broader social and historical context. Failure to include these principles while designing urban development may result in a building stock that will struggle to adapt over time.

What can be learned from this approach to resilience is that:

- In designing resilient places it is essential to consider the time factor, namely how meaningful the urban development planned today will be as the ‘details of the context’ shift;
- Adaptability is not only about the possibility to modify spatial configurations, but also about the capability to meet changing socio-cultural needs and different building uses;
- Similarly to the other categories, literature on urban adaptability shows an excessively narrowed focus. For example it fails integrating consideration on environmental performance, either because it was developed before environmental awareness (and resilience debate) came to prominence or because it lacks of a sufficiently robust systemic approach.

3.2.6 – Summary of the issues emerging from the literature review

The concept of resilience within ecology studies has been briefly reviewed in parallel with the topic of cities as self-organising systems within urban studies, thus eliciting strong analogies between natural and urban systems. Some recommendations for resilience that seem valid for both systems have emerged, which also draw from the complex systems theory. Recommendations include:

- The necessity to approach the issue of resilient cities with a complex system perspective;
- The necessity to define the finalities of a system in order to establish the purpose of resilience (resilience of what and to what);
- The necessity to widen the scope of resilience (general versus detailed);
- The necessity to consider sufficiently large spatial and temporal scales of systems;
- The necessity to identify feedback loops and leverage points that can help improve the resilience of the systems.

These basic principles have helped identify inconsistencies in the studies on urban resilience reviewed here, which are usually related to an excessively restricted scope, the lack of a systemic approach, and an insufficient integration amongst the systems' elements. Some of these inconsistencies are summarised below.

Urban resilience has been recently associated mainly with sudden shocks and consequent post emergency recovery. This has spurred a flurry of guidelines that address specific disruptions occurring within the urban context. Nevertheless a sustained and sustainable urban performance requires considering factors that are seldom included in disaster studies. Flexibility of spaces and uses, for example, although a traditional issue within the urban design and architectural debate, acquires particular relevance in the face of the fast pace of change of society and the short life span that too often new buildings and urban development tend to have. Within a permanent condition of uncertainty, resilience must be an attribute of all urban dimensions, not only of those that are directly connected to emergencies.

The literature review shows that in each category of resilience there are shortfalls, some of which become more evident when social and/or economic considerations come into play that could undermine the effectiveness of design schemes, if these too rigidly rely predominantly on physical performance. Resolving these contradictions can lead towards a more integrated approach. For this to happen, there must be clarity on the definition of urban resilience and on the necessary requirements for its implementation. Instead the picture resulting from the literature review is somewhat fragmented, with urban resilience defined alternately as a 'fast response to emergencies' (Cabinet Office, 2011), 'putting in place safety nets for the disadvantaged within the community' (Sellick et al., 2010), 'resistance to climate change effects' (HM Government, 2011; DCLG, 2007), 'withstand, recover from, and mitigate for, the impacts of extreme natural and human-induced hazards' (Bosher, 2009), 'the ability to withstand damage' (Hamilton, 2008), 'the capacity of a city to rebound from destruction' (Campanella, 2006), and more.

The fragmentation of the concept of urban resilience becomes more evident if one considers the likely eventuality of applying more guidelines simultaneously, with some of the correspondent measures overlapping or conflicting. For example, as discussed above, excessive security measures (i.e. resilience to man-made hazards) may hinder the vitality and the identity of the place, with the latter being one of the requisites for a fast post-shock community recovery (i.e. community or social resilience). Strong building structures and external walls can provide protection against terrorist attacks *and* offer the opportunity for enhanced thermal mass leading to energy savings (Coaffee and Bosher, 2008). These points of intersection need to be mapped and evaluated, as they can offer opportunities to connect the much fragmented picture of urban resilience. It is therefore critical to position and review all these different connotations within a common theoretical framework that can facilitate a systemic view. This should be based on a shared definition of urban resilience indicating its finality, and offering a baseline onto which measures to resilience can be identified and evaluated.

What follows is a list including some of the issues that have repeatedly emerged in the course of the literature review, which builds upon those identified in the initial section on ecology studies:

- Studies on resilience predominantly focus on specific aspects. To date, resilience lacks of a unitary definition or of a framework within which all these specific studies can be accommodated;
- Planning and designing for the long-term, and considering a sufficiently broad context in which each plan for development sits, are essential preconditions for an understanding of the 'workings of resilience'. Whether the system analysed is a Canadian forest or an English social housing estate, conditions for resilience can be understood only when focusing on the context and how it mutates over time;
- The need to approach things holistically when designing sustainably is fully acknowledged. The literature review shows that, because of its systemic nature, this is particularly true for resilience, and the key to its comprehension lies in the relationships and intersections amongst the diverse social, economic, and environmental factors;
- Learning from complex systems and from the systems thinking discipline, the examination of links that connect factors can lead to the identification of feedback loops, delay mechanisms, and leverage points. In other words the understanding of the conditions for resilience, comes with the identification of causes for adversities with connected reasons;
- The interconnectedness of scales of intervention (buildings resistant to flooding must be complemented with a permeable urban environment and a district water management; designing for climate change necessitate buildings, urban environments and infrastructure concurring to mitigate heat, protect against water, and ensure provision of utilities, etc.) is finally another feature inherent to resilience.

The resilience of urban environments must transcend single interpretations to look at its essence, which is systemic and time-bound. Resilience to natural hazards necessitates also communities to spring back to life in the post-disaster recovery, supported by an effective economic fabric and buildings that can be easily repaired and/or upgraded. All these dimensions must be looked at simultaneously, hence the systemic nature of resilience. Disasters are only some of the events that may cause disruption. Urban development may not resist economic downturns, market logics, and cultural shifts that will occur in the short and long-term future, hence the strong link between resilience and time. To analyse urban development against resilience requires considering holistically these factors. These basic findings will lead to the identification of an appropriate method to identify urban resilience.

Chapter four – Interviews with practitioners

The aim of this section is to present the findings of a series of structured interviews held with practitioners working in the field of the built environment. These were conducted so as to ascertain to what extent and in which ways urban resilience is understood within the interviewees' professional category. Whilst findings from a small series of interviews can by no means be generalised, they can nonetheless offer insights of relevance to this investigation.

4.1 – Interviews

Eleven out of the twelve invited participants agreed to be interviewed. The participants were carefully selected on the basis that they were:

- Experts with many years of experience in the sector of architecture and urban design;
- Directing renown architectural and urban design practices, and actively involved in research activities with professional organisations such as BRE;
- Central figures in prominent architectural organisations promoting good design and research such as RIBA and CABE.

The particular position within organisations of the sector and the professional experience of the interviewees ensure that their opinions are informed, and to an extent reflect, those of their professional group. Their comments reporting professional attitudes on resilience are therefore considered by the author sufficiently reliable. In Table 2 a short description of the interviewee's job position and/or area of expertise is provided.

4.1.2 - Questionnaire

Through the literature review some issues that are particularly relevant to resilience have been identified, which in turn constitute aspects to be further investigated. Based on these aspects a questionnaire was formulated that was used to conduct some structured interviews with practitioners. Such aspects include:

- The lack of a unitary vision, or interpretation, or framework that can be used as a general reference for understanding urban resilience, which leads to questions aimed at probing how this concept is understood within the professional domain (see section of the questionnaire: 'Individual and collective interpretation of resilience');
- A systemic approach to resilience requires consistent scales of intervention, which leads to questions concerning the spatial scales at which resilience should be examined (see section of the questionnaire: 'Scale');
- Establishing the purpose/finality of a system helps identify risks of failure and therefore effective strategies for resilience. In the case of urban systems, it is assumed that their ultimate purpose should be their sustainable state, and that the resilience of this state is desirable. This leads to question about the perceived relationship between sustainability and resilience (see section of the questionnaire: 'Sustainability and urban resilience');
- Finally, since this thesis aims at exploring practical applications of the concept of resilience into practice, a final set of questions is added that concerns its measurability and applicability (see section of the questionnaire: 'Applicability/measurability').

The complete list of questions is presented in Table 2.

Categories	Questions for interviewees
Individual and collective meaning and interpretation of resilience	1 - Do you think resilience is a familiar concept in the planning and urban design field? How do you think it is currently interpreted? How do you interpret it?
	2 - Do you think that in current practice the notion of resilience is also associated with one of longevity of buildings and of the built environment at large?
	3 - Given your interpretation of resilience, could you specify how such a concept is addressed in the planning/design process, and with what tools? Could you also specify how do you address resilience in your profession/practice?
	4 - There is an assumption, in many disciplines, that resilience is a positive quality. It implies that what is planned needs to last and perform well for as long as its physical form lasts. Do you think this is achievable as far as the built environment is concerned?
Applicability/measurability	5 - Do you think the long-term effectiveness of what we plan could be achieved through the application of a set of principles, or guidelines, that can inform the initial phase of the design/planning process? - (Qualitative approach)
	6 - Conversely, do you think that a long-term effectiveness can be best achieved through a value-based approach? For example, by establishing performances that should be maintained over the life time of the built environment (e.g. a level of energy efficiency, buildings adaptable to a given number of uses, percentage of open/green spaces available per inhabitant, etc.)? - (Quantitative approach)
	7 - Do you think that resilience is measurable? If so, how and with what (qualitative or quantitative) indicators?
	8 - Do you think resilience (as for the definition stated above) as an indicator could (and should) be integrated in assessment tools, or rating codes, such as Code for Sustainable Homes, BREEAM, or Green Print?
Scale	9 - Do you think the nature of resilience changes depending on the scale considered? If so, could you define how?
	10 - Do you think resilience is a concept applicable to a single intervention, or at a building scale, or at an urban development scale, or at a larger scale, or at all scales?
Sustainability and urban resilience	11 - Do you think resilience and sustainability are distinct or related issues? Could you define their relationship?

Table 2 - Questionnaire of the interviews to practitioners

4.2 – Analysis of the interviews

In this section some of the most significant opinions that emerged from the interviews are presented. It is important to notice, however, that there has been a tendency amongst the interviewees to discuss resilience beyond a restricted specialist standpoint, and mainly focus on traits of flexibility and adaptability at large. Thus, many have expressed opinions as to how embedding such traits not only in the face of extreme events but more in general against time, and socio-cultural and economic changes. At this level, the discussion has produced results that can be appreciated by a wide audience of practitioners (as opposed to a specialist one), and thus spur an understanding that goes beyond the simple measures included in checklists and guidance such as those mentioned in the previous chapter. Each following sub-section is dedicated to one of the categories of the questionnaire and presents a brief account of the interviewees' responses. Different responses are counted to ascertain which are predominant over others and in some cases relevant comments of the interviewees are provided. At the end of each sub-section emerging themes are summarised. The final section of the chapter attempts to draw conclusions. Comments gathered are summarised in Table 3 and transcripts of the interviews can be found in Appendix 1

Interviewees	**1 - Climate and Sustainability Manager for a Local Authority**	**2 - Architect: Designer, academic, and consultant**	**3 - Director in a big design practice; experience in teaching urban design; delivering CPD for RIBA**	**4 - Architect directing own practice and working in urban design schemes, also overseas**	**5 - Head of an organisation promoting good design in the built environment**	**6 - Project architect id design company, mainly working in architecture**
1. Currently, how is resilience interpreted in the planning and urban design field? How do you interpret it?	It is not particularly understood or a major criterion for assessment. Urban development is mostly designing for today not the future	It means different things to different people. It is confused with longevity. It could mean flexibility (a concept pursued since 70s)	It is familiar for those working in security. It is however difficult to discuss with others about changes that may happen 30 years away from now	Familiar although perceived as connected with technological, rather than socio-economical issues. The emphasis should shift	Becoming familiar. Set in the context of extreme events	It is not a not a concept that we are familiar with in buildings, which are currently designed with little built-in adaptability
2. Is it associated with one of longevity of buildings and of the built environment at large?	No, it is about fit for purpose over a period of time	Yes. We design for a design life of 20 years.	It is perceived as an attitude to adaptation	Current practice has a green bias. Wider issues are not considered	More commonly used in a societal context, rather than longevity	Yes. But different clients have different expectations. With community-owned properties longevity can be addressed
3. How is it addressed in the planning/design process, and with what tools?	Climate change is forcing professionals to lengthen the time-horizon of risk analysis	Do we want longevity? Building should be designed in parts where some could last and some are unlikely to last.	You have to think in terms of building elements which need continuity and others that need change	There is often a whitewash approach to resilience that doesn't take into account local diversities	It is addressed as a process of future proofing, thinking about change and risks that may arise	Through standards. Although these may lead to an engineered design whereas the agenda is much wider.
4. Do you think resilience can lead to longevity?	Yes. It shouldn't be tied down to a numeric factor. It must be more flexible.	Resilience requires legislation, but also the definition of what needs to be flexible since building's performance ends before its physical form	Yes, although the concept of 'long-lived' must be defined. There are places where building obsolescence is artificially determined by rising land values.	Looking at the local context and answering to those needs may result in resilient environments	I think the urban form because of its cultural power, is important. Stable evolution is needed and the more robust the urban form the more successful	It is about adaptability. But maybe it should be accepted that buildings can be demolished, whereas urban fabric needs to be permanent.
5. Does it require a qualitative approach?	There is a risk of locking yourself into numbers	You cannot quantify some environmental elements	Guidelines are necessary and must stay in place in spite of the alternation of governments	Qualitative analysis can be developed and detailed in a quantitative assessment, although time consuming	It helps to structure your thinking, however it is no substitute to good design	The danger with sets of principles and guidelines is the sheer preponderance that stops you thinking
6. Does it require	We need a	Both	Yes	I am diffident of	Can be useful,	Yes

a quantitative approach?	qualitative measure. Feedback loops should allow knowledge to be updated.			quantitative approaches	although not everything that can be counted counts	
7. Is it measurable?	Yes, but perhaps not sufficient in their own right	The concept is too fragmented. A tool could help assess potential for longevity	Scoring systems can be of help, although it may come with threats	You can only measure it in hindsight	Yes. You have to break it down and find ways of measuring it	Not sure it is possible to measure it in advance. Life time cost could be a parameter
8. Could it be integrated in existing design tools?	Yes	PFI had a in-built 25 years resilience, but it did not produce good architecture.	Yes	Tools fall in the trap of generalisation and can be manipulated	There is a danger that quantitative indicators can oscillate cultural acceptance.	I am not sure it can
9. At which scale of intervention it is best applicable?	it must connect with other infrastructure and also question how it connects to people	At all scales. Buildings cannot stand fashion. So we need tools that can tell what should last and what shouldn't	Particularly relevant at an urban scale because it relies on context. it is difficult to contribute to the resilience of the area with resilient buildings only	Applicable at all scales. Even a tree can transform a place and recoup a community	At all scales, I think it is less significant at a smaller scale	At all scales. There may be a risk of designing buildings that are too resilient
10. Does its nature change depending on the scale of intervention?	The more you intend to change the more that needs to be considered.	Decisions taken at one scale will have an impact on the longevity of classes of use.	Yes	It changes according to scale, although connected at all scales	At a larger scale you would need to look at design decisions that will impact the local	It is all about context
11. Are resilience and sustainability related?	We should focus on delivering resilience rather than sustainable development, which policy makers still do not fully embrace	Sustainability is environmental resilience and we can make statements about achieving it but we are a long way off a quantitative approach	Distinct concepts, although resilience is integral to sustainability	I think they are the same, although not strictly referring to environmental aspects	Different. Sustainability is about not messing up the future when Resilience is about coping with the future	They are not different

Interviewees	**7 - Architect with long experience in procurement in the government sector. Experience on building industry standards**	**8 - Planner, working with local council as site manager, previously working for HCA**	**9 - Academic working in Property, Planning and Construction**	**10 - Architect and urban designer providing policy and design advise**	**11 - Architect with a sustainability agenda, working in building industry**
1. Currently, how is resilience interpreted in the planning and urban design field? How do you interpret it?	It tends to be just physical. But I would think in terms of system's resilience. It could be determined through life-cost approach	Sustainability has been superseded by resilience, which has been the new buzzword for a couple of years	Familiar more to academics than planners, superseding overused concept of sustainability.	Sustainability dominates. Resilience entails flexibility and adaptation whereas sustainability suggests a permanent condition	Urban systems and buildings capacity to meet environmental changes

2. Is it associated with one of longevity of buildings and of the built environment at large?	I would say both. However, different sectors can develop these things in different ways	No. There is also resistance from the Building Industry to changing standards	It is one of the ingredients.	I don't really know	Mainly associated with building longevity rather than with urban development longevity
3. How is it addressed in the planning/design process, and with what tools?	POE looks at softer issues. LCA is reliable but doesn't look at social issues, which could be integrated in the classic LCA	Through codes, although they may become a boxticking exercise. There are also conflicting messages coming from local authorities	Nothing would be resilient without buy-in. What could make the difference is social learning	Resilience is very difficult to address because it requires thinking beyond the project´s timescale. Flexibility is key. Redundancy contributes	Studying environmental changes, actively engaging with users, and using materials appropriate for a changing climate
4. Do you think resilience can lead to longevity?	Flexibility and permanence can be conflicting, and resilience entails acceptability in relationship to cultural values that change	Historical buildings are there to witness. I have my concerns that we didn't learn any lesson from the 50s and 60s, especially when it comes to density and ghettoes.	Yes, It needs to last, endure and perform well.	Resilient structures can outlast the physical form as initially envisaged by the designer	It is about the system chain working effectively, although more research should be developed
5. Does it require a qualitative approach?	Qualitative and quantitative parameters should be integrated	It can and it has been done. But it also depends on how much it is left to interpretation. Compliance to non mandatory standards rarely happens.	You need a vision, then a set of principles and having got that you need benchmarks in order to test its performance	Possibly, although I would view these principles as rather simple and generic rather than highly detailed and rigid	Yes
6. Does it require a quantitative approach?		There is the risk that quantitative indicators become another boxticking exercise	Mixed methods seem to work best	Quantitative parameters can become redundant. Consider what happens when the fuel ends	Yes. Although priority should be given to qualitative approaches
7. Is it measurable?	Yes	Yes. I see qualitative indicators as mainly referring to sustainable communities	You can assess not measure, although indicators need to be developed	Hard to measure, although similarities may be considered with characteristics proved to be resilient in the past	Yes
8. Could it be integrated in existing design tools?	Yes	Yes, although I am not sure how it can fit with the local agenda	I certainly would like to see those codes reappraised, embedding the concept of resilience	Tools could be tested in terms of the extent to which they facilitate greater resilience.	Yes
9. At which scale of intervention it is best applicable?	It should be holistic	At all scales. But it needs to cascade down consistently	I favour the landscape scale, which is flexible and fluid enough. For a village hall to be resilient, the wider context should be considered.	At all scales, requiring different design characteristics	At a city/region scale
10. Does its nature change depending on the scale of intervention?	It is about money and investment, cost and value create problems	Strategies are determined by the logic of financial return. So they	The danger of working at a smaller scale means missing out, you don't	Is linked to time scales that are longer for urban environments and	Environment changes in different ways, thus resilience

		consider resilience depending on constraints.	recognise the wider system	shorter for buildings	should be applied accordingly
11. Are resilience and sustainability related?	Sustainability is all about numbers. Resilience is about recycling, decommissioning, and LC	They are one and the same	a subset of sustainability, a strand under the umbrella of sustainability	The difference is in the perception the term communicates. One is dynamic and the other is static.	They are strongly related

Table 3 – Summary of the opinions collected from the interviews. The first row of each table briefly describes the expertise or job of each interviewee

4.2.1 - Individual and collective interpretation of resilience

Responses on the issue of the interpretation of resilience within the professional category of architects and urban designers can be attributed to three main attitudes. The first one, with four out of eleven interviewees expressing this view, maintained that the term resilience is used predominantly by those that are specialised in fields such as security of buildings and places, or those that research on climate change in relationship to the built environment. Two out of eleven perceived it as associated with buildings and urban flexibility/adaptability. Finally, two more responses negated that the concept is familiar at all within practice. These opinions are all consistent with findings from the literature review, showing that resilience studies cover a wide range of avenues, thus offering a fragmented landscape which surely can cause confusion. In other words, to quote one of the interviewees: 'resilience means different things to different people' (interviewee n. 2).

Resilience is also viewed (two out of eleven) as an emerging concept that is superseding sustainability. Interviewees expressing this last opinion, however, did not further elaborate on the issue, and did not explain specifically in which way resilience could replace sustainable design approaches. However, it is possible to surmise from some comments that resilience evokes longevity, resistance, and durability: values with which people can easily connect with and that can be easily appreciated. Sustainability, instead, can be perceived as too abstract to produce tangible benefits. A further issue of relevance to this research is the one expressed by three interviewees maintaining that today buildings are designed and constructed for a rather short lifecycle. The interviewee n. 1 maintained that 'urban development is mostly designing for today, not for the future', whereas the interviewee n. 2 said that 'in current practice we design for a design life of 20 years. It is a concept related to insurance and performance of materials'. Moreover, the interviewee n. 3 said: 'it is difficult to discuss with other people about resilience in relationship to changes that can happen thirty years away from now. Buildings may not last that long'.

When asked if and in which way resilience can be implemented in practice, the majority of interviewees believed it possible (six out of eleven). Each one, however, believed there are some conditions for this to happen. These include: the necessity of appropriate legislation, thus showing scepticism on the engagement and sincere commitment of professionals and developers to design and build for resilience (interviewee n 2); the necessity of learning from the past (i.e. historical buildings surviving centuries) and from past mistakes (i.e. the short-lived social housing estates built in the 50s and 60s - interviewee n 8); an in-depth understanding of the local context and the local needs (interviewee n 4); and more. Five out of eleven interviewees mentioned as tools fit for facilitating its implementation environmental assessment methods such as those currently in use (i.e. BREEAM, Life Cycle

Analysis, post occupancy evaluations, etc.). It is, however, not explained how tools designed to measure environmental efficiency can also measure resilience, thus suggesting that the two issues are, to an extent, envisaged as overlapping. Many, however, (five out of eleven) did not answer directly to the question and did not offer any relevant opinion. One interviewee deemed adaptability and 'redundancy' as strategies fit for this purpose, with redundancy intended as over-capacity in some features such as building structure, internal space, multiplicity of uses, etc.

Finally, the majority of interviewees believed that professionals associate resilience with the longevity of the built environment at large, with one believing that they are generally more concerned about the longevity of buildings rather than the urban longevity (interviewee n. 11).

What follows is an attempt to identify the recurring issues that emerge from the opinions presented in this sub-section. Undoubtedly, this attempt implies a simplification of the many different, personal perspectives that cannot be easily categorised and brought under broad classifications. Nevertheless, by reducing the complexity and diversity of different opinions and classifying them under specific contents it is possible to track those strands that can be used for the purpose of this investigation. These are:

- The perception of the concept of resilience is erratic, divided between the belief that it pertains to specialist areas and the one that it is connected to adaptability, an issue traditionally debated in architecture and urban design;
- There are no established approaches to embed it into practice and there is no shared view on its meaning;
- The lifecycle of buildings designed and constructed today is shortening. Resilience can therefore express a tangible value that stakeholders can understand.

4.2.2 - Scale

When asked to express their opinion concerning the scale at which strategies for resilience should be implemented, the majority of interviewees (seven out of eleven) agreed that resilience needs to be embedded both at a building and a city scale. Some recognised the necessity to connect the different scales (interviewee n. 1, 5, and 8). The other interviewees, however, believed that larger scales should take precedence. The resilience of individual buildings may not be a sufficient contribution for endowing resilience into the wider context ('I think it is particularly relevant at an urban scale because it relies on context. You can have a resilient building in a neighbourhood that is not resilient, and in this case the resilience of the building can be undermined' - interviewee n. 3). Similarly, a resilient village can be such only if the wider region is resilient too, says the interviewee n. 9 adding: 'we should have fluid scales without barriers'.

When asked if principles for resilience are different depending on the scale considered, only four interviewees answered positively and directly to this question whereas the others eschewed it and their answers were only partially relevant to the topic explored here. The interviewee n. 10 believed that differences in scale correspond to differences in time cycles too (longer for urban environments and shorter for buildings). Another interviewee pointed at the connectedness of scales, and at strategies for resilience at a regional scale necessarily cascading at a local scale (interviewee n. 5).

Recurring issues emerging from the opinions collected show that there is a vague awareness of the systemic relationship amongst different spatial and temporal scales of the built environment.

4.2.3 - Sustainability and urban resilience

Are resilience and sustainability related? Three interviewees believed that the two terms represent identical meanings; three believed they are distinct and connected; and three answered by highlighting different attributes that characterise and distinguish them. For example the interviewee n. 10 described resilience as dynamic and sustainability as static (‘the term resilience suggests a condition of on-going adaptability and permanent mutability, whereas the term sustainability seems to suggest something which is achieved once and then relatively static. A sustainable design, once perfected, might never change. On the other hand, a resilient design may change very significantly over time’). The interviewee n. 5 (possibly referring to the concepts of adaptation and mitigation) states that sustainability is not messing up with the future, whereas resilience is coping with the future. Finally, the interviewee n. 7 believes that sustainability is about numbers whereas resilience is about focusing on the whole life cycle. Generally, however, the perception with regard to this relationship is very different across this group of professionals, and their opinions are sometimes of difficult comprehension. For example the interviewee n. 9 states that resilience is a sub-set of sustainability, a strand under the umbrella of sustainability. Finally the interviewee n.2, mentioning a concept that is close to the definition of resilience used in this thesis, states that sustainability is environmental resilience.

Recurring issues emerging from the opinions collected show that there is no shared view concerning the relationship between resilience and sustainability.

4.2.4 - Applicability/measurability

Questions concerning the measuring of resilience were posed to the interviewees. Many reports reviewed here (see section 3.2) provide list of principles and guidelines that constitute qualitative descriptions as to how resilience can be attained. Moreover, sustainable performance is often measured quantitatively. Design tools and design guides based on both approaches are by now important instruments for practitioners, solidly engrained in the professional practice. Gleaning opinions on this matter (i.e. qualitative versus quantitative) can therefore give useful information for the purpose of selecting a methodology to appraise resilience and, more in general, on the perceived significance of assessing building and urban performance.

All interviewees agreed that it is possible to define resilience qualitatively. Many, however, were the caveats. For example, one interviewee highlighted the sheer preponderance of existing guidelines, checklists, and other tools that are sometimes excessively time consuming (interviewee n. 4), or that limit with undue constraints design experimentation and innovation (interviewee n. 6). Similarly, the interviewee n. 10 believed that qualitative guidelines to resilience can be useful provided that these are simple and generic rather than highly detailed, prescriptive, and rigid. All interviewees but one agreed that it could be possible to express resilience numerically, although many highlighted the disadvantages and traps of numeric evaluations (‘not everything that can be counted counts’ - interviewee n. 5) and of the ‘sustainability accounting’ that can become a ‘boxticking’ exercise (interviewee n. 8). Others called for an integration of both approaches in the right sequence, believing that qualitative assessments of resilience can help define a strategic, initial design stage whereas quantitative assessments would help at a detailed design stage (interviewee n. 9). However, there was a clear general diffidence towards quantitative methodologies, with some of the comments mentioning their implicit leeway for manipulation (Interviewee n. 4).

Approximately half of the interviewees (five out of eleven) thought that measuring resilience is possible whereas many of the others did not reject the idea but questioned its feasibility. Some pointed at the difficulties implicit in developing an assessment of this kind, with interviewees recognising that a new set of indicators would need to be identified for this purpose (interviewee n. 5 and 9). The interviewee n. 2, however, believed that an assessment tool would bring clarity in a much fragmented context in which resilience takes many forms. Finally, two interviewees were quite negative about this issue, believing that resilience can be measured only in hindsight (interviewee n. 4 and 6).

When asked if they believe that the measuring of resilience could become integral part of current commonly used assessment tools, five interviewees expressed a positive opinion. However, three of the interviewees reiterated their diffidence on the capability of tools based on quantitative evaluations to effectively capture the essence of sustainability. ‘Tools fall in the trap of generalisation and can be manipulated’ says the interviewee n. 4. The interviewee n.5, although sceptical on this issue, adds: ‘resilience is a way of thinking about things and like sustainability there are indicators and maybe some indicators are the same that we are already using for other things. It’s a different angle, different prisms of looking at things.’ In other words it may not be necessary to research for new indicators, rather for a different angle of considering those that are already representative of sustainable performance. It is not about identifying particular elements conducive of resilience, but rather looking at solutions through a particular different lens. Finally, two interviewees, while mildly sceptical on the possibility of modifying current tools so as to measure resilience, clearly believed that a reformulation of rating codes in this direction would be desirable (interviewee n. 9 and 10).

Recurring issues emerging from the opinions collected show that:

- Quantitative approaches to measuring sustainable performance are perceived as limiting design experimentation and as potentially misleading;
- Qualitative approaches are unanimously preferred although there is recognition of the necessity of numeric evaluations;
- Current tools integrating the assessment of resilience may be of difficult accomplishment, although some would welcome their revision.

4.3 – Some conclusions introducing an approach to testing resilience

This section elaborates on some of the recurring themes that have been identified in the course of the analysis of the interviews as well as on other topics emerged that could constitute potential future avenues of research. Finally it concludes by summarising findings from the interviews.

4.3.1 - Integrating the conditions for resilience

Within the architectural and urban design disciplines, the attainment of longevity has been traditionally pursued through building attributes such as flexibility and adaptability. However, in pursuing resilience, practitioners need to merge two approaches: one that relates to preparedness to extreme events, and one that attempts to endow longevity in the face of time and the slow ‘aging’ of structures and formal features whilst still retaining quality. The former faces with emergencies that are becoming the norm, the latter with slow but constant change. Both are necessary, although the first is perceived by some of the interviewees as one that deals with ‘physical features’ (i.e. to be addressed through technologies and building techniques), and the other with design that connects with social and contextual conditions. Many responses focus on adaptability/flexibility of buildings and urban fabric (one of the main topics of the architectural debate from the 60s onwards (see Llewelyn – Davies, 2000; Lynch, 1960)) reconsidering it from new and stimulating angles. This attitude, however, tends to relegate other aspects of resilience (i.e. resilience to climate change, etc.) to the scope of engineers and specialists. Reluctance to engage with such issues can hinder their investigation, integration, and mainstreaming into architectural and urban design practice. This in turn can contribute to evolve the practitioners' attitude towards urban design, and to overcome possible tensions between recommendations for resilience and the objective of delivering liveable spaces. For example, as mentioned in the previous chapter, the recommended provision of active measures to prevent terrorist actions such as strong artificial lights, barriers, and CCTVs can produce sanitised spaces that lack vitality (Pierce and Williams, 2011). Similarly, physical barriers against water integrated into buildings, as the RIBA's publication on flooding disputes (RIBA, 2009c), can produce open spaces with poor liveability. Understandably, it is the constant widespread debating and researching on these tensions that can lead to innovative solutions.

4.3.2 - Innovative approaches to building adaptability

Post world war urban development designed under the pressure of delivering high numbers of dwellings, and the industrialisation of construction introducing fast technologies for mass production, have sometimes resulted in short lived places (Hall, 2002; see also White, 1965). In cities, the buildings and the open spaces that to date survive were often produced with building technologies and standards that can be no longer afforded. Possibly one factor contributing to their longevity is redundancy: abundance of space and over-dimensioned structure countenance flexibility in re-use. Although some suggest that 'designing for redundancy and spare capacity at all levels [can become] a new kind of post-scarcity effectivity' (a comment possibly pointing at the irony implicit in redundancy strategies for sustainable purposes in an age of scarcity of resources) (Goodbun, 2012), current building technologies, high urban densities, and possibly market logics are seldom compatible with built-in redundancy. This may change in the future (the future is unknown), although such a shift needs to be supported by new economic and social conscience. Instead, at present urban development must come to terms with the velocity and obsolescence dictated by the necessity of continuous growth, or by shifting cultural fashions and lifestyles. Still the imperative of a responsible use of resources suggests that if currently buildings (as also some interviewees believe) are prone to fast obsolescence, approaches must be elaborated to wed cultural shifts and market logics with the longevity of the building stock.

The topic of time and how it influences the design process is one of the themes that surface in many of the interviewees' answers. The interviewee n. 10 says: 'resilience is very difficult to address because it requires thinking beyond the project´s timescale. Flexibility is key. Redundancy contributes'. Moreover, the interviewee n. 2 maintains that buildings do not stand cultural fashions. If this assumption is to be taken seriously, 'do we want longevity?' 'Building should be designed in parts where some could last and some are unlikely to last' (Interviewee n. 2 and n. 3). Appreciation of styles, formal languages, and building typologies impinge on collective acceptance of the built environment. To circumvent this, a classification of the degree of longevity of building parts could be defined. This would result in guidance as to what should be retained over the building lifecycle, and what modified to meet evolving needs. A similar conclusion, although reached from a different perspective, is illustrated in the report on Climate Change commissioned by the Technology Strategy Board (Gething, 2010), in which higher investments on more resistant structural frames are recommended, in the light of uncertainties related to consequences of stronger winds or excessive soil subsidence. In parallel, 'other building elements have lower life expectancies and might be designed to lower standards in the anticipation that they could be upgraded when replaced or maintained'.

Possibilities as to how one might face this challenge could be working with, rather than resisting, change. Resilient buildings are those that can be re-used and recycled because of a resistant skeleton that can be redressed responding to socio-cultural shifts. Re-use as a transformational approach has also been investigated through innovative design strategies (van Hinte et al., 2007), or as a process facilitating the permanent and successful transformation and reuse of the urban fabric (Ciorra, 2012). A relatively fast substitution of the building skin and of 'soft' components would require an accurate life cycle analysis and an industry geared for a circular supply chain. Examples of this approach are beginning to emerge across the globe. For example, the Japanese Kajima Construction Corporation developed a new deconstruction method that allows it 'to recycle 99% of the steel and concrete and 92% from a building' (Ellen MacArthur Foundation, 2012). In this light designers and construction industry are called to reconsider building technologies and quality standards so as to invest in highly durable building parts (i.e. structure), highly interchangeable (but recyclable) soft components, and technologies and skills allowing an affordable and fast retrofitting. In parallel, new assessment tools would need to be developed for facilitating a different design attitude.

4.3.3 - Tools to design resilient urban development

Whether qualitative or quantitative, the measurability of urban resilience is essential to verify its good performance. Measurability ensures effective design. Standards or benchmarks can provide quantification of good building performance and in so doing give a baseline onto which design aspirations are assessed for their environmental effectiveness. However, establishing at the onset of a project its long-term functioning through numeric parameters can be complicated, whereas many of the recommendations summarised in the literature review (chapter three) are mostly qualitative criteria and recommendations. Amongst the interviewees, these are considered as a more effective guidance from a practitioner standpoint. Criticism voiced on the effectiveness of rating codes points at shortfalls implicit within their structure. There is rigidity in their assessment criteria that can lead to an excessively path-dependent, established procedure to design sustainable buildings. Instead, the definition of qualitative objectives does not restrict design possibilities, therefore possibly stimulating innovative thinking. However, as stated above (see section 3.2.6), the formulation of guidelines for urban resilience that can be included in assessment tools necessitates a clear definition that can encapsulate its many interpretations. If urban resilience is a necessary attribute for sustainable performance, in formulating guidance such a relationship needs to be elucidated, set in a correct perspective, linked to the several urban dimensions, and joined-up in its many aspects. Coaffee and Bosher (2008) give an example of integration of environmental efficiency and measures for enhancing resilience to man-made threats in buildings, two strategies that are treated as separate in literature. The mapping of two sets of different requirements shows that some of them can attain multiple benefits when designed having both strategies in mind (i.e. large windows, if well designed, can yield solar gains but also allow effective surveillance, etc.). Similarly, a stronger building structure can allow the re-use of the building and its resilience to stronger climatic events.

Understanding how effective attempts to achieve sustainable performance are requires measuring, although this task can sometimes be complicated. Much research over the last twenty years focused on the identification of indicators, metrics, or qualitative definitions of sustainable performance (Gosh et al., 2006). This research is still on-going. Similarly, evidence of good urban resilience comes through the identification of relevant factors/indicators and their quantification. This task is facilitated if resilience is regarded as strictly related to sustainability. In this perspective, it is the measure of how sustained in time is the sustainable performance.

4.3.4 - Urban resilience and urban sustainability

Opinions on this topic differ substantially. Some of them demonstrate a disenchanted view as a consequence of the failure of sustainability to be comprehended and accepted (The interviewee n. 1 says: 'maybe we should focus on delivering resilience rather than sustainable development, which policy makers still do not fully embrace. It is also seen as a preserve of the few, whereas the outcome affects everybody. Resilience, instead, could be a concept that industry and developers could easily understand: it can deliver quality'). More often the several interpretations signal a semiotic mismatch, and a struggle to translate too abstract concepts into pragmatic approaches to practice. Beyond the two fronts of those that believe the two concepts are or are not related, in most of the comments transpire a feeling that resilience and sustainability are representative of two distinct categories of 'utilisation'.

Sustainability has been discerned and debated for long enough to be integrated into professional tools, which are, as it will be discussed in section 7.3, largely about measuring environmental impact. Resilience, possibly because of its relative new introduction in the urban planning arena, has not yet been structured into tools and labelled as much as sustainability, hence the expectation that it could represent something new. The diffused perception of the two concepts being distinct suggests that recent debate has excessively treated the two terms in isolation, whereas one should be implemented so as to provide means to support and maintain over time the ultimate (sustainable) objectives of the other. For example, measures recommended for security that are supposed to deliver resilient places, can be applied independently from (and not linking to) any sustainable strategy of the place. In other words whether they are distinct or not, within the urban debate resilience has a purpose only if related to sustainability, since it would be meaningless promoting resilient but unsustainable cities.

4.3.5 - Summing up conclusions

What follows is a summary of the findings from the interviews as well as their relevance for the purpose of the thesis. Findings include:

- There are no established professional approaches amongst practitioners for embedding resilience as well as no shared understanding of its meaning. Consequently, as discussed above (see section 3.2.6), an integration of interpretations and approaches would bring clarity and help promote resilience into practice;
- In spite of the divergence of views on its meaning, there is recognition that resilience can be quantitatively and qualitatively defined. Appraisal tools are believed by some to be fit for this purpose. There is, however, diffidence towards extremely prescriptive forms of evaluation based on quantitative approaches whereas qualitative ones are believed to be more effective. Consequently, an appraisal tool for urban resilience should be sufficiently flexible so as to avoid prescriptive approaches and to avoid hindering innovation in design;
- The issue of interconnectedness of spatial scales is acknowledged, although vaguely perceived. There is also an awareness of the importance of designing for an extended lifecycle that goes beyond the time horizon of the design-and-delivery process. Nonetheless, interviewees seem to agree that these issues are generally ignored by practitioners and developers. Possibly, any professional aid for appraising resilience should particularly focus on these issue and attempt to elicit the systemic nature of

cities and of resilience itself, which in turn could facilitate an understanding of the time factor and the linking of scales;

- There is a diversity of opinions concerning the connections between urban resilience and sustainability. Possibly any structured approach to its understanding should attempt to establish clearly such a relationship. Conditions for resilience should be determined according to clear objectives, and the possibility of buildings to adapt should be designed with those in mind. Benchmarks and numeric values are important only if these finalities are clearly stated and pursued.

These findings complement those from the literature review (see chapter three), namely:

- Resilience should be pursued at a higher level. It cannot be confined to the idea of cities resisting natural or man-made disasters;
- Resilience must be considered at a systemic level, thus the entire system must be analysed to evaluate the resilience of some elements thereof;
- In designing cities sustainability should be strictly related to resilience. To be sustainable the built environment must be resilient and perform well over its entire and potentially long lifecycle, hence optimising the use of resources;
- Designing for resilience helps focus on the time factor. This is a complicated approach and one that is rarely attempted in the planning and design practice. As it will be illustrated in chapter five, methodologies for this purpose utilise scenarios as a way of envisioning the challenges that lay ahead and designing to respond to them;
- Finally, as the nature of resilience is systemic, any tool for its assessment should reflect such a connotation. Thinking in terms of systems can help identify feedback loops, links, and points of leverage. This in turn can facilitate the identification of strategies for endowing resilience.

These findings define the features that an evaluation method for resilience should possess. The following chapter will focus on the identification, description, and adaptation of a methodology that can be used by practitioners for the evaluation of plans for urban development with a view to resilience, and that reflects such findings.

Chapter Five – The resilience analysis - an alternative design and planning approach

This chapter introduces the method that is subsequently used to develop three case studies with the purpose of analysing the resilience of their energy efficient strategies. First, a brief section reviews and discusses how conventional planning approaches deal with long-term uncertainties. It argues that often plans for urban development are unduly influenced by necessities and pressures of the moment, with an eye to the short to medium-term trends, and that this attitude needs to be integrated with one that looks at the long-term in a holistic fashion. Next, it shows that scenario-based planning has been long used for this purpose, although rarely within urban development processes. Finally it introduces the Urban Futures method. This is a scenario-based technique to appraise the resilience of urban regeneration. It then illustrates the contribution of the author to adapt the method so as to appraise buildings and open spaces.

5.1 - Planning methodologies and uncertainty - conventional versus innovative approaches

5.1.1 - A critique to traditional planning methods - The concern about the future is inherent to both planning and urban design (Conroy, 2006). In these disciplines, policies and design strategies are used for governing urban development and the evolution of demographic, social, and economic conditions. Planning is an activity that involves decisions and, as Abbott notes (2005), 'the notion of a decision implies the future is not predetermined'. In other words, planning is a discipline in which decisions are taken to influence the course of the future so as to govern spatial changes in a way that can accommodate society needs. It is clearly a complicated process that can be tampered by factors on which there is little control. For example, local development frameworks previously deliberated may be disrupted by decisions taken at a higher level (e,g, modifications to the national planning policy).

Wilson (1969), in a paper that reviews the methodologies for planning available at that time, maintains that the three principal planning tasks are concerned with policy (i.e. goal formulation, decision-making, etc.), design (i.e. dealing with spatial growth), and analysis. The latter provides an evidence base for design and policy, mainly using statistical analysis (e.g. population growth, car use, etc.). Inevitable inaccuracy (i.e. uncertainty) in predictions should be accounted for through techniques such as statistical decision theory. In this conventional approach to planning, projections (i.e. a 'mechanistic quantitative procedure' aimed at extrapolating from a dataset a trend of evolution), forecasts (i.e. projections filtered through judgment), and plans (i.e. 'evaluation of the forecasted future for its level of desirability and potential alterability') are the essential tools that enable planners to take decisions and attempt to move towards a desired direction. However, they offer an elusive picture that requires interpretation, which can be influenced by the preoccupations of the moment.

Trends often pull in different directions (Bezold, 1999). Still, conventional planning practice often lacks of 'a systemic understanding of how multiple trends will extend forward and interact with one another, shaping new possibilities and patterns of behaviour in the process' (Myers and Kitsuse, 2000). Moreover, in the elaboration of a plan, planners tend to utilise projections as if they were forecasts (Myers and Kitsuse, 2000; Makropoulos et al., 2008). Forecasts offer a depiction of the future according to the most likely development (Borjesona, 2006), reflecting a purported continuity of historical trends that can happen only if structural conditions stay unchanged (IEA, 2003). Such an approach does not sufficiently take into account the eventuality of an inversion of trends, or of exceptional events that may happen and undermine plans predicated on the basis of forecasts. Forecasting techniques can be telling if used for the short term, but ineffective for long term evaluations, which need to consider uncertainties (Foresight, 2008). As Balducci explains (2011), conventional (and traditional) planning tools fail because they are designed for a condition of relative stability whereas today, society is characterised by the velocity of change (Auge', 1995). He maintains that 'traditional ideas of an orderly and hierarchical planning system, which mobilises resources according to planned or projected events, hold little conviction in an age of simultaneity and juxtaposition, the contiguous and the fragmented, the anticipated and the unpredictable'.

Possibly to circumvent the gap between traditional planning approaches and the dynamicity of society, objectives in planning processes are usually 'near enough in the future so as to be quite sure of its accomplishment' (Ratcliff and Sirr, 2008). How distant this future should be when formulating development frameworks is unclear. The former Planning Policy Statement 12 recommends Local Authorities to develop Core Strategies on a time horizon of at least fifteen years, although in the perspective of a 'long-term view and providing some flexibility' (DCLG, 2008a). Such a definition is open to many interpretations whereas the only time line explicitly mentioned (i.e. fifteen years) seems insufficient. The duration of regeneration processes (or any development project), can take more than one decade to be completed, during which the time gap between inception and delivery plays against the consistency of today's goals with tomorrow's necessities (Lichfield, 2009). For example, Thames Gateway in London was conceived as an ambitious regeneration programme to be carried out over 20 years (Raco and Henderson, 2006). Whenever plans have been developed with a view to a sufficiently distant time horizon uncertainty has been coped with either by ignoring or by deflecting its importance (Balducci et al., 2011).

5.1.2 - Towards alternative approaches to planning - Myers and Kitsuse (2008), almost forty years after the paper written by Wilson, report that planners have argued against the excessive use of quantitative models, and call for more balanced methods that integrate qualitative approaches. However, difficulties in interpreting forecasting data persist. They maintain that planners need to develop competence in connecting and interpreting past, present, and future and establish a baseline of continuity amongst these three states so as to understand what links the past with the present (see also Abbott, 2005). Moreover, policy makers are beginning to be aware of the importance of the uncertainty factor in space planning, and the limits of prescriptive targets that risk to remain unattained (e.g. provision of industrial floorspace, housing units and so on) (Balducci et al., 2011). Planning theory may have moved away from over-reliance on a mathematically-determined evidence base. However, this is not reflected into practice where conventional/traditional tools are still predominantly used to provide the evidence base of new plans.

Hillier (2011) suggests strategic planning as an alternative to the traditional one, and as a planning approach that deals with 'virtualities unseen in the present' (Balducci et al., 2011) rather than certainties. The extreme dynamism of the society does not leave much space for the predictable. New phenomena are relentlessly happening that could not have been conceived only a decade ago, and that pose series questions to current planning thinking. For example, there is a growing tendency to privatise public space. Increasingly, in the UK and abroad private investors renovate squares and parks where local authorities cannot afford the investment, retaining control over these spaces (Vasagar, 2012). In itself, this is not necessarily an alarming development. Local authorities are continuously attempting to attract public investments to regenerate cities. However, it is legitimate to question the consequences of a growing privatisation of the public realm that, if unchecked and unregulated, could have repercussion on an extensive number of factors, from how people use spaces to patterns of pedestrian (and therefore car) circulation

Elaborating on the idea of a strategic planning, Hillier (2011) introduces the concept of different ‘trajectories or visions of the longer term future’ as opposed to a future envisioned in continuity with the present, or as a path-dependent repetition of the past, which tends to form the basis for traditional planning, He argues for a ‘cartographic method’ to develop planning, in which potentialities are traced, and maps of the forces’ interplay are drawn up. The resulting map can support policy making and strategic planning. These maps of potentialities are, indeed, scenarios of how the present can unfold. Myers and Kitsuse (2008) reach the same conclusion when they say that scenarios have the power to ‘demystify‘ the future by ‘reducing complexity while bringing multiple perspectives into consideration’. As such, they can constitute a valuable methodology that can complement current planning tools. In addition to projections and forecasts, scenario analysis can be used ‘for thinking about the impact of decisions whatever the future may be’ (Makropoulos et al., 2008).

5.1.3 - *Scenarios as planning tools* - Other scholars have produced evidence of the merits of a scenario-based planning. Scenarios can use projections to assemble a cluster of possible alternatives, which may or may not happen. These offer a vision of the branching points in which the present can evolve towards different pathways (Börjesona et al., 2006). When using future scenarios as a tool, these should not be mistaken as visions of the future, which may be desirable but not grounded on present conditions (Wilson, 1969). Scenarios are tools to test decisions which will have an impact on the future. Planning practice usually focuses on conceiving objectives and pathways for their attainment, and much less on identifying objectives that are likely to adapt to changes (Ratcliff et al., 2008). However, it is precisely adaptation to change, and therefore resilience, that is crucial to delivering sustainable urban environments. Still, ‘there is little comment or guidance for practitioners and planners to simulate in a structured fashion any analysis on future and uncertainty’ (Wilson, 1969).

Scenario analysis techniques have been long used in planning, although never mainstreamed into practice, especially to test urban development at small to medium scale. Scenarios have been used at a national level, or at a regional level, or to investigate urban transformation in relationship to its region (see Chakraborty, 2010; Ravez, 2000). Today some involve the use of advanced GIS databases, or even computerised polling devices (Chakraborty, 2010). Scenario analysis can be normative if the exploration of one or more desirable futures is functional to gain an understanding of pathways for the accomplishment of a desired end point (i.e. an aspirational vision of urban development); it can be exploratory (or descriptive) if diverse future scenarios are used to interrogate plausible developments of the present in order to understand the significance of potential impacts (Mander, 2008; Börjesona et al., 2006; Shearer, 2005; IEA, 2003; see also Berkhout et al., 2002). Scenario analysis has the merit of enabling a discussion around any solution to a given challenge in the context of a narrative that can connect several facets of the same problem (IEA, 2003), thus leading to an interdisciplinary vision of the interplay among different overlapping dimensions. It is therefore a holistic process that can help overcome an attitude to compartmentalisation implicit in planning, which is a practice often fraught with erratic progress and difficult mediation amongst diverging stakeholders’ standpoints (Lichfield, 2009).

There is, however, a limit to what scenario-based analysis can attain, which is represented by institutional will. In a paper reconstructing the events that led to the drafting of the 1929 New York Regional plan, Abbot (2009) maintains that the committee that issued the plan chose ‘a more certain future rather than a better one’. The initial strategy for the plan was inspired by

Lewis Mumford. It proposed the creation of garden cities over the regional territory of New York to better redistribute population and lessen urban pressure. It had a vision underpinned by solid arguments and data; it recognised, and to an extent addressed, the eventuality of uncertainties coming about; and importantly, was giving solutions to current pressing urban issues. Instead, the final decision was to deliver a plan that eschewed visionary approaches. The final strategy reflected a pragmatic approach: 'ride the forces of change, channelling them where possible into more efficient or amenable patterns; avoid the impractical and the excessively visionary" (Johnson 1996, as quoted in Abbott, 2009). Similarly, describing the events behind the formulation of the 'Melbourne 2030: Planning for Sustainable Development', Wilkinson (2011) notes that even in the case of careful strategic planning complemented by a comprehensive implementation agenda, unintended changing external conditions and policy effects can unsettle plans. She argues for an 'adaptable' strategic approach.

It can be therefore concluded that scenarios-based planning can circumvent the rigidity of traditional planning aimed at 'defeat disorder' (Wilkinson, 2011). The instruments on which traditional planning is based are incapable to deal with fast change. Instead scenarios can identify eventualities to address. Nonetheless, this is not sufficient. The identification of future challenges by questioning future scenarios must be functional to the development of a process that will enable a strategic decision-making. The scrutinising of the past and the scenario-building exercise associated with the 1929 New York plan led to an end-vision which, to an extent, was contentious and predetermined. Instead, the adaptable strategic planning Wilkinson envisages is based on four steps: strategic intelligence (selective data gathering and analysis), strategic foresight (envisioning challenges through scenarios), strategic conversations (engaging with stakeholders) and strategic decision-making informed by the first three steps. In other words, insights gleaned by scenarios are functional to modify the initial vision rather than to its making. More importantly, the scenario analysis must be developed within a framework that can connect with planning procedures so as to enable insights to find immediate application.

The following section illustrates some relevant applications of scenarios-based techniques. It also provides a rationale for the selection of a particular set of scenarios that is at the heart of the methodology used here to appraise case studies.

5.2 – Future scenarios and scenario analysis

Raskin, in a chapter of the Millennium Assessment dedicated to scenarios techniques (Raskin et al., 2005) briefly outlines their origin and current applications. Scenario techniques were first utilised in war games during the first years of cold war, with Herman Kahn and his colleagues being some of the main experts in this field. Only in the 1970s this approach was developed into a stream of future studies, which were particularly appropriate to explore consequences of environmental degradation and excessive resource exploitation, in a point in time in which they were coming to public attention. 'Limits to Growth' for example (Meadows et al., 1979), is one of the most famous studies utilising scenarios developed with mathematical models. In parallel to quantitative approaches, scenario techniques were developed using qualitative ones. For example, Royal Dutch/Shell used them as a strategic management technique to explore the probable evolution of markets and the consequent impact on their business. This type of analysis implies projecting a plan of action (any plan of action) considered for implementation against the backdrop of a set of conditions that may happen in the mid/long-term. In so doing, the plan of action can be modified to be valid under the possible future conditions considered. Clearly the robustness of scenario buildings techniques and the internal consistency of scenarios are crucial to the relevance of the analysis. For this purpose, scenario building must follow some rigorous rules.

As mentioned before (see section 5.1.2), scenario techniques can be divided in ‘forward-looking’ (or explorative, or descriptive) and ‘backward-looking (or normative, or backcast). With the former, diverse future scenarios are used to interrogate plausible developments of the present in order to understand the significance of potential impacts. With the latter, the exploration of one or more desirable futures is functional to gain an understanding of pathways for the accomplishment of a desired end point (e.g. aspirational vision of urban development); (Mander, 2008; Börjesona et al., 2006; Shearer, 2005; IEA, 2003; see also Berkhout et al., 2002).

Modern scenarios techniques tend to merge quantitative and qualitative models. The development of a storyline, a narrative that can convey the several nested levels on which the future unravels, is a precious tool for discussions at a strategic level. The datasets that come with mathematic models provide the evidence base supporting the opinions developed through the exercise of scenario analysis. Scenarios used for the Millennium Assessment (Raskin et al., 2005) attempt first to integrate global key economic, social, and environmental subsystems to subsequently disaggregate them for different geopolitical regions. In doings so, this technique reflects the action of processes at a global level, and their manifestations in broad geo-socio-political localities.

‘Global outlooks that do not consider a broad range of plausible long-range visions are incomplete’ (Raskin et al., 2005). Since it is uncertainty we are considering, it must be acknowledged that systems can evolve differently, influenced by several sources of indeterminacy. The Millennium Assessment (a report that evaluates ecosystems) identifies three sources: *ignorance* (technological or scientific limits to knowledge impeding effective action); *surprise* (uncertainty inherent to complex systems that may undergo through structural change); and *volition* (human choices that cannot be predicted). It is possible to identify the sources of indeterminacy, as it is possible to establish drivers of change. It is impossible to predict how these will determine the future. Consequently, to ensure that a reasonable range of risks are explored, ‘the exploration of multiple futures is fundamental to the scenario enterprise’.

According to the Millennium Assessment, although to date many studies on scenarios have been developed, only six have the breadth and rigour to meet ‘the criteria of integration, regionalization, multiple futures, and quantification’. These are:

- Scenarios developed by the Global Scenario Group (GSG), a group formed with the support of the Stockholm Environment Institute in 1995. These are quantified with the use of the PoleStar System, a tool for synthesizing global data sets;
- The third Global Environment Outlook, partially based on the GSG scenarios, developed for the United Nations Environment Programme;
- The Intercontinental Panel for Climate Change Special Report on emissions scenarios;
- The set of scenarios developed by the World Business Council for Sustainable Development to engage the business community on the sustainable development debate;
- The World Water Vision by the World Water Council, presenting three scenarios at a global scale; and

- The Environmental Outlook of the Organisation for Economic Co-operation and Development focusing on the environmental challenges the European countries are faced with.

Hunt et al. (2012) in their comprehensive comparative study reviewing over 450 scenarios developed from 1997 onwards, ascertain that these can all be traced back and correspond to a few archetypal narratives. One of the reasons for this is that scenarios are generated considering the impacts of drivers of change which are similar (often identical) across all scenario studies since these are the driving forces that can provoke radical shifts of conditions. Thus the 'approach or adoption of identical 'key drivers', leads to unavoidable similarities' (Hunt et al., 2012). The drivers include: Population (i.e. demographics and the evolving patterns of population distribution); Solidarity (i.e. redistribution of wealth and equity); Technology (i.e. the application of scientific knowledge to optimise performance of processes that meet human needs, or to create new processes previously undiscovered); Economy (i.e. the generation of wealth); Environment (i.e. the exploitation of resources and the condition of ecosystem services); Regulation (i.e. the legislative architecture regulating relationships and rights among individuals, communities as well as the management of commons); and Globalisation (i.e. dynamics related to the free circulation of goods and people). Depending on the variations of performance of these combined key drivers, and at the point in time in which these manifest, the evolution of society can follow different trajectories. What makes the GSG study on future scenarios utterly robust is that 'whatever the methodological framework adopted, a significant number of scenario variants developed by a range of authors all align to [their] 3 world states and 6 visions' (Hunt et al.,2012). This study therefore maintains that the GSG set of scenarios lends itself to be used as basis for further scenario-based studies, and that it would be futile to develop new ones for such a purpose, given the proven correspondence to those archetypes to which all scenarios conform. Hunt et al. argue that the use of a set of six scenarios may be unpractical, since experts of scenario analysis recommend a set of two to four as sufficient basis for analysis. Moreover, it is reasonable to assume that in order to be used as an effective tool, scenarios must be thoroughly understood. This will happen if narratives are able to relate to a shared experience of the world. In other words, they must contain elements that are recognisable because previously or currently collectively experienced.

Between 1995 and 2002, the Global Scenario Group produced a series of reports illustrating their body of work, which built on the Pole Star Project, 'devoted to collecting and systematically organizing a vast global data set covering a vast range of economic, social, resource, and environmental parameters, and building a flexible computer-based tool for constructing integrated, long-range scenarios (Electris et al., 2007). This extensive dataset was subsequently synthesised and articulated into narratives that could encapsulate the richness of information gathered. The datasets offer projections of the world condition into 2050 and 2100. The GSG group, coordinated by physicist Paul Raskin and ecologist Gilberto Gallopín took the project forward producing literature documenting scenarios and their relevance. The GSG work intends to be a contribution for the understanding of the powerful forces that shape society, in this particular moment in history in which human development has become increasingly incompatible with the structure of a finite world. GSG scenarios view the world as a complex socio-ecological system, in which events happen and connect at multiple scales: global, regional, and local. Scenarios provide structures in which it is possible to zoom in and out and understand the impact that events at a global scale have on the other scales, and vice-versa.

Although events in scenarios are based on and backed by mathematical models, their strength lies in a powerful narrative that can convey the complexity of links and interrelationships of scales and drivers. Moreover, the narrative can make explicit the historical context and the ulterior motives that generated that particular scenario, thus offering insights on the consequences of political and cultural choices society is asked to take now. 'Major surprises that can influence the future strongly - a world war, "miracle" technologies, an extreme natural disaster, a pandemic, the breakdown of the climate system' (Gallopin et al., 1997) are also integrated in the structure of the scenarios. In itself the assumptions that generates the three original scenarios (therein defined *classes*) are relatively simple and therefore thoroughly reliable: 'essential continuity with current pattern, fundamental but undesirable social change, and fundamental and favourable social transformation' (Gallopin et al., 1997). It is a simple but inevitable-three way path: mankind can proceed with a 'business-as-usual' attitude, it can be tore apart by exacerbated tensions (i.e. inequity, geopolitical instability, environmental degradation, etc.), or it can acknowledge the necessity of a radical shift of values to solve the conundrum of sustainable development (i.e. a neutral/positive/negative mode). Each class is than developed in two variants, reflecting different possible evolutions of each vision. Classes and variants are reported in Table 4.

Classes	Variants
Conventional Worlds (Global systems evolving following current patterns of globalisation and free market)	**Reference** Business as usual with a 'mid-range population and development projections, and typical technological change assumptions. Resolving the social and environmental stress is left to the self-correcting logic of competitive markets.' *
	Policy Reform As for the Reference variant but with 'strong, comprehensive and coordinated government action to achieve greater social equity and environmental protection' *
Barbarization (The capability of markets and policy to tackle socio-environmental problems collapses)	**Breakdown** 'Civilization deteriorate with consequent institutional disintegration, and economic collapse' *
	Fortress world In response to the threat of breakdown, the rich protect themselves inside enclaves and control natural resources, while outside the majority live in poverty
Great Transitions (The world moves towards 'new socio-economic arrangements and fundamental changes in values')*	**Eco-communalism** 'Fundamental shift of system value, with society embracing environmentalism and equity. Bio-regionalism, localism, face-to-face democracy, small technology, and economic autarky are the prevailing models' *
	New Sustainability Paradigm 'A more humane and equitable global civilization emerges as opposed to localism and regional models of governance' *

*(Raskin et al., 2008; Raskin, 2006; Raskin et al., 2002; Gallopin, 1997)

Table 4 – A summary of the six GSG scenarios originated by three classes, each one with two variants

The plausibility of the six scenarios in Table 4 also lies in their deep connection with eminent philosophical theories that are part of the collective cultural heritage, each one containing a set of values and a vision of the world, which impacted (and still impacts) on currents of thought and political views. These visions are familiar to, and to an extent shared by, the majority of western civilisation. Scenarios build on them and on their effects on social and economic trends that are currently present in society. Depending on how the future will unravel, on the evolution of the key drivers, and on external events, these trends may scale up and become strongly embedded in society. For example, the role of the Keynesian view of state institutions as a regulator of the free market, which resonates in many of the political analysis on the current structural economic crisis of developed countries, could be embraced by many as the solution to such mighty challenge, and shape the policy at a European level over the next decades. If successful, this new political direction could have global impact. This constitutes one of the underlying assumptions of the Policy Reform scenario. Summarised in Table 5 are the reference sources for each scenario (Raskin et al., 2002).

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

*Table 5 - Reference sources for each GSG scenario, including philosophical currents of thought, eminent characters, and values/common places (*source: Raskin et al., 2002)

Plausibility is not sufficient. Narratives fit for a scenario-based analysis must also diverge. This is because an appraisal against uncertainty must evaluate a range of possibilities, which may happen in the future, wide enough to address as many risks as possible. To ensure the divergence of narratives, it is useful to consider the two dichotomies that characterise much of the socio-political thinking, namely self-interest/solidarity (i.e. a vision of society based on the rights for each individual to pursue its interest versus one based on the greater good of the wider community and on the redistribution of wealth) and global/local (i.e. the pursuit of an interconnected system of exchange and – to an extent – governance versus one that privileges autarchy). If mapped on a diagram with the axis representing the dichotomies, the six scenarios spread on the space, covering all possible combinations. The two axes can be viewed also as axis of uncertainty (Hunt et al., 2012). Directions can point in different, unpredictable ways, depending on the key drivers that have been mentioned above. This exercise also helps detect visually how radical a scenario can be or how it can mediate across different socio-political positions (e.g. global/self-interest, local/self-interest, etc.). Clearly, in developing each scenario, the 'behaviour' of drivers of change will be consistent with the stance that society takes. For example, in the Conventional World Market, it is reasonable to assume that technological progress will be accelerated because of the inherent idiosyncrasy of free market to use innovation as an engine for consumption. Following the same logic, environmental damage, in this scenario, will accelerate because society values remain strongly individualistic and this takes precedence on the dangers of the exploitation of commons. Figure 2 and Table 6 show the dichotomy diagram and the behaviour of drivers of change under some scenarios.

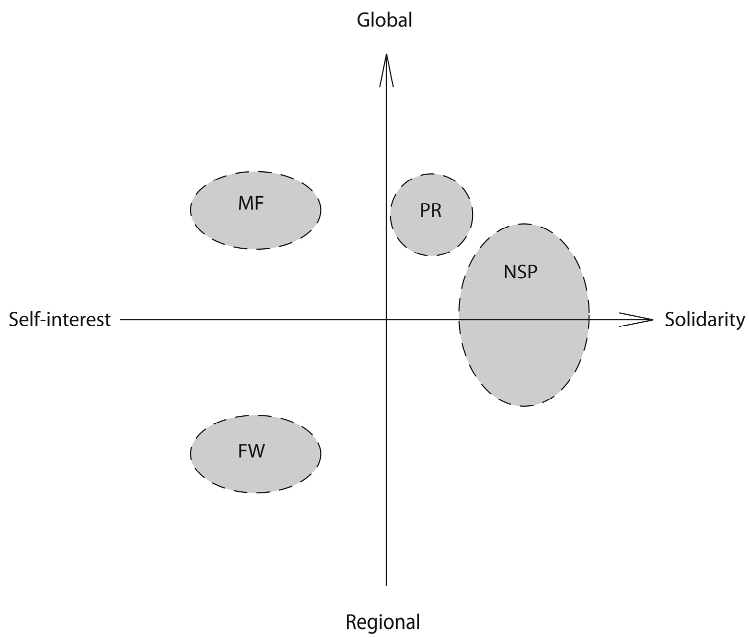


Figure 2 – The four scenarios used for the UF methodologu deployed on a diagram with axes Global/Regional and Self-interest/Solidarity

Scenario	Population	Economy	Environment	Equity	Technology	Conflict
New Sustainability Paradigm	⤴	⤴	⤴	↗	↗	↘
Policy Reform	↗	↗	→	→	↗	↘
Market Forces	↗	↗	↘	↘	↗	↗
Fortress World	⤴	⤴	↘↗	↘	→	↗

Table 6 – Direction of key drivers in the four GSG scenarios used in the UF methodology (source: Raskin et al., 2002). The direction of arrowheads indicates the performance of drivers of change (e.g. the technology arrowhead pointing upwards means that the rate of technological progress is increasing; equity arrowhead pointing downwards means that social equity is decreasing, etc.). Arrowheads with a curved trajectory can indicate growth followed by a tendency to stabilisation (i.e. population growth. Economic growth, and environmental conditions in New Sustainability Paradigm) or a decrease followed by growth (i.e. environmental conditions in Fortress World)

Concluding their study on scenario archetypes, Hunt et al. ((2012) see also Rogers et al., 2012b) remark that two of the six end-worlds/variations are rarely traceable in other scenario-based studies, namely ‘Barbarism’ and ‘Eco-communalism’. This could be, as discussed above, because of understandable difficulties in empathising with the extreme hypothesis of society collapsing with no control (i.e. Barbarism), which is rarely experienced in developed countries. Recent dramatic events such as the disintegration of the former USSR, or the former Yugoslavia, for example, were – to an extent – overcome because of cooperation with other developed countries. Ultimately, breakdown was avoided and did not spread. Moreover, in its desperate vision, the world of Barbarism, one in which institutions and regulations crumble, offers little aid for the purpose of focusing on challenges to elicit answers. Eco-communalism, which does not present similar traits of extremeness, is partially contained in the second Great Transition’s variation. Both reconcile the global and the local dimension to strike the balance between human aspirations and environmental limits. Possibly, New Sustainability Paradigm is more compatible with the current architecture of society systems, thus making it more reliable as an analytical tool.

5.3 – The Urban Futures method/Contribution of this research to the method

5.3.1 – Rationale for the methodology and first research phases

The objective of the ‘Urban Futures’ research programme, a four-year programme ended in April 2012 and funded by the UK Engineering and Physical Sciences Research Council (EPSRC), is to develop a methodology for appraising the resilience of urban regeneration. This objective is stated in the headline under the programme’s title: ‘Sustainable Regeneration: from evidence-based urban futures to implementation’. Urban regeneration is regarded as one of the most effective policies to deliver sustainable urban development in the UK and in many other developed countries (ODPM, 2005; Colantonio and Dixon, 2009). Since 1997, the UK government has privileged development on brownfield (i.e. previously developed land) on other forms of development, because ‘firmly linked with the concept of sustainable development’ (Dixon, 2007). A measure of the appreciation of this strategy is perhaps captured by the scale of the UK government expenditure on urban regeneration projects between 2001 and 2002, consisting in over £1 billion (Greenhalgh and Shaw, 2002), or by the 303,400 hectares (equivalent to twice the size of London) that the then English Partnerships (the former agency for urban regeneration now merged into Homes and Communities Agency) earmarked for regeneration, claiming this land had the potential to attract £18,6 billion of private investments (www.englishpartnerships, 2010).

With its investigation, the Urban Futures team attempts to develop instruments ensuring that this high level of public and private investment delivers on its promises of sustainability, with a particular focus on performance and longevity. In a paper presenting the first phases of the development of the method, Boyko et al. (2012a) pose one of the questions at the core of the UF programme: ‘How can the impact of uncertain futures on the performance of different indicators for sustainability in an urban regeneration context be systematically quantified and qualified?’ For this purpose, the GSG scenarios of the world in 2050 (envisaged as a sufficiently distant time to allow substantial but comprehensible change, whereas 2100 would be too distant a time to relate to) were identified as a suitable basis on which to build the methodology.

In the GSG work the recount of futures of society is supported by quantitative indicators that are consistent with the direction of change of the key drivers. Indicators are disaggregated for broad geo-political regions. Because of the specific focus of the research programme, datasets available required a further level of detailing. The UF methods (see below section 5.3.2) is specifically aimed at an urban context whereas GSG scenarios have a broader scope, therefore indicators for sustainable urban development had to be finalised so as to enrich scenarios with appropriate urban characteristics. Moreover, the UF research intended to investigate urban regeneration in its multifaceted nature. Eight different urban dimensions were therefore investigated in depth. These are: Biodiversity, Air Quality, Water and Wastewater, Sub-Surface Built Environment, Infrastructure and Utility Services, Surface Built Environment and Open Spaces, Density and Design Decision-Making, Organisational Behaviour and Innovation, and Social Needs, Aspirations, and Imposed Policy. Understandably each one of these dimensions requires appropriate discipline-specific indicators, all of which cannot be found in the GSG body of work. First, data available in the GSG and GSG-related body of work was selected that refer specifically to Western Europe. Next, data were compared and integrated with material available in each discipline specific literature 'from a variety of 'good sustainability practice' sources, including governmental (e.g., DCLG, DoE) and non-governmental organisations (e.g., CABE) as well as the private sector (e.g., Water UK)' (Boyko et al., 2012a). This process involved also the identification of appropriate metrics for each indicator as well as benchmarks that could be regarded as a baseline against which the indicators' performance under each scenario could be compared. These benchmarks are often available in codes, regulation, or best practice guidance pertaining to each discipline. For example, the benchmarks selected for the indicator 'Building energy efficiency' is given by the minimum mandatory U-levels specified in the UK Building Regulations Part L. The resulting list of indicators forms a matrix comprising about 120 characteristics/indicators capable of capturing either quantitatively or qualitatively the condition of the UK urban context in its many aspects (see Table 7 for a complete list of characteristics, indicators and performances see www.urban-future.org).

In the final matrix, the list of indicators is arranged under thirteen different categories, namely: *Demography*, *Society*, *Governance*, *Economy*, *Planning & Use*, *Housing*, *Urban Form*, *Air Quality*, *Transportation*, *Water*, *Energy*, *Waste*, and *Biodiversity*. Understandably, within each category indicators can pertain to different scales. For example, under the category of *Energy*, 'Domestic energy consumption' is an indicator that refers to individual dwellings; 'Building energy efficiency' is one that refers to individual buildings; and 'Total energy demand' is one that refers to the national level of consumption. These are all linked, and are all necessary to provide an understanding of the causes behind energy consumption and/or the energy performance of urban development. Moreover, the diversity of the indicators included in the matrix allows connecting the different urban scales and facets. For those interested, it is therefore possible to investigate the energy efficiency of buildings not only through its specific parameters (i.e. domestic energy consumption, etc.), but also through a range of others that directly or indirectly concur to the energy performance, such as 'Energy efficient user technologies' (measuring the potential for carbon emission reduction through technology); or 'Planning policy' (measuring the potential to achieve carbon reduction through tighter regulation); or 'Attitudes to consumerism', 'Income', and 'income inequality' (measuring the general inclination to a thrifty or profligate lifestyle that impinges on levels of energy use). This diversity allows investigating solutions that cross spatial scales (Lombardi et al., 2012). It also mirrors the interdisciplinary nature of the scenario analysis. Scenarios, being narratives describing society, encompass diverse factors, with causes, relationships, and effects. Table 7 shows categories and indicators of the matrix. A brief excerpt of each scenario's narrative is reported in Box 1.

Cathegories	Characteristics/Indicators
Demographics	Population
	Urbanisation
	Urban population density
	Urban dwelling Density
	Household overcrowding
	Ageing population
	Life expectancy
Community	Community cohesion
	Attitudes to consumerism
Economy	Quality of life
	Income inequality
	Unemployment
	Quality of life
	Housing affordability
	Support for Public Services (e.g. recycling, bike pools etc.)
Governance	Urban governance models
Business and Innovation	Business models
	Technological Innovation
Land use	Land area
	Land recycling (infill, brownfield)
	Land ownership majority
	Planning policy
	Strength of planning enforcement/adherence
	Adaptability of (new and existing) buildings and supporting infrastructure to the demands of new uses
	Need for/supply of government provided affordable housing with externally imposed price control
Urban form	Settlement pattern (City scale)
	Settlement pattern (Neighbourhood scale)
	Provision of network of open spaces
	Use of underground Space
	What “mixed use” looks like in each future (business mix and typical spatial arrangements
	Character of the place
	Quality (and management of) of public realm
	Artificial external lighting quality, intensity, type, spatial distribution
	Urban 'Building' Canopy (City Scale)
Air quality	Particulate matter (PM)
	NO_2
	Ozone
Transportation	Transportation types and usage - Use of petrol or hybrid cars, public transportation etc. How goods transported
	Accessibility
	Traffic levels
	Road and parking characteristics
	Emissions from traffic
Water	Urban waterway arrangement and amount
	Rainfall
	Water distribution system pattern at the city scale
	Water supply infrastructure: Ownership and management
	Water sources
	Total water demand
	Domestic water withdrawal
	Daily domestic water consumption
	Water efficiency and recycling measures
	Quality of water supplies
	Mains sewerage
	Urban water pollution levels
	Impervious/pervious surfaces
Energy	Total energy demands
	Domestic energy demands

	Energy efficient user technologies
	Energy efficiency of buildings
	Carbon Dioxide Emissions
Waste	Domestic Waste
Biodiversity	Urban tree/hedge cover arrangement + amount change at city scale
	Tree species
	Total area (and arrangement) of green space
	Degree of maintenance for ecological features
	Degree of protection for ecological features

Table 7 – List of characteristics of scenarios

Market Forces - In this scenario, current demographic, economic, environmental, and technological trends unfold without major surprise. The self-correcting logic of the market is expected to cope with problems as they arise, although the elasticity of market-driven control is not infinite. Sustainability issues are addressed more through rhetoric than action. Materialism and individualism spread as core human values, whereas social and environmental concerns are secondary. Competitive, open markets drive development. In terms of planning, this translates into policy that is generally less prescriptive and more market led, with more freedom about the location and form of new developments (including more domestic water use and less energy-efficient technologies being employed). This results in more land being taken up by the built environment. Brownfield re-development is less likely to be favoured because of the costs of de-contamination and the cheaper cost of green field land. The need for affordable housing increases, as attention is focussed on more niche markets (e.g., luxury flats for couples with no children) at the expense of equality. Access to public green space also will suffer, as such land uses may be converted for development purposes, or may become private or semi-private spaces. Less access to a city's 'green lungs' across the population may lead to poorer respiratory health overall. Such deficiencies, coupled with more individualistic attitudes, may result in low civic activism.
Policy Reform In this scenario, co-ordinated and comprehensive government action is initiated to reduce poverty and social conflict while enhancing environmental sustainability; market forces are 'encouraged' to produce socially desirable outcomes, but by no means are they silent. Strong policies and growing environmental and social consciousness emerge to support some changes in consumer behaviour. Such policies also slow, but do not reverse, trends towards high distributional inequity that the market alone would do little to address. Tensions still exist between the continued dominance of conventional ideologies and values and the key sustainability goals espoused in the World Commission on Environment and Development (1987) report. Planning policy is strong in this scenario, with greater regulation of development proposals and a more regional focus than today. This means more land recycling, a stabilisation (or slight increase) of land for built environment purposes, a decrease in the need for affordable housing, greater overall access to public green space, very high uptake of energy efficient user technology and a decrease in the negative health effects from air pollution. Moreover, global population growth decreases, lower domestic water withdrawals. In addition, despite government action to be more sustainable, people are less actively involved in decision-making about local services because policymaking remains top-down and decisions are still made by key, influential people, rather than by a larger majority.
New Sustainability Paradigm In this scenario, new socio-economic arrangements and fundamental alterations in societal values change the character of civilisation. The conventional notion of progress via economic growth is openly challenged, such that sustainability becomes embedded in decision-makers' thinking about how society grows, and the search for a deeper basis for human happiness and fulfilment is sought. An ethos of 'one planet living' pervades, facilitating a shared vision for a more equitable and sustained quality of life, now and in the future. Planning policies are highly regulated, emphasising ecological imperatives, regional planning and sustainability. This results in an increase in active land recycling and a decrease in land devoted to the built environment. In addition, there is almost no need for affordable housing, as the urban underclass is eliminated and society is more equitable, and access to public green space is high. Because of strong ecological imperatives, strong regulation and a push for much more renewable energy generation, there is a very high uptake of energy-efficient user technology. In addition, domestic water withdrawals decrease substantially as well as the negative health effects from air pollution. Finally, in line with the idea of 'one planet living', global population growth decreases substantially and civic activism in making areas more liveable increases substantially.

Fortress World In this scenario, powerful actors organise themselves into alliances in an effort to safeguard their own interests and resources. The world divides into two groups: an authoritarian elite who live in interconnected, protected enclaves controlling access to resources (called the 'haves'), and an impoverished majority outside (called the 'have nots'). Planning policies serve to protect the resources and quality of life of the 'haves' and effectively segregate the 'haves' from the 'have nots'. The built environment sprawls, with the 'haves' gobbling up land for low-density, single-use developments and areas, and the 'have nots' using leftover land to create high- density, mixed-use areas out of necessity. Re-use of land and infrastructure is predominantly by the 'have nots' and is characterised by low-tech recycling and repair rather than remediation and regeneration. Affordable housing is much- needed for 'have nots', but of little or no need for the 'haves', who live in relative luxury. The impoverished majority also are denied access, by spatial and financial patterns, to public green space. In terms of the negative health effects of air pollution, there is a general reduction in life expectancy, as emissions from traffic and other sources cannot be contained to one area. Although NIMBYism drives strong enforcement inside the enclaves and newer technology keeps emissions close to present-day levels, emissions outside the enclaves increase and spread due to poor vehicle maintenance and outdated technology. Furthermore, energy-efficient user technologies are readily adopted in 'haves' areas because they are affordable to this group; the 'have nots', on the other hand, do not use such technologies because they cost too much. Interestingly, even though population growth increases, domestic water withdrawals decrease. This may be due in small part to the use of more energy-efficient technologies by the 'haves' and the restriction of water use for the 'have nots'. Finally, civic activism is not high on the 'have nots' agenda, as their opinions and ideas are not considered in this scenario. However, the 'haves' are more active in civic decision-making, although many of the decisions and policies attempt to exclude the 'have nots' from areas, activities and services.

Box 1 Excerpts of the narratives describing scenarios (source: Lombardi et al., 2012)

5.3.2 – The Urban Futures method

The scenario-based Urban Futures (UF) method is structured in five steps (Figure 3). The sequence is designed to be circular and iterative rather than linear. It allows the analysis of single particular aspects (e.g. material, technology, system, policy, etc.) of urban development. Findings can be used to modify the initial design and make it more resilient, thus closing the loop. The first step consists in the identification of the intended purpose of a 'solution for sustainability'. It prompts answering questions such as: is this solution fit for the purpose stated? Has it really the potential to attain it? This is important, since decisions are sometimes taken on the basis of what is generally deemed valid. It is also functional to establish precisely the purpose, the circumstances, and the features that require resilience. For example, as Lombardi et al. (2012) argue, a green roof is installed (and investments are made) because it can improve the richness of local biodiversity. However, for this to happen many issues must be addressed that may have been overlooked or may even conflict with the building programme. Which one is the most effective green roof technology to foster local biodiversity? Which plants are attractive to native insect and bird species? Is the use of the building roof compatible with insects and birds that need to be undisturbed while feeding? The formulation of these questions leads to the second step, aimed at detecting the 'necessary conditions' for delivering the initially stated benefit, not only now but, more importantly, over the potential lifetime of the building. For example, since climatic changes may result in an environment unsuitable for the plants initially selected, a 'necessary condition' for the green roof to continue foster biodiversity is that plants must be resistant to (or protected against) rising temperatures and/or changing climatic patterns. The third step consists in assessing these 'necessary conditions' against the four scenarios. This can be done consulting characteristics and performances of relevant indicators. In the forth step, findings are aggregated to determine the degree of resilience of the solution/option examined. Finally, in the last step a decision informed by the analysis' result can be taken. If conditions are supported in all futures, the 'solution for sustainability' is robust. Conversely, causes of adversity must be identified so as to address them, or another solution must be selected (for an extensive presentation of the Urban Futures Method see Lombardi et al., 2012, see also Rogers et al., 2012).

The process has been tested already on case studies and has produced interesting results It has been applied at several scales of intervention, at different levels of complexity, and from different discipline-specific standpoints (to see a wide range of application see Boyko et al., 2012b; Pugh et al., 2012; Brown et. al., 2012; Hale et al., 2012; Caputo et al., 2012; Caputo and Gaterell, 2011). One peculiarity of the structure of the method is that it can be applied only on single couples of solution/benefits. If the necessity of examining more than one option arises, or of evaluating different benefits that the option could yield (e.g. green roof to foster biodiversity *and* green roof to reduce water runoff, etc.), then many distinct analyses must be developed. This is because the conditions necessary to allow the functioning of the option for different benefits can be different or even conflict with each other. A second important peculiarity is that the nature of this scenario-based analysis requires considering the characteristics of the place and how they impact the option examined. This is because the identification of the 'necessary conditions' requires focusing on the contextual circumstances. For example, depending on the climate of the place, there will be the need of frequently watering the green roof (if the place is particularly dry), or of protecting it from strong winds, etc.

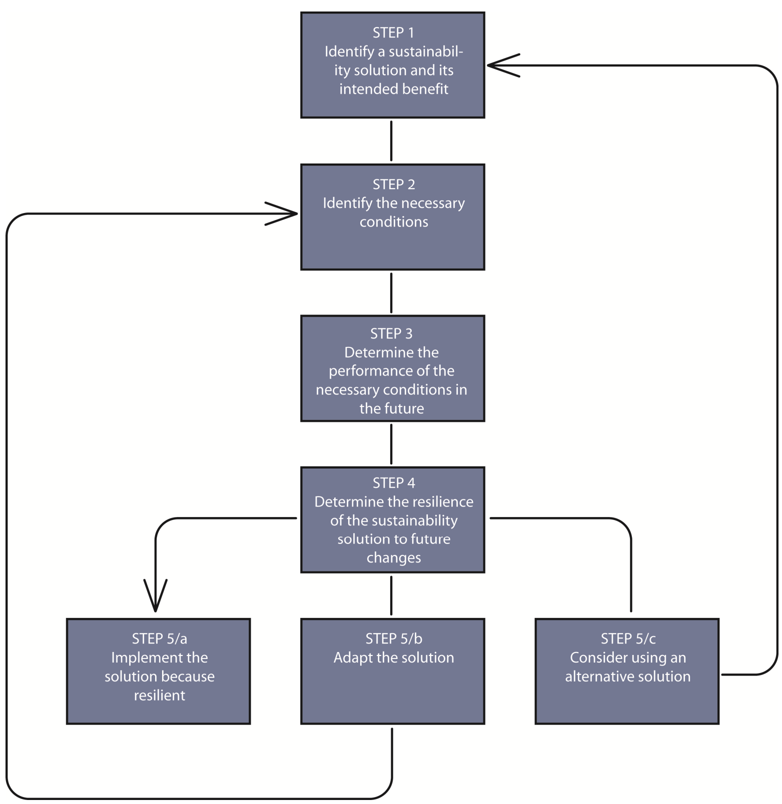


Figure 3 – diagram of the five-step sequence of the UF method (source: modified from Lombardi et al. 2012)

5.3.2.1 - Relevance of the UF method compared to the findings of the literature review - As a conclusion of the previous sections, a list of characteristics inherent to scenario-analysis and the Urban Futures scenario-base methodology is summarised, which demonstrates how these methods are appropriate to meeting the principles enumerated as a conclusion of the chapter 4 (i.e. summary of conclusion from the literature review and interviews with practitioners). This demonstrates the suitability of the Urban Futures methodology for the purpose of appraising resilience. These characteristics are:

- Scenarios offer a systemic representation of the urban environment, which is capable of capturing the environmental, social, and economic dimensions of that context and, through their narratives, to connect them and elicit interplays;
- The systemic nature of scenarios helps connect spatial scales and is time-based. Scenarios are projections of the urban context in 2050. Therefore any analysis will have to consider current options for development and their suitability to different future condition. Moreover, the identification of the conditions for the future functioning of the option appraised inevitably requires evaluating risks at a regional or urban scale that have an impact at the development scale;
- The Urban Futures method interprets the concept of resilience broadly and not in relationship to any specific expert's area. It therefore transcends individual interpretations and focuses on the capability of any particular urban situation to continue functioning as intended, over its lifetime. However, because of its scenario-based nature, it is capable of connecting 'detailed resilience' (i.e. the resilience of the option examined) with 'general resilience' (i.e. the resilience of the entire urban system);
- The Urban Futures method emphasises the necessity to define finalities to resilience. It is an important step that helps answer the question: 'resilience of what and to what?'. In particular the method utilises indicators of urban sustainability, thus linking the concept of resilience to the one of sustainability;
- The Urban Futures method is used here as a qualitative form of appraisal, although it lends itself to quantitative forms of appraisal as well (see Hunt, 2012; see Farmani, 2012). In doing so, it does not restrict opportunities to select technologies or formulate design strategies;
- Because of its nature, the Urban Futures method prompts users to undertake a process of analysis as opposed to ascertain conformity to checklists.

5.3.2.2 - Limits of the UF method - Limits of the UF method may be represented by the complexity inherent to the third step. The assessment of the 'necessary conditions' necessitates a long and careful examination of the many scenarios characteristics as well as an evaluation of the quantitative and qualitative performances associated. Moreover, characteristics may not directly relate to a particular condition. For example, the condition of compatibility of the use of the roof with the option 'green roof to foster biodiversity' is too specific to be easily appraised with a matching characteristic. Instead, relevant characteristics must be identified, that can give relevant clues for this particular issue (i.e. 'attitude to consumerism' and 'civic participation' as indicators of socio-cultural attitudes; 'planning policy' and 'planning adherence' as indicators of the attitude to planning and building regulations, etc.). Another limit is given by the method's structure allowing the examination of a single option at a time. For those working in the field of the built environment, this is a substantial inconvenience since many are the elements (and all tightly interwoven) that must be simultaneously considered in drafting plans for urban development. Developing an analysis for each of the elements can prove to be unduly lengthy and unmanageable. Finally, another limit is represented by the paucity of scenario characteristics portraying the urban form and the building performance. These are necessary for the analysis of buildings and spaces. The following section illustrates how such limits have been addressed in this study.

5.3.3 – Contribution of the author to the Urban Futures research

The contribution of the author to the development of the methodology is threefold. Firstly, as a member of the team he contributed to the collective effort of producing this structured technique of analysis. Secondly, as the team's expert for the built environment and open spaces he identified those indicators representative of the urban form and its efficiency, to subsequently define related metrics, benchmarks, and performances under all scenarios. Finally, he attempted to apply the methodology simultaneously on several solutions whereas it is designed to appraise individual solutions/benefits. This last point is particularly relevant. Planning and designing urban development requires addressing simultaneously several solutions. Thus, in order to be usable as a practitioner's tool the method must be capable of examining complex and multifarious aspects of plans. What follows is the presentation of the process leading to the identification of indicators for urban form and efficiency, and the testing of the UF method on multiple solutions.

5.3.3.1 - Spatial characteristics of the UK urban environments - The purpose of these indicators is to represent aspects of urban performance that are relevant to its sustainability, particularly from a spatial as well as energy efficiency perspective both at building and city scale. The physical configuration of buildings and spaces can substantially influence the perception of the quality of places. Good design (i.e. a design that 'improves the quality of people's lives (DETR/CABE, 2000)) is one of the cornerstones of the former national planning policy. Planning Policy Statement 1 states: 'Good design ensures attractive usable, durable and adaptable places and is a key element in achieving sustainable development' (DCLG, 2005). In turn, sustainable development is one that contributes to sustainable economic development; ensures good and inclusive design and the efficient use of resources; and delivers places with good access to jobs and key services (DCLG, 2005). By Design, the influential urban guide compiled by CABE and commissioned by the Department of Energy, Transport and Regions which reflects and elaborates the positions of the former UK government on sustainable urban development, lists as elements of urban design: *Character* (a place with its own identity); *Continuity and Enclosure* (a place where public and private spaces are clearly distinguished); *Quality of the Public Realm* (a place with attractive and successful outdoor areas); *Ease of Movement* (a place that is easy to get to and move through); *Legibility* (a place that has a clear image and is easy to understand); *Adaptability* (a place that can change easily); and *Diversity* (a place with variety and choice) (DETR/CABE, 2000). In elaborating and detailing further the urban design guidelines provided in By Design, as well as the findings of the Urban Task Force (1999), the Urban Design Compendium (Llewelyn – Davies, 2000) stresses further the sustainable urban development principle of a correct use of resources. For example, it recommends harnessing wind, water and sun for building as well as an urban design, based on passive solar principles. The relationship between energy efficiency and urban form has been fully discussed in the section 1.2 as well as demonstrated in many studies (see Ratti et al., 2005; Littlefair, 1991; Littlefair, 2000; Alberti 1999). Correct orientation and form of buildings (i.e. passive solar principles) 'provide a one-off opportunity to save up to 20–25% of heating and lighting energy (in residential buildings during the lifetime of a building, generally at no cost' (ODPM, 2004b; 2004c). Inevitably, solar gains deriving from correct orientation and urban form can be yielded only if the building fabric has high levels of building insulation. Thus these two factors are strictly connected. The energy efficiency of buildings and the urban form with its potential to store solar energy (i.e. high density-high rise versus medium-to-low density) is captured in some of the indicators listed below.

The indicators for sustainable urban development selected for the matrix, which can be mapped on the elements of urban design enumerated in the urban design guide 'By Design' and mentioned above, are:

- Character of the place (see '*Character'*) - The use of local elements, materials, and typologies help shape places in the respect of local identity and culture. A strong identity of the place, in turn, contributes to retain communities. Nobody likes anonymous 'anywhere places';
- Accessibility (see '*Ease of Movement'*) - Road pattern connecting effectively places, street design, availability of cycling lanes, and streets in which is easy and safe to walk. These features can contribute to a walkable neighbourhood. Public transport is also an important factor for the purpose of accessibility, although it is not within the scope of this research;
- Provision of open spaces (see '*Quality of the Public Realm'*) – Open spaces and green spaces are essential to social life and healthy lifestyles and are recommended in former planning policies, which are providing a classification of spaces and their function in relationship to urban life (DCLG, 2006a);
- Adaptability of buildings and supporting infrastructure to new use (see '*Adaptability'*)(developed in collaboration with Dr. Maria Caserio) – It is one of the principles promoted in all best practice manuals (see DETR/CABE, 2000; Llewelyn – Davies, 2000; Burton et al., 20003; Ritchie and Thomas, 2009; CABE, 2008). It is inevitable that buildings will change use over their lifecycle and infrastructure will be adapted to changing needs. Thus an in-built flexibility to change configuration or to adapt to new technologies is the key to their longevity;
- Energy efficiency of building – It measures building insulation. Both former planning policies and the Urban Design Compendium stress the importance of environmental efficiency. Arguably building fabrics can give a substantial contribution for this purpose, and much of the studies developed by organisations such as the Zero Carbon Hub (2009), the Energy Saving Trust (2008a; 2008b; 2008c), or NHBC (Yuzbasioglu, 2010) point at it as the one measure that can deliver higher, durable energy saving;
- Settlement pattern at city scale; and Settlement pattern at neighbourhood scale – the city form is the result of many components. In its seminal book 'The image of a city', Lynch (1960) enumerates and describes the components through which the city can be experienced. These are: paths, edges, districts, nodes, and landmarks. The layout of the streets and where these lead, the density and composition of the street fronts, the identity of the neighbourhoods and how they seamlessly or abruptly join, and the most trafficked nodes and landmarks form this image of city which is part of a collective perception. Alexander (1977) offers a theory of elements combining and, through their permutations, shaping the city in its diversity. Kostof (1991) instead, believes that form can be read only through the lens of the 'cultural conditions that generated it'. These two indicators elude the complex debate around the city form to capture only its spatial density (compact, sprawling, fragmented) and spatial organisation (centralised, polycentric, etc.). Urban density and organisation are representative of the policies of land use, accessibility, patterns of public services provision, and energy efficiency. For example, compact cities are considered efficient because live, work, and play are at a walking distance; because a sufficiently high density of inhabitants justifies investments for public transportation; because they can be energy efficient; because of their potential to capture and store heat or to counter the heat island effect, etc. The UK former planning policies recommend high urban density believing the compact city is a sustainable urban form (ODPM, 2005). On this account, regeneration is promoted as a sustainability strategy because it uses land

> efficiently (Raco and Henderson, 2006; Williams and Dair, 2007). Clearly, this is a simplification. Dense cities may have poor transportation and lack of schools and hospitals. Yet their urban form offers the possibilities to implement measures for environmental efficiency. Arguments that oppose these views are many (see Sieverts, 2003; Jenks et al., 1996). For the purpose of this research, the urban form is taken as an indicator for its potential to be environmentally efficient. It was decided to develop two indicators corresponding to two different urban scales to better encapsulate the implications on a given urban form at a development level and more broadly, on the city.

Similarly to all the indicators included in the complete Urban Futures matrix, also for those listed in this section metrics and benchmarks have been established and the performance under each scenario has been determined. This has been done with the same methodology illustrated above (i.e. literature research, consultation with experts, etc.). More importantly, the GSG scenarios have been interrogated in their essence and relevant clues identified. Furthermore, as each one of the scenarios captures – to an extent – the radicalisation of conflicting trends that globally (and also regionally) co-exist today (e.g. market-led political agenda, the strong emergence of environmental and equity values, etc.), policy and society attitudes, and responses to such trends as they can be observed today, offer inklings of what will happen in 2050. For example, in a Policy Reform scenario, where policy is committed to environmental values, it is likely that energy conservation regulation will be tighter than today. This assumption is corroborated by the evidence of the UK carbon reduction commitments, taken by a government that, to an extent, was embracing the same values depicted in the scenario, and that seemed to be engaged in tightening mandatory regulations for building energy performance.

Finally, data sets supporting GSG scenarios complemented with those collected from several sources allow a rigorous evaluation of indicators' performances. For example, in the case of the city form, political and social attitudes captured in the narratives point at different stances depending on the scenario considered. In Policy Reform it can be surmised that the policies to promote and enforce a good land use, medium to high urban densities, efficient public transport, etc., will be implemented. Thus the compact city is the city model that can confidently be representative of this world. In Market Forces, a Conventional World in which the market logic takes precedence, planning policies are deregulated to reduce bureaucracy and allow faster development processes. Private enterprises can choose the most cost effective solutions thus generally avoiding development on brownfield and regeneration, in favour of development on green or agricultural land because less expensive. This process therefore results in fragmented patterns of urban growth and sprawl.

A similar process has been adopted for the other indicators for the Character of the place, Accessibility, Provision of open spaces, and Adaptability. These are strongly dependent by the political attitude towards urban development, in itself a mediation between an ideological vision and the pressure exerted by disparate pressure groups from the civil society and industry. Because of difficult quantification, these indicators have been in general described with qualitative performance although for one of them (Provision of open spaces), a quantification has been attempted based on literature available (DCLG, 2006a; Burton et al.; 2003). The energy efficiency of buildings, instead, has been quantified considering the several levels of the Code for Sustainable Homes and the levels of insulation necessary to their attainment as suggested in a report of the Energy Saving Trust (2008a; 2008b; 2008c). Level 6, for example, has been deemed the only standard allowed in a world like New Sustainability Paradigm, where society has shifted towards sustainable living and the environment and equity are collective priorities. Level 4 has been taken as the mandatory level in a Policy Reform world where policy-making is concerned with the environment, albeit forced to mediate with private sector, which still is a powerful actor, and the value system of society at large, which is still strongly influenced by individualism and consumerism. In Table 8a and 8b, indicators, benchmarks, and performances under each scenario are provided, as well as a text motivating the analysis.

Indicator	Definition	UK baseline
Settlement pattern (City scale)	Current planning policies recommend an efficient use of land for new urban development, with consequent medium-to-high dwelling densities resulting in reduced car use, and a financially viable public transport network (see DCLG, 2005; DCLG, 2006). This approach corresponds to the urban model of the compact city, which is regarded here as the UK baseline for the urban characteristics of settlement pattern at a city and at a neighbourhood scale. The other two forms (i.e. fragmented and polycentric) convey a planning attitude towards urban development consistent with the value system of society in each scenario.	**COMPACT**
Settlement pattern (Neighbourhood scale)	Individual neighbourhood should be designed in conformity with the urban form recommended in planning policies. However, the situation on the ground varies greatly, with many low density, suburban residential development delivered together with high density mixed-use ones	**VARIABLE**
Character of the place	'By Design' states that in order to design places with an identity and a character it is necessary 'To promote character in townscape and landscape by responding to and reinforcing locally distinctive patterns of development, landscape and culture' (DETR/CABE, 2000). In turn places with identity are valued and appreciated by the community and visitors. In spite of such clear guidance, not many recent developments seem to show a distinctive identity. This condition is regarded as the UK current baseline	**VARIABLE**
Energy efficiency of building	In the UK, Building Regulations (2010) set minimal mandatory targets for thermal transmittance of the building fabric (U-values), which are inferior to those set by voluntary rating codes such as the Code for Sustainable Homes (CSH) and BREEAM. The Building Regulations mandatory targets are taken as the current UK baseline whereas those available in CSH or BREEAM are taken as reference for those scenarios in which mandatory building fabric efficiency is tighter	**Building Regulations (U=0.24 for outer walls)**
Adaptability of buildings and cities (in collaboration with Dr. Caserio)	Adaptable places are those that 'can change easily' (DETR/CABE, 2000). This can be achieved through simple but adaptable building forms and places that can be used for a range of future activities. At present not all new developments seem to possess this capacity. This condition is regarded as the UK baseline	**VARIABLE**
Accessibility	'By Design' describes places with good accessibility as those where live, work, and play is well connected and where it is easy 'to move through, putting people before traffic and integrating land uses and transport' (DETR/CABE, 2000). Not all new development can claim to be designed with good accessibility. This conditions is regarded as the UK baseline	**VARIABLE**
Provision of public open spaces	The former Planning Policy Statement 8 (Department of Environment, 2004) suggests an average of 2.4 ha outdoor play space per 1000 population. It also emphasises the importance of providing 'open space, playing facilities, woodland and landscaping within easy walking reach of homes, for physical activity, rest and leisure use, especially in densely populated and disadvantaged communities, and in new developments'	**2.4 ha outdoor play space per 1000 population**

Table 8a - List of characteristics/indicators with correspondent benchmarks developed by the author

Indicator	NSP	PR	MF	FW
Settlement pattern (City scale)	**POLYCENTRIC**	**COMPACT**	**FRAGMENTED**	**FRAGMENTED**
	The urban form promoted in planning policy is compact (with an efficient use of land) but polycentric. This is because the size of each neighbourhood tends to be contained and with much green and open space within and around it, following the tradition of the Garden City and the need to better integrate green infrastructure with the built environment	Planning policies strongly promote high building densities and development on brownfield. There is a limited expansion of the city boundaries	The planning system is deregulated and urban development investments follow market logics, thus privileging building on greenland (as opposed to brownfield) since requiring lower investments. Dwelling densities are high in development targeting low-income groups, and low for those targeting medium to high income groups. The city expands outwards and in a fragmented fashion, with much previously developed land left abandoned	The rich residential areas (mainly built at low density) are strategically positioned in cities, contained in discrete pockets connected by rapid transport routes, and surrounded by informal settlements for the poor, built at high dwelling density. Urban sprawl expands and many previously developed urban areas remain abandoned
Settlement pattern (neighbourhood scale)	**MIXED-USE / COMPACT**	**MIXED-USE / COMPACT**	**SINGLE-USE / DIFFERENT DENSITY**	**SINGLE-USE / DIFFERENT DENSITY**
	Compact, mixed-use, mixed-tenure neighbourhoods with sufficient green space within and around them	Compact, mixed-use neighbourhoods provided with sufficient green space	Mainly residential (generally single use) neighbourhood for high-to-medium income groups are built to low density whereas those for low-income groups are built at high density and with an inferior provision of open spaces	Low density, exclusively residential settlements with ample provision of open spaces and services for the rich. High density settlements for the poor, with low provision of open spaces, and with residential spaces mixed with informal working spaces such as laboratories, etc.
Character of the place	**HIGH**	**VARIABLE**	**LOW**	**LOW**
	The design and construction of buildings is strongly inspired by the local environmental conditions and traditions in order to endow distinctive character to the new urban development. Similarly, existing development designed following such principles is appreciated	Planning policies put strong emphasis on the delivery of places with a strong character and identity. Nevertheless, developers are still reluctant to embrace principles that require high design commitment and possibly longer design and construction times	In a society on which the free market is the principal actor globalized trends tend to reduce cultural differences and diminish their importance for society. Moreover, uniformed building components and technologies result in undifferentiated formal and technical building solutions. Prevailing consumerist culture privileges what is promoted on the market, regarding it as innovative and iconic. New development is designed and built accordingly	The character and identity of new development for the rich is dictated by global cultural trends. For the poor, The quality of the newly built is generally low, with a high level of standardisation in design solutions, and building materials and components

Energy efficiency of buildings	**HIGH** (U-value for external walls = 0.1 W/m^2K – level 6 CSH)	**HIGH** (U-value for external walls = 0.18 W/m^2K – level 4 CSH)	**SAME** (U-value for external walls = 0.24 W/m^2K)	**SAME/LOW** (U-value for external walls = 0.24 W/m^2K or lower)
	All new residential buildings must attain the level 6 of the CSH. All non-residential buildings must exceed BREEAM Excellent. Passive Solar Principles are used when possible and appropriate. Since the target is to deliver Zero Carbon buildings, on-site renewable energy generation is widely used	Mandatory energy targets are tighter compared to current UK Building Regulations, and building technologies progress accordingly. New residential buildings must meet level 4 to 5 of the CSH and non-residential meet the BREEAM Excellent rating. A percentage of energy use must be met by zero/low carbon energy production. Passive solar principles are recommended in planning policies, but not always used, since this may result in lower building densities	Planning policy is deregulated and Building Regulations are made non mandatory unless conflicting with Health & Safety issues. Generally, however, construction industry delivers buildings with the same standards that are currently mandatory. Technological innovation and economy of scale allow improvement in efficiency at affordable costs. Low/zero carbon technologies become more efficient and affordable but energy consumption is still high because of unchanged behaviour	Planning policy is deregulated and Building Regulations are made non mandatory. The rich, however, live in buildings designed and built at high quality standards, and sometimes utilising zero/low carbon technologies so as to gain a level of self-sufficiency. Nevertheless, energy consumption is high because of unchanged behaviour. The poor live in places built with low standards. However, energy consumption is low because unaffordable
Adaptability of buildings and cities (in collaboration with Dr. Caserio)	**HIGH**	**HIGH**	**LOW**	**LOW/MEDIUM**
	High adaptability of existing and new building stock. Internal and external spaces allow for adaption, conversion and extension. Development is driven with a view to retain communities and conserve resources	Policy dictates that new built must be adaptable to new uses and able to respond to changing social, technological and economic conditions. Policy conforms to 'Building for Life' criteria and supports the adaptability for retro-fitting of existing building whenever commercially viable	Developers pay little attention to flexibility and adaptability of dwellings and replacement levels are high. Developers respond to market requirements and there is no policy enforcing or supporting adaptability	For the rich, adaptability of buildings is not a priority. For the poor adaptability is a necessity even if the design, the construction methods, and the technologies used for new and existing buildings do not allow it
Accessibility	**GOOD**	**EXCELLENT**	**GOOD**	**GOOD/POOR**
	Good accessibility to services and jobs mainly through pedestrian and cycling paths, and an excellent public transport service. Road network is designed to encourage car circulation on urban peripheral main roads and the use of public transport for local trips	Good provision of cycling lanes and walkable roads. Car circulation is strongly deterred and streets are reasonably safe for pedestrians and cyclists. However, people, to an extent, resist change. and use private cars whenever possible	Excellent network of roads connecting all urban areas, since good infrastructure is fundamental to economic development. Public transport is not always efficient, and high levels of car circulation discourage walking. Cycling lanes are not always available and do not connect jobs with homes	Rich enclaves are well connected with business and commercial districts, and services. Within enclaves (mainly residential) cycling and walking lanes are available although not always used. Outside the enclaves, the road network is fragmented, limited public transport is available, roads are unsafe and there are no cycling lane
Provision of public open spaces	**EXCELLENT**	**GOOD**	**POOR**	**GOOD/POOR**
	Excellent provision of open spaces for many uses (e.g. play areas, green spaces, community gardens, parks, etc) well connected with homes. Neighbourhoods are	The provision of open public space is good, and it is generally well maintained. Places for leisure and sport activities are provided as much as possible, although medium-to-high urban density is a	Sufficient open space is provided in high-income neighbourhoods but not in those for low-income groups. Green areas for sport and leisure are generally available whereas play	Enclaves for the rich are provided with green areas, playing facilities, etc., but not with parks where animal species can roam undisturbed. Outside the enclaves, there are no public

	designed to support healthy lifestyles and promote community cohesion. Spaces to grow food are available as well as green areas to enhance biodiversity	priority, thus limiting to an extent the diversity and the number of open spaces provided	areas for children are quite limited. Not everywhere maintenance is provided	open spaces designed as such. The poor utilise for this purpose unoccupied places such as those available on brownfield left undeveloped

Table 8b - List of characteristics/indicators with correspondent performances for each scenario developed by the author

5.3.3.2 - Multiple solutions analysis – One of the advantages of an analysis on individual solutions/benefits consists in isolating the solution considered so as to precisely focus on all its aspects and consequences. It is therefore possible to eliminate from the process other factors thus simplifying it and, in doing so, observing the object of analysis without interference and more in-depth. This approach, in which discrete issues are systematically examined, does not reflect, however, the non-linear process characterising urban planning and design that often requires the integration and harmonisation of multiple perspectives, and the consequent relentless renegotiation of spatial strategies. Within this process, coordination is a key element. An initial investigation aimed at defining issues, aspirations, and challenges is used to form a vision. Next, the examination of constraints and opportunities of a particular site is used to transform the vision into a spatial strategy. Broad design elements to be addressed in such a strategy are listed above (i.e. character, accessibility, ease of movement etc.). Many of these are evaluated often simultaneously and in their relationship with the others so as to identify tensions and finally stipulate a final plan for development. In this perspective, to analyse a solution in isolation could be regarded as misleading, since it would not reflect the essence of the design process, which is to link and coordinate disparate elements within a wider picture. Following the method's structure, practitioners can attempt to analyse a particular building technology (e.g. greywater recycling), or component (e.g. triple glazing), or strategy (e.g. passive solar principles). However, if the scope of analysis is broader, the method is difficult to apply. Arguably, in order to examine a building in its entirety, it would be inconvenient to develop as many analyses as the technologies, strategies, and components that compose it.

To avoid this, the author attempted a multiple analysis. A cluster of solutions was selected to be examined in parallel. Although these solutions are congruous, in that they are those that typically can be selected for energy conservation purposes (thus with a common objective of reducing energy use), because of its systemic approach, the analytical process draws into discussion other important urban parameters. By doing so, these parameters are themselves appraised against the scenarios and through the structured progression of the analysis. Thus, starting from a reduced number of congruent solutions analysed simultaneously (in itself already a multiple-analysis), it is possible to broaden the scoping so as to better chime with planning and urban design processes. To an extent, this is intuitive. It has been highlighted already that energy (and with it other urban factors) cannot be viewed in isolation and there is abundant literature that investigates its possible links (Ratti et al, 2005; Littlefair et al, 2000; Alberti 1999). A point in case is the solution 'solar gains' that, in a feedback loop, is dependent on the building density to maximise benefits. Nevertheless, as the case studies demonstrate (see chapter 6), the discussion elicited through the analysis is much broader and rich than those available in literature on this topic. More importantly, it can be expanded so as to include other connected elements such as, say, the quality of open spaces in function of the building density, the developer's return in building at low-to-medium densities, etc. In a game of mirrors, the complex systems approach allows expanding the view at will.

Possibly, a crucial step of the analysis for triggering the process outlined above (see section 5.3.2) is the identification of the conditions necessary to maintain the solution functioning. It leads directly to the identification of other elements apparently external to the technical milieu pertaining to the solution (i.e. energy and energy efficient technologies), thus broadening its scoping. It is critical, however, that this process is captured so as to chart all the connections, the feedback loops and the leverage points (i.e. all the connotations of the system) surfaced during the analysis. A compilation of a table with necessary conditions and their assessment against scenarios ensures the recording of important passages of the process. The use of a table for this purpose is part of the UF method. In the case of the multiple analysis its compilation becomes more complex but still manageable. Figure 4 attempts to visualise the process, building on the diagram of the five-step analysis (see Figure 3).

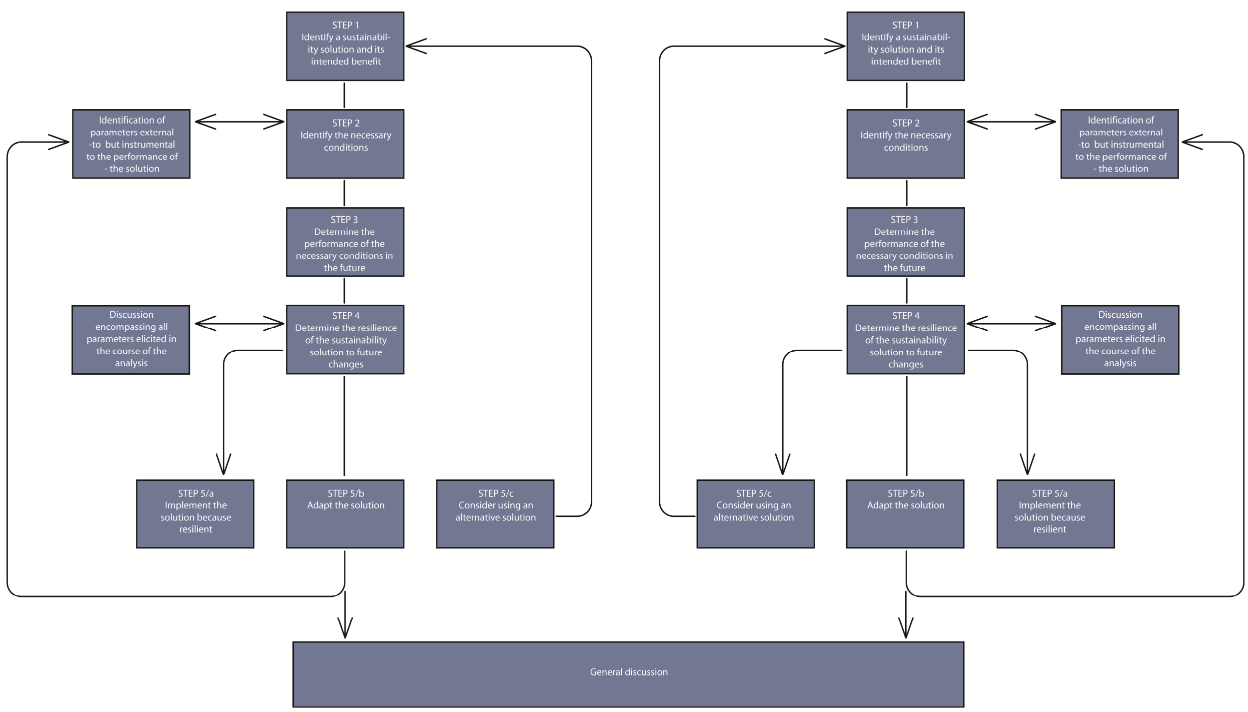


Figure 4- Diagram illustrating the resilience analysis process

For the purpose of attempting a multiple analysis, general energy efficiency strategies are examined, which are of general application, thus not contextualised. It is therefore the general efficacy of energy conservation policies (but not their contextual application) that is analysed here. Nonetheless the exercise is fruitful in that it elucidates vulnerabilities and loopholes within such policies. The following sub-sections present this first attempt of multiple analysis (henceforth called resilience analysis) as well as an attempt to operationalise it through an Excell-based interactive spreadsheet.

5.3.3.3 - Resilience analysis on energy efficiency solutions - The strategies considered for the purpose of the resilience analysis (multiple analysis application of the UF method) are: building insulation; solar gains through orientation and built form; natural light penetration (daylighting); and on-site renewable energy production. These are embedded in planning policies (see ODPM, 2004b; 2004c). Other measures such as low carbon technologies have not been included (e.g. CHP, etc.), because of the extent of the options available, their dependence on the particular profile of energy demand, and their relatively minor relationship with the built form.

Energy efficiency measures are usually implemented following targets provided in mandatory and voluntary benchmarks. This particular resilience analysis examines ranges of performance targets. The purpose is to offer an understanding of the long-term effectiveness of varying degrees (from lower to higher) of energy efficiency that are likely to be considered for implementation when drafting plans for urban development. Understandably, professionals base their choices on directions given through regulation, codes, and rating systems, which often are flexible enough to allow the application of a range of performances, depending on aspirations, context, and other constraints. The analysis therefore appraises those ranges (i.e. levels of thermal conductivity of building fabric, etc.) so as to establish which performances are more likely to be successful and why. Some of these can be found in existing legislation or guidance, while others have been surmised on the basis of the literature consulted. The author acknowledges that some of these assumptions are arbitrary. Nevertheless they serve the purpose of demonstrating the validity, usefulness, and flexibility of a model of appraisal, which reflects current professional operational approaches.

Benchmarks for building insulation are taken by Building Regulations, the Code for Sustainable Homes (CSH) as well as other studies which suggest specifications appropriate for the attainment of the several CSH levels (DCLG, 2010b, see also EST, 2008a; EST, 2008b; EST, 2008c). Existing benchmarks for the other energy strategies considered herein (i.e. daylighting and sun access (see CIBSE, 1999; see also BSI, 1992)) refer only to minimal performance. The benchmark for solar access, for example, provides the minimum amount of winter solar hours (WPSH) necessary to make a space liveable and pleasant. A sufficient level of natural light penetration is given as a percentage of the vertical sky component (VSC), which is a function of the obstacles facing windows. Tighter benchmarks for energy savings through solar gains and vertical sky component are currently unavailable. Similarly, benchmarks for percentages of energy use to be delivered through decentralised, local generation are inexistent. Best practice sets the bar to ten percent for developments over a certain size (Merton rule), however as reports for energy security, and some academic research, recommend decentralised production for the purpose of building a more resilient energy system (see Bouffard and Kirschen, 2008; Walker, 2008; O'Brien and Hope, 2010; Foresight, 2008; DECC, 2011), it may be possible that levels of production required for local development may soon increase. Table 9 shows the range of performances assessed as well as the sources where these were found. It is important to note that the absence of a range of clear benchmarks for, say, solar gains, suggests it is difficult and impractical to define in local planning policies targets for energy savings deriving from the application of passive solar principles. This absence is therefore a deterrent for applying those very principles promoted in former planning policies.

As mentioned in the previous section, this analysis offers only a first general level of investigation on energy solutions, which needs to be complemented with the evaluation of contextual conditions. For example high levels of sun access with resulting solar gains may not be achievable because of the morphology of the area, or because density required is not compatible with sun penetration, thus the strategy for energy conservation needs to rely on other options. The analysis that follows is useful as an initial evaluation which can inform pre-planning decisions. However, it is the evaluation of local conditions which will determine a more accurate and consistent level of conclusions. Moreover, it is important to note that this analysis does not reach unequivocal conclusions, or provide precise quantitative results. Rather, it offers a view, and generates awareness, of the consequences of decisions concerning the energy efficiency of places. Detailed analysis for each energy efficiency strategy, with a full text supporting the analysis, is available on the tables included in the Appendix 2. A summary of the analysis can be found in Table 10

Energy strategy	Performances
Building envelope U value (W/m^{2}k)	BR 2000* Walls / 0.35; Floors /0.25 Roof /0.25; Windows /2.2
	CSH level 3** Walls / 0.28; Floors /0.20 Roof /0.16; Windows /1.8
	CSH level 4*** Walls / 0.18; Floors /0.18 Roof /0.13; Windows /1.4
	CSH level 5-6**** Walls / 0.1-0.15; Floors /0.1-0.15 Roof /0.10; Windows /0.8-1.0
Solar Access WPSH (Winter Possible Sunlight Hours)	5%^
	20%[X]
	30%[X]
	50%[X]
Daylighting VSC (Vertical Sky Component)	>27%[X]
	27%•
	<27% >40%[X]
	40%[X]
On-site renewable production Percentage of local energy demand	0%[X]
	10%[⊗]
	15%[X]
	20%[X]

* BR L1A for new dwellings, 2000; ** EST, 2008; *** EST, 2008b;
**** EST, 2008c; ^ British Standards, 1992; • CIBSE, 1999;
⊗ Yuzbasioglu et al., 2009; [X] proposed by the authors (see chapter 2)

Table 9 - List of energy strategies with related range of performances, and the necessary conditions to retain the intended performance over the lifetime of buildings

A first glance at the table 9 and 10 shows those elements that may impede each level of performance, and that need to be addressed from the onset of the project. As anticipated above (see section 3.3.3.2), these elements call into play other urban design parameters. What follows is a list of first findings:

- Building to current mandatory insulation levels may deliver a building stock that, in some scenarios, will not comply with future, tighter mandatory levels, thus resulting in a depreciation of the perceived value of the building stock. Moreover, long-term maintenance investments are contained if compared to those related to, say, on-site energy generation;

Energy strategy	Performances	Necessary conditions	MF	PR	NSP	FW Haves	FW Have nots	
Building envelope **U value (W/m^2k)**	BR 2000	Maintenance	?	X	X	X	?	D
		Legislation*	√	X	X	√	√	C
		User behaviour	X	√	√	X	√	B
	CSH level 3	Maintenance	?	X	X	?	?	D
		Legislation*	√	X	X	√	√	C
		User behaviour	X	√	√	X	√	B
	CSH level 4	Maintenance	?	√	√	√	?	A
		Legislation*	√	√	?	√	√	A
		User behaviour	X	√	√	X	√	B
	CSH level 5-6	Maintenance	?	√	√	√	?	A
		Legislation*	√	√	√	√	√	A
		User behaviour	X	√	√	X	√	B
Solar Access **WPSH (Winter Possible Sunlight Hours)**	5%	Overshadowing	?	X	X	X	X	D
		Maintenance	n/a	n/a	n/a	n/a	n/a	n/a
		User behaviour	n/a	n/a	n/a	n/a	n/a	n/a
	20%	Overshadowing	?	√	?	√	X	B
		Maintenance	n/a	n/a	n/a	n/a	n/a	n/a
		User behaviour	n/a	n/a	n/a	n/a	n/a	n/a
	30%	Overshadowing	X	?	√	√	X	C
		Maintenance	?	√	√	√	X	B
		User behaviour	X	√	√	X	√	B
	50%	Overshadowing	X	X	?	√	X	D
		Maintenance	?	√	√	√	X	B
		User behaviour	X	√	√	X	√	B
Daylighting **VSC (Vertical Sky Component)**	>27%	Overshadowing	?	X	X	X	X	D
		User behaviour	X	X	X	X	√	D
	27%	Overshadowing	?	X	?	√	√	B
		User behaviour	X	√	√	X	√	B
	<27% >40%	Overshadowing	X	?	√	√	X	B
		User behaviour	X	√	√	X	√	B
	40%	Overshadowing	X	X	?	√	X	D
		User behaviour	X	√	√	X	√	B
On-site renewable production **Percentage of local energy demand**	0%	Maintenance	n/a	n/a	n/a	n/a	n/a	n/a
		Legislation*	n/a	X	X	n/a	n/a	n/a
		User behaviour	n/a	n/a	n/a	n/a	n/a	n/a
	10%	Maintenance	X	√	X	√	X	C
		Legislation*	X	√	X	√	X	C
		User behaviour	X	√	√	X	√	B
	15%	Maintenance	X	?	?	√	X	C
		Legislation*	X	?	X	√	X	C
		User behaviour	X	√	√	X	√	B
	20%	Maintenance	X	X	√	√	X	C
		Legislation*	X	X	√	√	X	C
		User behaviour	X	√	√	X	√	B

** Legislation has been considered a necessary condition only for building fabric and renewable energy, since these are either already included in current regulation or are very much debated. Conversely, sun access and daylighting at an urban scale have always been considered only as a best practice approach, which has many constraints that need to be addressed locally and negotiated.*

Table 10 - Summary of the Futures Analysis on energy strategies. Key: √ = supported in this scenario; **X** *= not supported in this scenario;* **?** *= questionable if in this scenario. The resulting evaluation is an average expressed in letters, with* **A** *= resilient and* **D** *= vulnerable*

- Success of passive solar strategies in accomplishing energy savings over the entire lifetime of the development entails the enforcement of right-to-light either with appropriate regulation (e.g. future adjacent development cannot alter and curtail levels of natural light penetration and sun access; building shapes are designed so as to allow sun penetration, etc.), and/or with design solutions (e.g. green buffer zones that influence the distances between existing and possible future buildings). Understandably, this will have an impact on the overall density. Nevertheless, because of the spatial constraints it imposes, passive solar design could be envisaged as a factor facilitating the selection of balanced densities, which could in turn support an urban form compatible with a sufficient provision of open public areas;
- Investments in renewable energy production present many long-term vulnerabilities, which could be mitigated through appropriate forms of ownership. Reliance on sophisticated technologies for energy savings entails high maintenance and replacement of components costs (e.g. photo-voltaic and solar thermal panels can last 15-20 years (Twidell, J. and Weir, 2006), which in the case of individual ownership may be sustained only by those who can afford it;
- High provision of sun access and daylighting may be difficult to defend even in scenarios where the environmental protection is strongly promoted, possibly because it conflicts with efficient land use;
- User's behaviour can undermine any effort and investment in energy efficiency. It is therefore essential to invest upfront on information and design solutions that facilitate behavioural change. These may include smart energy metering, provisions of user guides, community involvement in energy strategies from the onset of the project, and more. It is however crucial to consider this issue as an integral part of the planning and design process.

As the case studies will demonstrate, these findings are recurrent. In the following chapter, they will be largely elaborated and circumstantiated.

5.3.3.4 - The Excel-based interactive tool - The Excel-based tool presented here was designed as part of this investigation in the attempt to operationalise the resilience analysis and transpose it in a format that can facilitate its use, particularly for practitioners. It also represents an attempt to further test the potential of the multiple analysis on resilience by expanding the number of solutions analysed simultaneously. The tool has not been developed beyond the first conceptual stage. It can be considered, however, a further contribution to explore practitioner-oriented approaches for embedding urban resilience within design processes.

The Excel-based tool is based on the same energy analysis illustrated above as well as on some other essential urban design parameters, which are those that can be found in 'By Design' (DETR/CABE, 2000). These were added in an attempt to further test the efficacy of the UF method (and the resilience analysis) when used with multiple and disparate solutions. Similarly to the strategies for energy efficiency, also these parameters are appraised in a range of performances. The interactive spreadsheet in the form presented here is clearly illustrative, in that it is not related to any particular project. Each user can evaluate his/her plans using the solutions therein included or insert other solutions following the structure of the spreadsheet. The spreadsheet's format is useful in that it facilitates an intuitive progression across the five steps of the resilience analysis, an immediate visualisation of the analysis results, and, more importantly, the recording of the analytical process on a table (a map) that captures the breadth of factors and relationships between them that is called into question (i.e. elements of the system, feedback loops, and leverage points).

In the interactive tool, the scenario analysis of the energy and urban design solutions is fully developed, and for each solution a range of performances is provided that can be selected. Once selected, it is possible to read the correspondent scenario-based evaluation together with a concise supporting text. By following the structured sequence the user can retrace the analytical process and appreciate (or question) its results to subsequently draw conclusions. Whether there is divergence or convergence on the analytical process, the user is projected into its workings, and prompted to take a stance against possible long-term risks in implementing a sustainability solution with a particular performance target.

The tool is interactive in that users can choose a level of performance and, more importantly, towards the end of the assessment process, they are asked to fill in boxes with conclusions (corresponding to the step five of the UF method). The column before these boxes lists some possible measures that can increase the resilience of the solution implemented with that particular performance target, which have been identified as a logical consequence of the analytical process. These prompt the user to provide feedback in the adjacent columns, as to how the scenario-based analysis on generic (not contextual) sustainability solutions can apply to the specificity of a given project, on the consequences of implementing such a solution, and, in case of implementation, on the identification of the actors involved.

What follows is the description of how the steps of the UF method map on the multiple analysis tool and an illustration of its workings.

Board One – *Case Study Profile* (see Figure 5): This box must be filled in with the details of the urban development to be appraised. It serves the purpose of recording the performances that, at the end of the analytical process, have been regarded as resilient. As the analysis unravels, users can fill in the boxes dedicated to each solution appraised, thus composing the final project's profile. It is possible, once the user familiarises with the process, to add more, or change, the solutions at present included in the tool, according to the user's necessities.

Board Two – *UK urban scenarios and characteristics* (see Figure 6): The box is divided in four sections, one for each scenario. Through a system of drop-down menus, it is possible to select a particular characteristic. The correspondent text describing its performance appears in the box next to the drop-down menu. Since the scenario-based analysis on each solution/performance is already fully developed, browsing through the characteristics provides users the possibility to acknowledge the evidence base underpinning the analytical process. This board is particularly useful during the step three of the UF method, where users must peruse through the list of characteristics to identify those fit to describe if the conditions necessary for resilience are supported in each scenario. The drop-down menu system facilitates substantially this process.

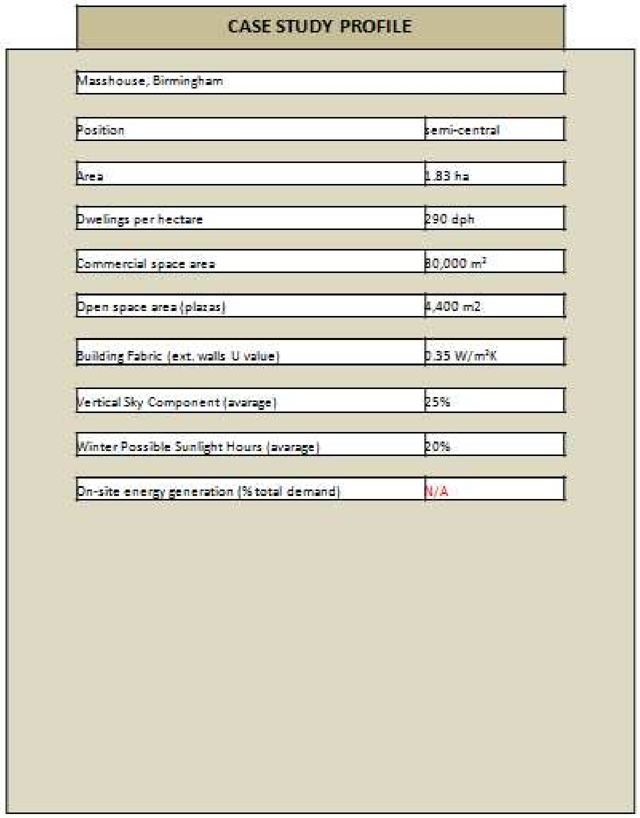


Figure 5 - Board One of the interactive Excell-based tool

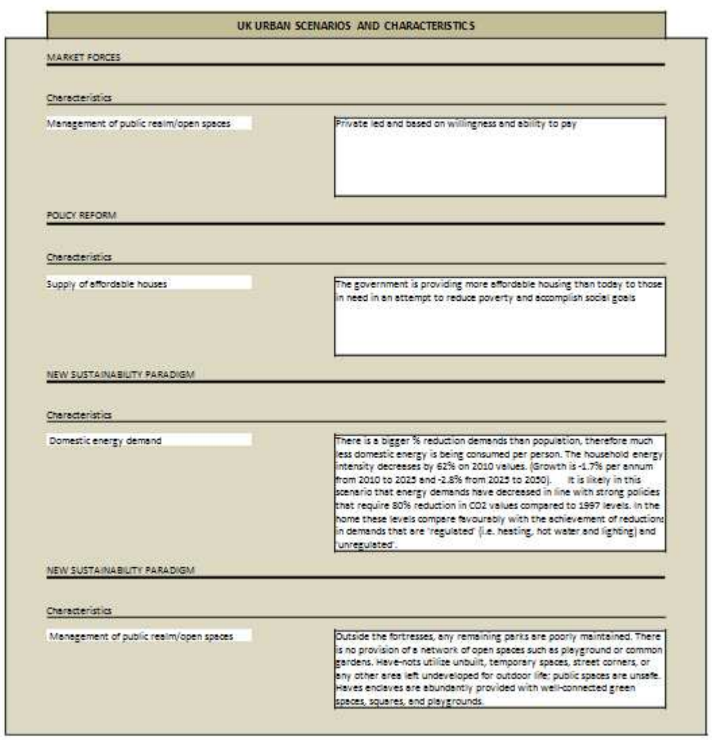


Figure 6 - Board Two of the interactive Excell-based tool, corresponding to step three of the UF method

Board Three - *Scenario analysis* (see Figure 7)*:* Solutions have been grouped under three categories. The category 'Energy' includes the energy efficiency solutions already appraised in the previous sub-section. The category 'Accessibility/Connectivity' (as well as the following category) includes urban design elements that have been selected amongst those provided in 'By Design' and 'Urban Design Compendium'. The list of these elements is by no means exhaustive for the category. As explained above, the interactive tool in its present form is merely illustrative. The selection of solutions and the determination of the range of performances are, to an extent, arbitrary, since the focus is on testing the efficacy of the interactive tool's operability. Nevertheless, all the solutions therein included are described in those eminent guides as crucial for the success of a sustainable urban development. These are: Open space; Pedestrian routes; Cycling lanes; Public transport; and Streets. The last category is 'Urban fabric'. It includes: Urban flexibility; Neighbourhood unit; and Dwelling density. The range of performances, when not available in the two design guides consulted, was deduced by consulting other sources such as planning policies and CABE and RIBA reports.

For each solution, a list of necessary conditions is provided (step two of the UF method). By selecting a performance in the drop-down menu, the adjacent boxes in the row display a summary of the scenario-based analysis correspondent to step four of the UF method. Users, however, can follow the full appraisal process for each necessary condition (i.e. step three of the UF method) leading to the final conclusion displayed in the box, on the other spreadsheets included and linked to the principal spreadsheet where the tool is located. These contain a series of tables where the full analysis is developed. A traffic light colour-code system signals if the performance selected is considered resilient (green), vulnerable (red), or questionable (yellow). A calibrated numeric average of the results of the analysis in all scenarios is finally provided (with resilient = 10; questionable = 5; and vulnerable = 0) at the end of each row. The average is expressed in four degrees ranging from A (resilient) to D (vulnerable).

It is worth noting that the list of necessary conditions can be expanded or changed once the user familiarises with the process. Those provided in this version may not apply locally or may be insufficient. Clearly, this would require revising the entire analysis' evaluations and the correspondent tables in the other worksheets of the tool.

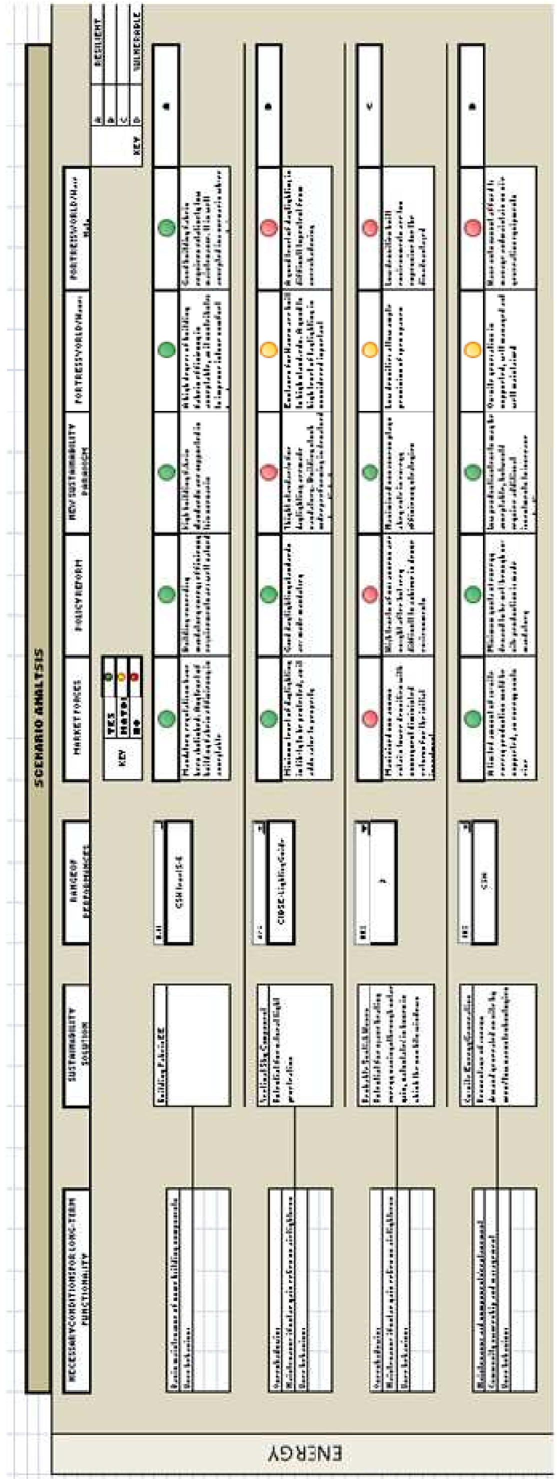
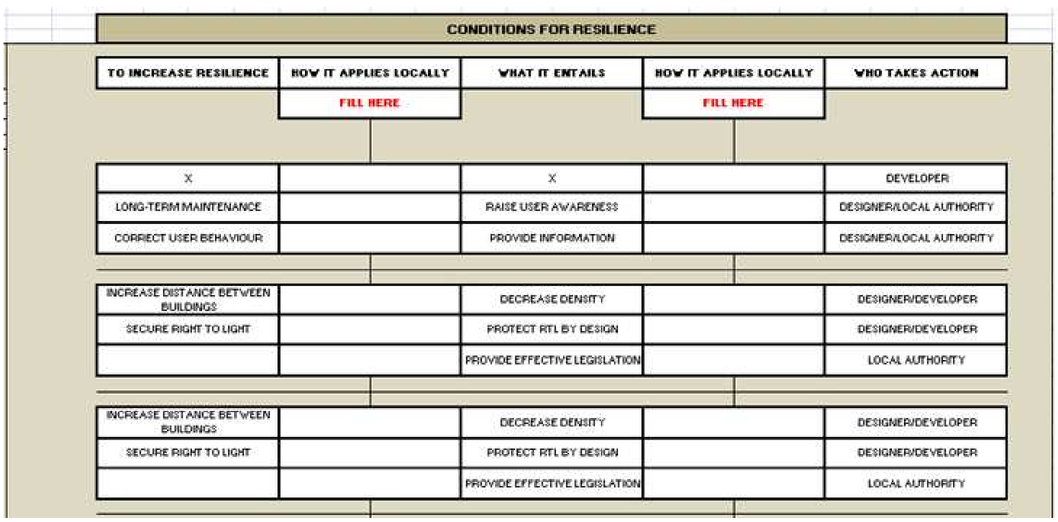


Figure 7 - Board Three of the interactive Excel-based tool, corresponding to step two and four of the UF method

Board Four – *Conditions for resilience* (see Figure 8): This board corresponds with the step five of the UF method. Some of the columns must be filled in by the users once performances have been selected and the analysis acknowledged. The first column provides hints as to how improve resilience for each performance selected. Users can add or substitute these hints before answering to the crucial question: how these apply locally? Answers can lead to modify the hint or propose other conditions for resilience, and record conclusions in the second column. Similarly, the following two columns are meant to give hints for developing an understanding of the difficulties, disadvantages, and knock-on effects on the other solutions included in the tool on the local situation. Users are asked to respond to those hints, draw their conclusions, and record them in the adjacent column. Finally, the last column can be used to identify and list the stakeholders that are directly involved if those measures to improve resilience were to be implemented. Ideally, at the end of this process a rich map of pathways to resilience is outlined, and consequences and connections amongst the solutions all traced to form a complex system. This is a valuable resource to evaluate the most effective strategies for resilience as well as a way to robustly structure a critical evaluation of urban development with a view to the long-term.



CONDITIONS FOR RESILIENCE

TO INCREASE RESILIENCE	HOW IT APPLIES LOCALLY	WHAT IT ENTAILS	HOW IT APPLIES LOCALLY	WHO TAKES ACTION
	FILL HERE		FILL HERE	
X		X		DEVELOPER
LONG-TERM MAINTENANCE		RAISE USER AWARENESS		DESIGNER/LOCAL AUTHORITY
CORRECT USER BEHAVIOUR		PROVIDE INFORMATION		DESIGNER/LOCAL AUTHORITY
INCREASE DISTANCE BETWEEN BUILDINGS		DECREASE DENSITY		DESIGNER/DEVELOPER
SECURE RIGHT TO LIGHT		PROTECT RTL BY DESIGN		DESIGNER/DEVELOPER
		PROVIDE EFFECTIVE LEGISLATION		LOCAL AUTHORITY
INCREASE DISTANCE BETWEEN BUILDINGS		DECREASE DENSITY		DESIGNER/DEVELOPER
SECURE RIGHT TO LIGHT		PROTECT RTL BY DESIGN		DESIGNER/DEVELOPER
		PROVIDE EFFECTIVE LEGISLATION		LOCAL AUTHORITY

Figure 8 - Board Four of the interactive Excell-based tool, corresponding to step five of the UF method

The three case studies illustrated in the next chapter show how the resilience analysis introduced in this chapter can be applied on urban regeneration schemes. By examining the context in which they are situated as well as their environmental strategies, these analyses can provide a range of relevant recommendations for practitioners and planners.

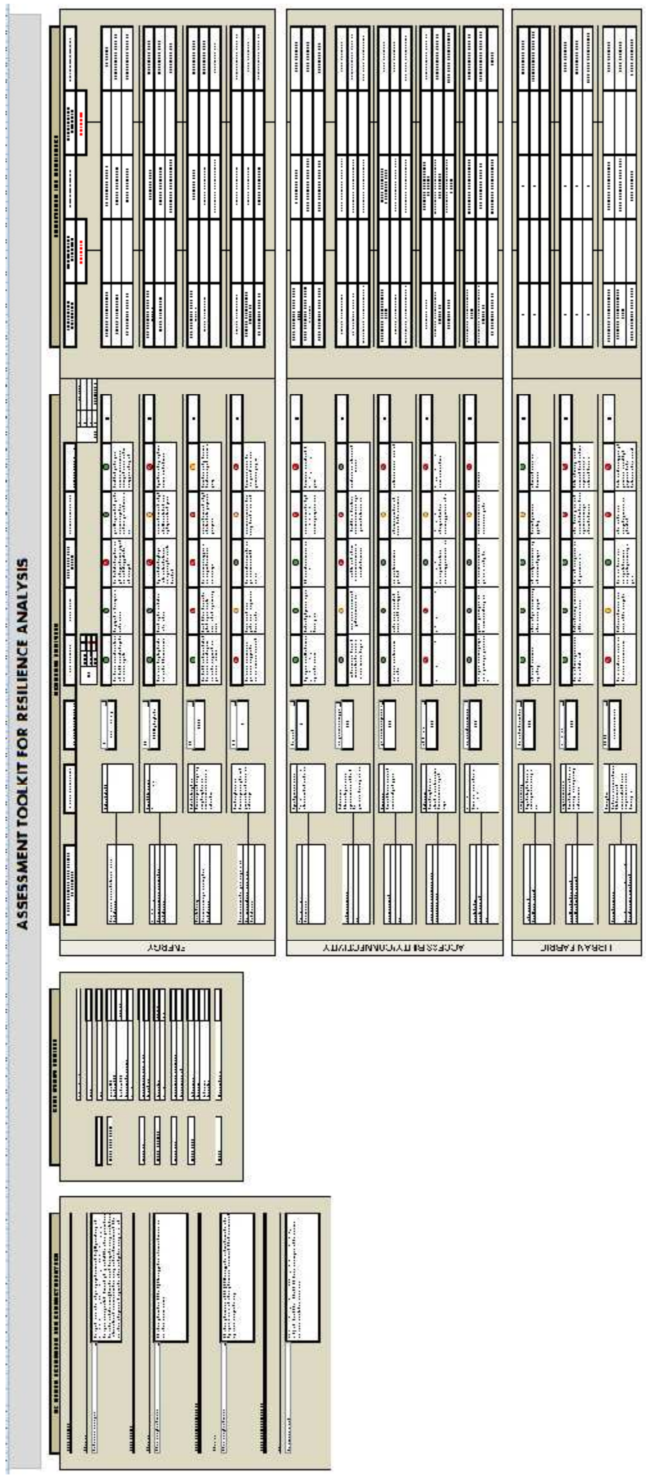


Figure 9 – Excell interactive spreadsheet with all the boards in sequence

Chapter Six - Case studies

The three UK urban regeneration case studies presented in this chapter have different site areas, different characteristics, and they are at different stages of the development process. Their diversity shows that the resilience analysis can be applied regardless of the particular nature of the project (i.e. mixed-use, predominantly residential, commercial, etc.) and of the stage of development of the design scheme at the time of the analysis. For example, in the first case study, the development is at a very initial planning stage in which the vision and the sustainability strategy of the place is only briefly outlined in planning guidance, and no further detail is available. Therefore the analysis appraises the long-term validity of an environmental strategy that is broad and quite generic. The ensuing findings are at a strategic level and, understandably, lack of detail. Nevertheless they can provide valuable insights for a revision of the planning guidance. The third case study is on a commercial development at an advanced design stage and before the technical design phase. The type of documentation available allows a more precise analysis with ensuing recommendations that touch on specific elements such as the building structure and envelope, and the flexibility to future uses of the place.

The first case study was developed during the UF research programme as part of a joint effort from all the sub-teams to trial the methodology with different discipline-specific perspectives. The resulting set of analyses constitutes a broad and in-depth long-term assessment on a regeneration project in Lancaster that was used by the city planning department to review planning guidance. The case study presented here, however, applies the UF methodology with an approach that differs from those of the other sub-teams, in that it examines a range of policies and not a specific, discrete solution (i.e. resilience analysis). The other two case studies were developed independently from the joint activities of the research programme, one as part of the investigation of the sub-team ‘Surface Built Environment and Open Spaces’ and the other for the purpose of this thesis. The former was selected because of the availability of abundant material allowing a detailed analysis of the energy efficiency in function of building shapes, fenestration, orientation, etc. This resulted in an analytical approach substantially different from the first case study and an accurate measurement of the environmental performance of buildings on a digital model of the development constructed with IES (Integrated Environmental Solutions). The latter was developed with the collaboration of the management of the company that is developing the site, thus resulting in the attempt to ascertain the relevance of the UF methodology for the construction industry.

The three case studies are written following slightly different formats. Whilst the first one presents a full account of the assessment process of the conditions necessary to enable long-term functionality (step three of the UF method), the presentations of the other two case studies are more succinct and their accounts present only the essential parts. Furthermore, the last case study concludes the section presenting the analysis for each energy strategy with a summary of the resulting recommendations. These can be read independently from the whole analysis, thus making the consultation of the report faster and more appropriate for an audience such as companies working in the building sectors and developers. Each section of this chapter begins with the description of the site conditions and of the characteristics of the project. Next it discusses in detail its particular energy strategy, reviewing how planning requirements and national regulations apply locally. Finally, the resilience analysis is undertaken and its conclusions discussed.

6.1 - Lancaster - Luneside East urban regeneration case study

6.1.1. Site conditions and planning guidance e- Luneside East is a previously developed, 6.6 hectare site in Lancaster earmarked as a Regeneration Priority Area, designated as a mixed-use waterfront regeneration (LCC, 2008), and regarded as 'the Council's most important physical regeneration project' (LCC, 2004). This derelict, dismissed industrial quarter is located between the city centre and the western urban fringe, and its triangular shape is delimited by two green embankments and the river Lune (Figure 10). These are both railways embankments although only one is currently in service whilst the other is out of use. The latest Supplementary Planning Guidance 4 (SPG4), issued in 2004, is at present subject to review. In the SPG4, the vision of a mixed-use development with 350 mixed-type dwellings, 8000m^2 commercial space, and a range of leisure opportunities and new public spaces is outlined. This new development is deemed as key to connect the city centre with the western 'disadvantaged' areas of Lancaster (LCC, 2004). The embankment between Luneside East and Marsh Lane, the adjacent area predominantly occupied by low-income groups, is therefore viewed as a potential barrier to the permeability between the two neighbourhoods. The eastern section of Luneside East was the site of the Town's Gasworks from 1845 onwards, and some of the buildings still standing possess historical value. The significant existing land contamination entails substantial investments prior construction. Initial plans for development had not progressed past the original conceptual design stage due to a downturn in the market. That which is therefore analysed here is the initial planning guidance that informed the previous, now outdated masterplan. Because of the decision of the City Council to re-launch the regeneration process, this analysis is meant to generate insights that could be used to revise planning guidance and help endow resiliency to the place.

6.1.2 – Considerations on the energy efficiency strategy for Luneside East - The energy efficiency strategy for Luneside East is succinctly exposed in a short paragraph, within the 'sustainability' policy section of the SPG4. The paragraph sets as an objective for the forthcoming regeneration to embody 'best practise in sustainable development'. In line with this, it is required that that the housing provision must be energy efficient and low impact, thus meeting the following criteria:

- orientation;
- maximised natural lighting;
- incorporated energy efficiency measures and
- renewable energy technologies' (LCC, 2004)

Although these measures follow the general recommendations for new development as stated in the Lancaster Core Strategy (LCC, 2008), which in turn reflects the national planning policies (ODPM, 2004b; ODPM, 2005) available at the time, the brevity of the headlines (and the lack of any specific element as to how these should be understood) offers ample

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Figure 10 – Aerial view of the Luneside East site, showing the two green embankments delimiting two sides of the triangular site (courtesy of FaulknerBrowns and LCC, 2004)

leeway for interpretation to developers and designers. A more specific formulation including their intended objectives, as well as correspondent benchmarks, could help identify the level of best practice (in itself a concept which does not refer to any particular degree of energy efficiency) sought by the City Council. For example, orientation and maximised natural lighting can be aimed at providing enjoyable and healthy places, and to a lesser extent at reducing energy use, depending on the duration of sun penetration over the day and over the year (Littlefair, 2000). Moreover, the definition 'incorporated energy efficiency measures' is too vague to suggest any specific intended purpose. Still, clarity is paramount for achieving the 'best practice in sustainable development' heralded in the planning guidance. In order to enable the resilience analysis, the SPG4 headlines are elaborated here so as to embody best practice. What follows is a definition of each of the energy efficiency headlines with their expected function and some of the conditions for these to be implemented effectively.

Orientation and maximised natural light - Correct orientation and maximised natural lighting can result in energy savings in space heating and artificial lighting. Distances between buildings, building profiles and building forms play an important role (Ratti et al., 2005; Littlefair, 1998; Alberti 1999). The quantity of sun that reaches vertical outer surfaces of buildings and the resulting indoor thermal comfort, as well as the quantity of natural light that penetrates indoor spaces, is a function of the design of the interior and of the exterior environment (Littlefair, 2000). Orientation and overshadowing are some of the necessary conditions that need to be addressed for the exterior; whilst elements such as room layout, and window sizing and position are factors that pertain to the interior (ODPM, 2004b). Benchmarks for sun and daylight penetration are given by the Building Research Establishment (Littlefair, 1998), the Chartered Institute of British Service Engineers (CIBSE, 1999), and British Standards (BSI, 1992). With regard to sunlight, however, the standard given refers to a ‘reasonable expectation of direct sunlight’ from which interiors could benefit (BSI, 1992). This definition does not specifically reflect an energy reduction objective, but rather the one of amenity and quality of places. Therefore, the aim of orientation for the purpose of planning guidance necessitates clarification (i.e. amenity, or amenity/energy saving), as well as the benchmark for performance.

What follows is a summary of the conditions that are necessary for orientation to be implemented as a design principle that can yield energy savings. For the purpose of this analysis only the last three are discussed since the first one is a pre-condition for its immediate implementation and not for its long term functioning. These are:

- High commitment of planners, developers and designers at all stages of the development process (ODPM, 2004c);
- Protection from subsequent developments around the edges of the site or even within the site itself, so as to preserve the ‘right to light’ over time (Littelfair, 2000);
- A degree of maintenance of buildings to maintain good performance of building envelopes and retain energy savings yielded through solar gains;
- User behaviour in order to observe the simple rules necessary to retain heat accrued from solar gains (i.e. keeping windows closed, etc.).

Incorporated energy efficiency measures - The generic definition of ‘incorporated energy efficiency measures’ used in the SPG4 presumably refers to high performance building materials and technologies, as well as building services that assist in making the building efficient. As solutions herein are analysed on the basis of planning guidance rather than on design elements, only the former will be considered, since the range of options with regard to building services is vast and needs to be considered contextually to each building use, size, occupancy profile etc. A high degree of the building envelope insulation generally results in reduced space heating demand. The latest revised Building Regulations (BR) Part L 1A and 2A (2010) sets parameters to limit heat gains and losses. Although the mandatory target is measured on carbon emissions, and there is no obligation to adopt any particular solution in order to attain it, compliance with minimum values is required as far as the thermal transmittance (U-value) of the building fabric is concerned. However, this mandatory standard could evolve in the light of the recently adopted Code for Sustainable Homes (CSH) (DCLG, 2010b). The CSH is also likely to impact the energy conservation requirements that local authorities may adopt in the coming years, and the higher standards required therein will in turn affect the long term viability of a development built now to lower standards, that could quickly be considered as performing poorly in energy efficiency terms. Building with fabric standards exceeding current national regulations may thus contribute to the resilience of Luneside East.

As above, the summary of the conditions necessary to attain energy savings through building insulation is listed below. However, only the condition enabling to retain such a benefit over the lifetime of the building is analysed to resilience (i.e. the third). Conditions are:

- Higher initial investments in building insulation and high performance components;
- Skilled labour for building at a high specifications level. This is not a secondary issue. Evidence suggests that carbon emissions associated with new buildings are almost twice as much as predicted at the design stage, part of which is due to construction (CarbonBuzz, 2010, cited in O’Brien and Hope, 2010);

- Basic building maintenance when necessary over the whole asset life time. For instance, window frames and sealing may require painting or replacing; fans for mechanical ventilation may need replacement etc.

Renewable energy production - Planning policies put particular emphasis on the implementation of micro and medium scale renewable energy generation as well as on the involvement of communities in planning and managing schemes. The recently reviewed Lancaster Council Planning Application Validation Guide (LCC, 2009) requires a minimum of 10% on-site renewable energy production for new developments. Thus the new plans for Luneside East have to comply accordingly. Technologies selected for this purpose should depend on the availability of local natural resources (wind, water, geothermal etc.), the energy demand profile of the community (ODPM, 2004b; Manfren et al., 2011), and more. As recommendations on the particular technology suitable for Luneside East are not available in planning guidance, this appraisal focuses on those organisational aspects which may contribute to building a resilient energy provision.

Production at a community scale can engage and motivate users, whereas centralised production, necessarily focused on profit, may lack strong motivation for facilitating behavioural change (Byrne et al, 2009). Community energy production is not the only option for decentralised production. For example, the London borough of Woking has set up a company in partnership with private investors, investing in a district scale renewable energy plant, with the aim of supplying affordable energy to the communities of the borough (Thorp and Curran, 2009). For the purpose of this analysis, three typologies of investments for renewable energy production are considered:

- Micro-scale production: regardless of the technology selected (photovoltaic, solar thermal, micro wind turbine etc.), the objective is achieved through the deployment of small units on each individual building, possibly owned by each building owner;
- Production at a community scale: regardless of the technology selected (CHP or a combination of technologies) the ownership is with the community;
- Production at a district scale: it can take many forms. It could be envisaged as a generic form of investment in energy infrastructure, with yielded benefits returned to the community. This arrangement is suggested in The Zero Carbon Hub report (2009) and called allowable solution (i.e. a solution that accrues carbon savings away from the site (DCLG, 2008b)). Conversely, the contribution of the developer could be directed to an off-site plant that the council controls through a company. In such a case benefits don't accrue directly to the community, but to wider society. The latter is considered in this analysis, as it fits with the concept of decentralised production discussed above.

Taking as a given the correct formulation of the technology (appropriate for the local resources and conditions), the only necessary condition to preserve the functioning of the energy generation schemes in the long term is the replacement of the obsolete components and an appropriate level of maintenance, with related investment. Some technologies may yield benefits for only a limited period of time. For example photovoltaic panels and small scale wind turbines have a life expectancy of 20-25 years (Twidell and Weir, 2006). However, in spite of the technology selected, and considering the year 2050 as the end-point of this exercise, replacements over the life of the schemes are inevitable.

6.1.3 - Multiple resilience analysis

The strategy for energy efficiency indicated in the Lancaster Core Strategy, and detailed in the SPG4, adopts a coherent approach, in that it recommends a combination of energy saving measures consistent with national planning policies which, if all adopted, could yield substantial results. However, in a long-term perspective, it would be useful to have some insights into the strengths and weaknesses for each one of the energy efficiency strategies. What follows is an extended description of the analytical process, summarised in Table 11, in which conditions are appraised against scenarios (step three of the Urban Futures methodology). In order to privilege the brevity and fluidity of the description, the text does not include a full report of all the characteristics that support the scenario-based evaluation for each condition. Table 12 summarises step four, in which the aggregation of all evaluations generates the final conclusion.

Orientation and maximised natural light

Currently national planning policies recommend design principles that allow maximisation of solar gains and daylighting. It is therefore assumed that in scenarios where sustainable development is a policy priority (PR), or it becomes culturally embedded in society (NSP), such a solution is increasingly promoted and/or included in legislation and regulation is in place to protect from the overshadowing that new developments may cause. Regular maintenance of building assets ensures solar gains continue delivering energy savings.

Necessary conditions	**New Sustainability Paradigm**	**Policy Reform**	**Market Forces**	**Fortress World**
Orientation and maximised natural lighting				
Protection from overshadowing	The application of design principles for the maximisation of solar gains and daylighting are required for any new development.. Furthermore legislation is in place to protect the right-to-light	Appropriate legislation is in place to avoid overshadowing	Planning policy is deregulated and there is no protection against overshadowing.	The rich may be willing to protect the right to light, although sun penetration is perceived only as necessary for the good quality of the place, not as a means to save energy. The poor cannot avoid overshadowing
Building maintenance	Maintenance is carried out regularly	Maintenance is carried out regularly, also because incentives are in place for those with lower incomes	Maintenance is carried out regularly only by those who can afford it	Maintenance is carried out regularly only by those who can afford it
User behaviour	Responsible behaviour ensures that energy savings are maintained over the life cycle of the development.	Occupiers resist change since the environment is not a priority in their value system	Environmental amelioration is far from being a priority in society. People behave accordingly	Environmental amelioration is not a priority of the rich. The poor, by necessity, behave thriftily
Efficient building fabric				
Building maintenance	Tights standards of building insulation are made mandatory. Old building stock underperforming may be considered for demolition or expensive upgrading.	Standards of building insulation are tighter than current ones. The market value of old building stock underperforming	Planning policy is deregulated. Nevertheless the market value of building stock built at high specifications is high. Minor maintenance is often	The rich appreciate old building stock constructed with high building fabric specifications and so the poor, since this implies lower operational costs.

	Maintenance is regularly carried out.	may be reduced. Maintenance is made mandatory and incentives are in place for those who need them	carried out	Nevertheless the poor struggle to carry out regular maintenance
On-site energy generation and access to and control of the energy production				
Ownership - individual				
Replacement of components and/or maintenance	Incentives for on-site renewables are maintained. Moreover the energy network relies greatly on decentralised production.	Incentives for on-site renewable are maintained.	Incentives are not in place. Middle to high income groups can be motivated to replace obsolete components, not so the low-income groups.	The rich maintain generation schemes. The poor, which are the majority, cannot afford it.
Ownership - community				
Replacement of components and/or maintenance	Community generation schemes are favoured in this scenario	Community generation schemes are promoted and incentives are in place.	Energy prices are higher. Low-income communities are willing to maintain generation scheme, can benefit from a community management of the plant. High income communities are not interested	The rich may be interested in retaining these schemes since they endow a degree of self-sufficiency within the enclaves whereas the poor cannot afford it
Ownership - partnership public + private sector				
Replacement of components and/or maintenance	New schemes based on PPP are encouraged and the old one retained	New schemes based on PPP are encouraged and the old one retained	The market opposes PPP and privileges a centralisation of energy production since this can offer immediate and higher financial returns	Local authorities have no sufficient power to implement and manage these schemes

Table 11 - Summary of the necessary conditions for the long-term functionality of energy efficiency measures in Luneside East, appraised against future scenarios. Text highlighted in green indicates that the condition is *likely to be supported within a particular scenario; text highlighted in red the indicates that the condition is not likely to be supported; text highlighted in orange indicates uncertainty*

Energy strategy	NSP	PR	MF	FW	
Orientation and maximised natural lighting	Resilient	Maybe resilient. Occupiers do not behave responsibly	Vulnerable	Vulnerable	Solution with many vulnerabilities. Particular attention to protect sun and light access with effective design solutions
Efficient building fabric	Resilient	Resilient	Resilient	Maybe resilient	More resilient than all other solutions. Any level of efficient building fabric can yield resilient benefits
Ownership - individual	Resilient	Resilient	Maybe resilient	Vulnerable	Vulnerable since often dependent on individual household (or business) financial

					situation
Ownership - community	Resilient	Resilient	Maybe resilient	Maybe resilient	Possibly resilient if communities run and manage effectively the generation units
Ownership - partnership public + private sector	Resilient	Resilient	Vulnerable	Vulnerable	Possibly vulnerable since the public sector may not be willing or be able to kick-start PPP

Table 12 - Step four of the resilience analysis, in which the appraisal of all conditions is synthesised to reach a final evaluation. If conditions necessary to the functionality of a particular solution are supported within most of the scenarios, the solution is considered resilient and the text coloured green. If conditions are not supported within most of the scenarios, the solution is considered vulnerable and the text coloured red. Solutions are considered (maybe) resilient or vulnerable, and the text coloured orange, whenever there is no clear predominance of the related conditions being (or not being) supported within the majority of scenarios.

In NSP basic rules for retaining heat accrued from solar gains (i.e. keeping windows closed in winter, etc.) are respected because of a collective sense of responsibility towards the environment and relevant information constantly provided to occupants. In PR, in spite of top-down efforts to develop awareness and provide information, people are still reluctant to change their behaviour. In a scenario in which market logic is unfettered (MF) investors may want to renovate the site and increase its density, or overshadow buildings by developing at high-rise/high-densities along the border of the site with Marsh Lane estate. This is a ‘disadvantaged’ (LCC, 2004) confining neighbourhood, and as such prone to be earmarked in the future for regeneration. In a world where disparity of earnings is increasing and equity is decreasing, maintenance may, or may not, be carried out according to the financial possibility of each household. Regardless of the income class, however, occupiers are not generally well informed as to how energy savings can be accrued through the correct use of dwellings, nor are willing to use less energy to curtail environmental degradation. Similarly, in the FW scenarios, the rich has the power to keep and maintain Luneside East as it is originally physically configured, whereas the poor disregard, by necessity, any routine building maintenance, and possibly increase densities through unregulated extensions of existing buildings. However, the poor pay attention to use less energy because of its cost whereas the rich has no motivation to behave responsibly.

The identification of factors undermining conditions necessary for the functioning of this solution leads to a discussion to improve its resilience. This corresponds to the step five of the resilience analysis, in which the causes of vulnerabilities are addressed. The existing embankments can potentially deter a future expansion from neighbouring areas, thus preserving the sun access from the south in the immediate and long-term. For this purpose appropriate protection needs to be put in place, in order to ensure that their physical configuration is maintained. For example, if landscaped appropriately, the embankments could provide habitat for biodiversity, and therefore gain a degree of protection if included in the local and regional green infrastructure network. They could also be utilised as green open spaces, whose provision in the SPG4 is confined to the site of the old gas holder (see Figure 11). It must be noted that a green landscaping, if appropriately planted, could carry further benefits in terms of microclimate and air temperature (Ritchie and Thomas, 2009).

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Figure 11 – In the supplementary planning guidance for Luneside East, only part of one of the embankments is designated as open space (courtesy of LCC, 2004)

Maintenance is another necessary condition. The failure to provide it to those building features necessary to minimise heat losses and guarantee good air exchange may invalidate high building efficiency put in place today. In the case of an MF or FW scenario, and in the case of a largely disadvantaged Luneside East community, a degree of resilience may be provided through community ownership of the development in which responsibilities for maintenance are shared, overriding individual failure of action. Finally, information about correct use of dwellings is essential in most of the scenarios (i.e. correct use of solar shading devices simple principles to retain heat, etc.), and ways to transfer this knowledge to users should be explored.

Incorporated energy efficiency measures

Although benefits accrued through efficient building fabric can potentially last for the entire lifecycle of buildings, maintenance is once again the key factor. Windows and mechanical air ventilation (a requirement where high levels of air-tightness are necessary) requires routine care over time. It is likely that maintenance work is largely carried out under the PR, NSP, and – to an extent – MF scenarios, as the level of investment and commitment required is relatively low. In contrast, in FW, the majority of disadvantaged is not be able to afford the basic expenditure required. Nevertheless, compared to the other solutions, incorporated energy efficiency measures have the potential to preserve their efficiency (or part thereof), in most cases, over an extended period of time.

As outlined in the previous paragraph, exceeding current national mandatory standards for building envelope, particularly in light of increasing fossil fuel costs and consequent space heat costs, seems the best way to deliver an efficient building stock to future generations. Conversely, complying simply with today's mandatory standards could result in insufficient building performance in the face of tomorrow's expected tighter mandatory requirements, with consequent devaluation and possibly obsolescence of the development. This is in line with the recommendations formulated in the Zero Carbon Hub report (2009). Maintenance remains a vulnerable aspect. It can be supposed that community ownership of the development could lead to effective organisational structures for local management, which could establish, for example, financing models that are compatible with the average household tenure.

Renewable energy technologies

Subsidies for micro scale renewable energy production (i.e. feed-in tariff) have been recently made available in UK with the objective of expanding the number of small schemes for renewable energy generation. It is likely that they are maintained in a PR and NSP scenario where the environment is a priority, thus schemes installed today will be substituted at the end of their life cycle (20-25 years). Conversely, it is unlikely that under MF incentives are still available. However, it is possible that in a market driven world technology advances and components for energy generation are more efficient and possibly more affordable. Nevertheless, the substitution of the micro-scale units on each property is dictated by the economic conditions of the household. Thus the replacement of obsolete components is carried out only by those who can afford the investment. This can be a consideration valid also in the FW scenario, where in most cases obsolete components may not be substituted, since low income households are the majority.

Community renewable energy units are not favoured in a MF world, where energy production and distribution is almost exclusively in the hands of private companies. Conversely, district scale units in partnership with public administrations could still present an attractive opportunity for the private sector. In the FW, community units may be an attractive opportunity for the rich, as it could provide a degree of autonomy to their quarters. Further it is unlikely that local authorities have means and political will to co-own district scale units, which are probably acquired by companies. In both scenarios maintenance is carried out only by those who can afford it. Under PR both options are viable, although income disparities may still persist and less affluent communities may still find it difficult to manage their energy units. Under NSP, renewable energy production is decentralised and possibly owned by communities, which have the means and the legal framework in place to ensure efficiency of the unit, and hold benefits.

As for the final step of the resilience analysis, it must be noted that conditions for resilience of micro scale energy production are difficult to surmise. When schemes are being owned individually, the onus of the investment for components' replacement and maintenance falls on each single household. In contrast, community ownership allows spreading costs. Profits derived from the sale of the energy produced may be set aside and reinvested in maintenance, depending on the cohesion and organisation of each community. Investing now in participation and involvement of communities can result in increased awareness, appropriate organisational structures and sufficient knowledge to circumvent individual financial difficulties, which may impede effective management and maintenance. This requires the provision of information with regards to energy options and the facilitation in building appropriate community management structures. Diverting developers' investments from on-site renewables to a community scale low/zero carbon energy production, which may be owned by the community, may provide a degree of energy security. District scale plants require a magnitude of initial investments and, more importantly, appropriate maintenance which is beyond the financial reach of single communities, whereas local authorities have sufficient means and structure. However, the role and power of local governments may change in the future, particularly in a MF and FW scenario, and they may not be in the position to represent communities' interests effectively.

6.1.4 – Further findings

A parallel outcome of the resilience analysis consists in the identification of the synergies and conflicts amongst the sustainability solutions appraised. Their evaluation against scenarios facilitates an integrated approach, in which the entire spectrum of implications of their implementation is examined. This section intends to illustrate some of the points of discussion arisen in the unfolding of the analysis to demonstrate the richness of reasoning that it can trigger. For example, the embankments have been identified as a local feature that, if retained and protected, can provide a degree of resilience to benefits yielded through 'orientation and maximised natural light'. This leads to view the embankments as a physical element that if correctly enhanced can provide character and individuality to the place, as well as visual links, and a pleasant environment for pedestrian and cycling use, which is one of the stated objectives of the PSG4. More importantly, the landscaping of the embankments can have an influence on the microclimate of the place. This, in turn, can have an impact on the air temperature by raising local humidity through evapotranspiration and hence counteracting the urban heat island (UHI) effect (Von Borcke, 2009), and creating sunnier, warmer spaces in winter and cooler spaces in summer (Ritchie and Thomas, 2009). Mitigation of the UHI effect is much needed since higher urban temperatures represent a health hazard especially for some classes of the population at health risk (Zaharan et al., 2008), and has a direct impact on the energy demand in summer. The landscaping of the embankments, however, requires an adequate tree selection for the purpose of attracting birds and insects (Ritchie and Thomas, 2009). Deciduous trees can provide helpful shade in summer and let the sun through in winter. However, should those species not be compatible with required biodiversity outcomes, shading devices integrated in the building envelopes can effectively deflect sun rays in summer, and natural ventilation strategies can provide indoor cooling.

In order to maintain the benefits of the microclimate either in the form of cooling or heating, 'local ventilation rates need to be minimised' (Littelefair, 2000). Appropriate site layout can harness air velocity through street canyons. Building heights and widths, as well as the density of the urban canopy, have an impact on wind speeds and air pollution. However there could be a conflict between the objective of cooling through microclimate and the objective of reducing pollutant concentration, which is achieved by increasing local ventilation. Also, as car emissions substantially contribute to the local air quality, it is important to consider that sites with low traffic density are generally cooler, and beneficial effects related to microclimate may be offset by high levels of traffic (Littlefair, 2000). Therefore, sustainability solutions for maximised solar gains and microclimate need to be examined together with transportation policies aiming at reduced car use. Generally, there seems to be little consideration given in planning guidance on local microclimate, which is strictly linked to the shape of the built environment (see Ratti et al., 2005), and the provision and arrangement of green spaces (see Coburn, 2009). Still, if these links are not considered when developing planning guidance, the application of sustainability solutions may trigger unintended consequences.

The urban density[1], and related spatial configuration, of the site can also have consequences on the solar access. Littlefair (2000) maintains that densities above 40 dwellings per hectare may not allow full solar access for every house. This limitation may be overcome through design strategies. For instance, a small, medium-rise block of flats has the advantage of a lower land use compared to single houses, thus giving the opportunity to free more space in between buildings. Consequently higher densities may be achieved with appropriate building typologies, and without causing excessive overshadowing. High densities may engender a negative perception of the 'social density' of the place, namely the number of people within the same space (Zaharan et al., 2008). However, good design can create attractive environments that ultimately overcome drawbacks related to such a negative perception, hence local characteristics (the embankments, the mills) that persist in the collective memory of citizens can play an important role in creating a high quality environment.

Finally, while considering user behaviour and alternative forms of community energy generation, it should be noted that many experiments of community involvement to explore alternative pathways to energy use have been carried out. For example, Low Carb Lane, an initiative undertaken within the DOTT 2007[2] programme, set up a non-profit energy utility for a low-income community in North West England, aimed at buying energy in bulk cheaper than the market rate, selling it at market prices (as cheaper energy would not encourage energy saving within the community) and reinvesting profits for community purposes (Thackara, 2007). Houghton (2005) suggests that community energy utilities can lead to a reduced energy demand, and an improvement of the efficiency of the building stock and the related operations, since local power stations may not have the capacity to meet excessive, unsustainable energy consumption. Furthermore such utilities may create local jobs (one of the stated aims of regeneration processes), and profits generated can be reinvested in maintenance. In London, St. Pancras Housing, a housing association, installed and took ownership of a CHP unit serving 95 dwellings, which produces an income stream of £45,000 p.a. that pays for the unit (Houghton, 2005). Local authorities can be important agents to provide knowledge and know-how as well as foster a form of self-governance which may counter potential vulnerabilities of current energy production and supply systems. Within the process of consultation, community energy strategies could be discussed and community structures and permanent fora could be established.

6.2 – Birmingham, Masshouse regeneration case study

6.2.1 – Site conditions

The second case study is very different from the previous one, in that it is developed on a regeneration scheme at an advanced design stage. Energy efficiency is still the focus of analysis, and some of the conclusions reached here are very similar to those resulting from the Luneside East case study. Nevertheless this is not a repetition. The design documents

[1] The term *density* herein used refers to is a term that represents' the relationship between a given physical area and the number of people who inhabit or use that area' (Zaharan *et al*, 2008)

[2] Design of The Time 2007 was a year of community projects, events and exhibitions based in North West England, explored what life in a sustainable region could be like – and how design can help us get there (Thackara, 2007)

allow a greater detail of examination, and energy efficiency is measured on a digital model of the design scheme. Design statements show no particular ambition to deliver buildings exceeding mandatory standards of energy efficiency. Therefore the analysis looks at the building performance in relationship to the well known measures for energy efficiency that are embedded in national planning policies and best practice (discussed in sections 6.1.2 and 6.1.3) and highlights the future consequences of ignoring them. Finally, this case study also shows the importance of the context. Recommendations resulting from the analysis may be similar to other cases, but ultimately they apply differently because of the peculiar conditions of the context and the way the design scheme responds to it.

Site description - Masshouse is a 1.8 hectares site, part of the ambitious 130 hectares regeneration project of Eastside, a dismissed industrial area adjacent to Birmingham city centre. In the initial Masshouse Design Statement approved by the city council, sustainability is delivered through the mixed-use nature of the development, as well as its connectedness through public transportation and provision of pedestrian access, whereas there is no mention of particular measures concerning sustainable buildings (GVA Grimley, 2002). Ground floors overlooking the open spaces enclosed between buildings host shops and restaurants, contributing to attract people and create a thriving public realm. The latest master plan drafted in 2003 proposes a series of high density/high rise buildings on two plots, totalling 20,000m^2 of residential space, and 80,000m^2 of commercial space. The delivery of 520 dwelling units is also proposed, for a density which exceeds average recommendations for inner city (see Llewelyn – Davies, 2000). The development has not progressed on site as originally planned, and to date only a small part of it has been constructed. The range of dwelling types in the buildings already delivered is overwhelmingly composed of studio, one, and two bedroom flats. This design choice limits the variety of household composition, which may result mainly of singles and couples. The future of the project is unclear, but for the purpose of this analysis the original approved master plan is evaluated. The masterplan of Masshouse that received planning approval is represented in Figure 12.

The design statement shows that no particular energy efficiency benchmark was established for the scheme, thus suggesting that only mandatory targets would be adopted during construction (i.e. Building Regulations valid at the time of planning approval). Nevertheless, as the analysis focuses on the long-term, the attempt is to identify what could be the consequences of adopting relatively modest, mandatory energy efficiency targets, as well as omitting to consider other options promoted in planning policy and best practice, in the light of a future where scarcity of resources could require higher efficiencies, and make them mandatory. The development as proposed in planning application was modelled with an environmental software (Integrated Environmental Solutions – IES), and levels of daylighting in terms of Vertical Sky Component (VSC), and of sun access in terms of Winter Possible Sunlight Hours (WPSH), were measured (see Figure 13 and 14). The relevance of these energy strategies and where they sit within the planning framework has been discussed in the section 6.1.2.

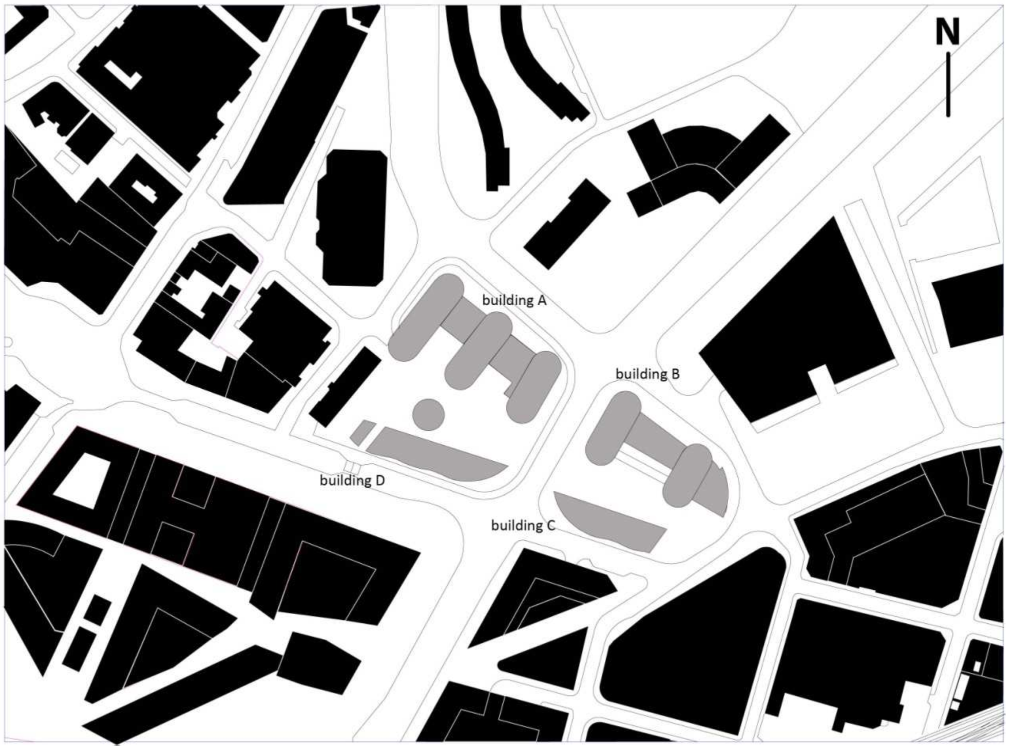

Figure 12 – Masterplan of Masshouse

Figure 13 – IES model of Masshouse for measuring direct sun access through Winter Possible Sunlight Hours

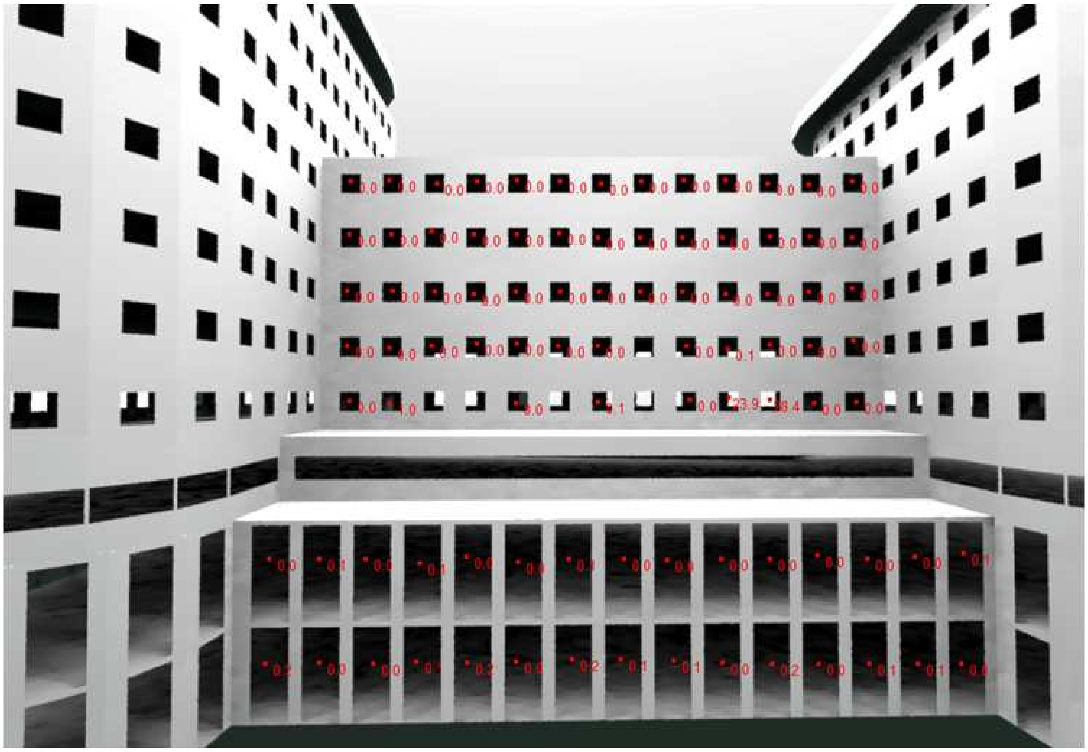

Figure 14 – IES model of Masshouse for measuring quality of daylighting through the Vertical Sky Component

The resilience analysis that follows is exposed in a leaner form than the previous one, since solutions, related benefits, and necessary conditions for their functionality are the same. Instead, the contextual application of the energy efficiency strategies is discussed, followed by one concerning the results of the analysis. Table 13 also summarises the results of the IES environmental appraisal of the design scheme. The resilience analysis is developed on the basis of these results, and it is summarised in the tables 14 and 15 (step three and four).

	WPSH	**VSC**
Building A	0.20	26.00%
Building B	0.24	27.00%
Building C	0.16	24.00%
Building D	0.28	24.00%
Average	0.22	25.25%

Table 13 - Average of VSC and WSPH measured on digital IES model of Masshouse

Necessary conditions	NSP	PR	MF	FW
Orientation (solar gains) (Masshouse performance = 22% WPSH)				
Daylighting (Masshouse performance = 25% VSC)				
Protection from overshadowing	The application of design principles for the maximisation of solar gains and daylighting are required for any new development and legislation is in place to protect the right-to-light. Nevertheless the performance of Masshouse in terms of daylighting and sun access is much lower than the mandatory target and the development is considered for demolition	The application of design principles for the maximisation of solar gains and daylighting are required for any new development and legislation is in place to protect the right-to-light. Nevertheless the performance of Masshouse in terms of daylighting and sun access is much lower than the mandatory target and the development could be considered fo expensive upgrading	Planning policy is deregulated and there is no protection against overshadowing. Nevertheless, high densities and profile of Masshouse are compatible with characteristics of this scenario	The rich may be willing to protect the right to light for the amenity of the place. However, since Masshouse has a limited amount of daylight and sun access the place is not considered of sufficient quality. The poor cannot protect the place from further overshadowing. The nature of the development makes it suitable for the poor and undesirable for the rich.
Building maintenance	Maintenance is carried out regularly	Maintenance is carried out regularly	Maintenance is carried out regularly only by those who can afford it	Maintenance is carried out regularly only by those who can afford it
User behaviour	Responsible behaviour ensures that energy savings are maintained over the life cycle of the development.	Occupiers resist change since the environment is not a priority in their value system	Environmental amelioration is far from being a priority in society. People behave accordingly	Environmental amelioration is not a priority of the rich. The poor, by necessity, behave thriftily
Building envelope - U values as per BR 2010				
Building maintenance	Maintenance is regularly carried out. However, since tight U-values are made mandatory, Masshouse is considered for costly upgrading or demolition.	Maintenance is regularly carried out. Mandatory U-values are very tight. Masshouse is considered for a costly upgrading	Minor maintenance is often carried out Planning policy is deregulated, nevertheless property values on the market are determined by the quality of the development	The rich appreciate old building stock constructed with high building fabric specifications and so the poor, since this implies lower operational costs. Nevertheless the poor struggle to carry out regular maintenance
On-site energy generation - N/A				
Replacement of components and/or maintenance	The configuration of the development does not allow much onsite energy generation	The configuration of the development does not allow much onsite energy generation	The configuration of the development does not allow much onsite energy generation	The configuration of the development does not allow much onsite energy generation

Table 14 - Step three of the resilience analysis of Masshouse. The colour of text indicates the analysis result as for the previous case study

Energy strategy	NSP	PR	MF	FW	
Solar gains and daylighting	Vulnerable	Vulnerable	Resilient	Maybe resilient	Sunlight and daylight are insufficient. A more resilient development would need at least a good level of daylighting for lower floors and open spaces. However, risk of future overshadowing should be dealt with
Efficient building fabric	Vulnerable	Vulnerable	Resilient	Maybe resilient	It is advisable to greatly exceed in current mandatory targets, since this solution is potentially more resilient than all other energy strategies
On-site energy generation	N/A	N/A	N/A	N/A	N/A

Table 15 - Step four of the resilience analysis of Masshuse. The colour of text indicates the analysis result as for the previous case study

6.2.2 – Resilience Analysis

Solar gains - Masshouse was designed to represent a gateway to the city centre, with building heights offering a strong and visible edge from the distance, and thriving public spaces enclosed within the buildings (Birmingham City Council, 2006). The south front of the development faces plots which are earmarked for future development, and on which building design follows similar high rise configurations (see www.eastside.co.uk). These have been modelled in the digital model, based on the approved planning application. Sun access measured on all East-South-West windows reported in the Table 13 as a total average exceeds the CIBSE benchmark (5% WPSH), although, as noted before, this benchmark is too modest to apply to solar gains. These, in order to contribute to a space heating reduction, would require a higher percentage of winter sun hours. Performance reported on the table 13 (22% WPSH) is calculated as an average of the five Massohouse buildings. This quantification is however misleading since the 'insolation' rate is very erratic, with top floors receiving excessive sunlight and raising the mean value. The examination of the tables of hours of the day, and months of the year, of sun exposure for each window of the Masshouse residential buildings shows some important issues. First, there is a great disparity of sun exposure across the building and across each floor. For example, the table 16 shows the sun exposure on some windows at the sixth floor, which is the middle one of the two residential buildings. In particular, the windows selected are those at the extremities and at the centre of the building. One has no sun exposure over the year (see table 15f), others have limited (15a; 16c), or sufficient (16b); or excellent exposures (16d and 16e). This suggests that the building design did not sufficiently considered the contextual physical environment (i.e. surrounding buildings and their profiles), possibly because orientation and solar gains were not a design priority.

Table 16 - The tables show the sun exposure over the year of three windows at the sixth floor of the two Masshouse residential buildings.15a, 15b, and 15c show the sun exposure of three windows (center and both extremities) of the building C. Similarly 15d, 15e, and 15f show the correspondent windows of the building

Month	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00
Jan						100	100	0	0	0	0	0	0				
Feb					0	100	100	0	0	0	0	0	0	0			
Mar				0	0	100	100	0	0	0	0	0	0	19.6	0		
Apr			0	0	0	91.8	100	0	0	0	0	0	0	100	0	100	
May		0	0	0	0	0	100	0	0	0	0	0	100	100	100	0	
Jun	0	0	0	0	0	0	100	100	0	0	0	0	100	100	100	0	0
Jul		0	0	0	0	0	100	99.4	0	0	0	0	61.7	100	100	0	0
Aug			0	0	0	100	100	0	0	0	0	0	0	100	0	100	
Sep				0	0	100	100	0	0	0	0	0	0	0			
Oct				0	100	100	36.1	0	0	0	0	0	0				
Nov					100	100	0	0	0	0	0	0					
Dec						100	23.1	0	0	0	0	0					

Table 16a - Sixth floor south-facing window at the left hand side

Month	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00
Jan						100	100	100	100	100	0	0	0				
Feb					100	100	100	100	100	100	0	0	0	0			
Mar				0.1	100	100	100	100	100	100	0	0	0	0	0		
Apr			0	0	0	100	100	100	100	28.2	0	0	0	0	0	100	
May		0	0	0	0	100	100	100	100	0	0	0	0	0	100	0	
Jun	0	0	0	0	0	100	100	100	100	0	0	0	0	100	100	0	0
Jul		0	0	0	0	100	100	100	100	20.3	0	0	0	0	100	0	0
Aug			0	0	0	100	100	100	100	55.6	0	0	0	0	100	100	
Sep				0	100	100	100	100	100	49.7	0	0	0	0			
Oct				0.7	100	100	100	100	100	57.5	0	0	0				
Nov					55.3	100	100	100	100	100	0	0					
Dec						100	100	100	100	100	0	0					

Table 16b - Sixth floor south-facing window at the centre

Month	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00
Jan						100	100	96.3	80.1	54.8	0	0	0				
Feb					100	100	92.9	74.7	49.9	8.3	0	0	0	0			
Mar				100	99.7	85.6	66.2	41	6.1	0	0	0	0	0	0		
Apr			100	92.7	74.3	54.3	29	2.6	0	0	0	0	0	0	0	0	
May		100	86.9	68.9	50.3	27.7	4.4	0	0	0	0	0	0	0	0	0	
Jun	72.3	95.7	76.8	59.8	41.3	18.2	1.3	0	0	0	0	0	0	0	0	0	0
Jul		100	88.9	70.8	52.5	30.7	6.5	0	0	0	0	0	0	0	0	0	0
Aug			100	93.4	75.1	55.2	30.3	3.3	0	0	0	0	0	0	0	0	
Sep				100	97.3	80.4	59.8	31.8	0.9	0	0	0	0	0			
Oct				8.8	100	99.3	85.5	65.2	34.1	0	0	0	0				
Nov					41.3	100	100	91.3	72.7	39.8	0	0					
Dec						100	100	99.5	87.9	67	0	0					

Table 16c - Sixth floor south-facing window at the right hand side

Month	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00
Jan						0	0	0	0	0	0	0	0				
Feb					0	0	0	0	0	0	0	0	0	0			
Mar				0	0	0	0	0	0	0	0	0	0	0	0		
Apr			0	0	0	0	0	0	0	0	0	0	0	30.8	0	0	
May		0	0	0	0	0	0	0	0	0	0	0	0	1.4	0	0	
Jun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jul		0	0	0	0	0	0	0	0	0	0	0	0	1.5	0	0	0
Aug			0	0	0	0	0	0	0	0	0	0	0	25.1	0	0	
Sep				0	0	0	0	0	0	0	0	0	0	0			
Oct				0	0	0	0	0	0	0	0	0	0				
Nov					0	0	0	0	0	0	0	0					
Dec						0	0	0	0	0	0	0					

Table 16d - Sixth floor south-facing window at the left hand side

Month	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00
Jan						0	0	100	0	0	0	0	0				
Feb					0	0	1.2	100	100	100	14.1	0	0	0			
Mar				0	0	0	100	100	100	100	100	100	100	0	0		
Apr			0	0	0	100	100	100	100	100	100	100	100	0	100	10.4	
May		0	0	0	0	0	100	100	100	100	100	100	100	100	100	0	
Jun	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	0	0
Jul		0	0	0	0	0	100	100	100	100	100	100	100	100	100	0	0
Aug			0	0	0	0	100	100	100	100	100	100	100	0	100	46	
Sep				0	0	100	100	100	100	100	100	100	40.7	0			
Oct				0	0	0	100	100	100	98.4	0	0	0				
Nov					0	0	0	100	0	0	0	0					
Dec						0	0	100	0	0	0	0					

Table 16e - Sixth floor south-facing window at the centre

Month	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00
Jan						0	0	0	2	100	100	0	0				
Feb					100	0	0	0	100	100	100	0	0	0			
Mar				0	0	0	0	100	100	100	100	100	100	0	0		
Apr			0	100	100	100	100	100	100	100	100	100	100	83.3	0	0	
May		0	0	0	100	100	100	100	100	100	100	100	100	100	0	0	
Jun	0	0	0	0	100	100	100	100	100	100	100	100	100	100	0	0	0
Jul		0	0	0	100	100	100	100	100	100	100	100	100	100	0	0	0
Aug			0	31.5	100	100	100	100	100	100	100	100	100	100	0	0	
Sep				0	100	0	0	100	100	100	100	100	100	0			
Oct				0	100	0	0	68.9	100	100	0	0	0				
Nov					0	0	0	0	100	100	100	0					
Dec						0	0	0	0	100	100	0					

Table 16f - Sixth floor south-facing window at the right hand side

Second, the majority of the south facing windows of the lower eight floors receives sun in hours and months that are not relevant for the purpose of reducing space heat demand. The Winter Possible Sun Hours benchmark measures sun access as an average over the five winter months. It therefore allows the most unfavourable hours to be included in the calculation (e.g. early hours in March as opposed to mid-day hours in January). For example, in winter months the sun reaches some windows on the sixth floor (see table 15a; 15c; 15e) only for one to three hours, predominantly in the first part of the day, when the sun has reduced heating capacity. Nonetheless this is sufficient to attain the CIBSE benchmark. Such a benchmark, as mentioned before, measures the capacity of a place to be healthy and enjoyable because reached by direct sun. Still, it is difficult to deem a room pleasurable if reached by the direct sun only two hours a day. Understandably, performance of windows below the sixth floor is inferior. Many of the windows of the first three floors of all buildings do not even attain the CIBSE benchmark, with only floors above the ninth receiving more than 15 percent WPSH. Moreover, all windows above the tenth floor are overheated in summer, with possible consequent increase in energy demand for air conditioning. Finally, it must be noted that the layout of the dwelling units in both buildings is such that these face either only north or only south. Thus half of the dwellings have almost no direct sun access (see figure 15).

Figure 15 –Typical floor plan of one of the two residential buildings in Masshouse (source:www.masshouse.co.uk)

Daylighting - Natural light penetration as an average is below the minimum quantity suggested in British Standards, with only top floors exceeding the minimum benchmark of 27% Vertical Sky Component (VSC). Figure 16 shows diagrams of average VSC per floor of one of the two office buildings on the north side of the site. Their masses and profiles are complex, with parallel towers in close vicinity connected by a transversal wing. This particular articulation impedes natural light penetration where buildings join, or where towers closely face each other. Open spaces, since enclosed amongst tall buildings, often lack direct sunlight or even sufficient daylight. This should be an essential requirement for enjoying open, public spaces, which is one of the stated ambitions of this scheme. The impression is that, similarly to the sun access, natural daylight penetration was not sufficiently considered in developing the design scheme. It must be noted, however, that the very decision to attain so high a building density and heights strongly limits the design alternatives for energy efficiency through solar gains and daylighting. In addition, the objective of delivering a landmark to the city has originated here building forms that impede even further sun and light access.

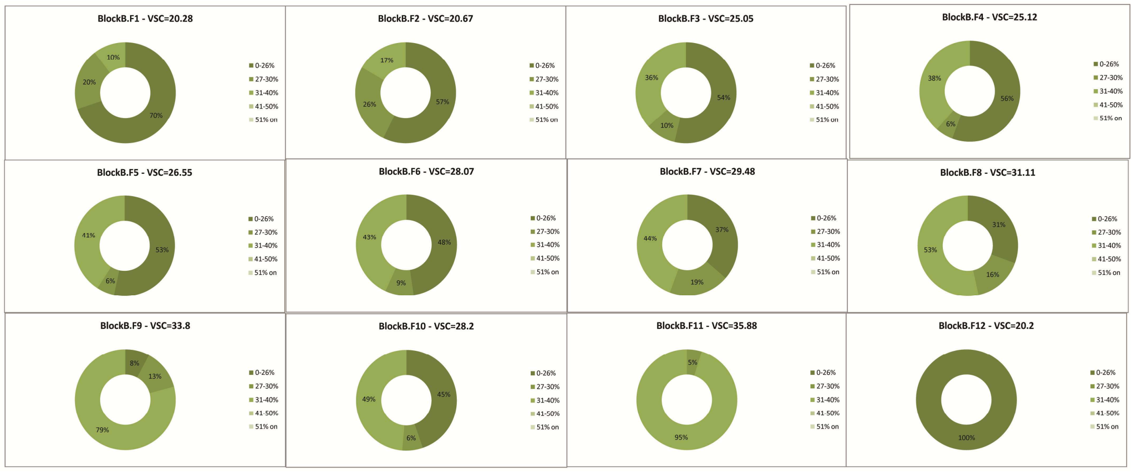

Figure 16 – Diagrams of VSC per floor of the building B in Masshouse

Similarly to the previous case study, in NSP and in PR conditions necessary for the delivery of the performance as designed are largely met, although in PR responsible behaviour of users is generally lacking, thus hindering efforts to reduce energy use through regulation. However, Masshouse is designed to very low performance. In both scenarios the development is therefore regarded as underperforming and non-compliant to the tight mandatory energy targets. It is difficult to see how such a densely built scheme can be upgraded so as to meet those without costly interventions, thus making it likely to be replaced after only forty years from its construction, even if this implies an evident waste of resources. In MF and FW, instead, Masshouse is not demolished on environmental grounds, since these are not a priority in society and policy. However, the paucity of sun access, the high dwelling density, and reduced amount of public spaces are such that the place can be perceived as one of a lesser quality. In MF this results in a place with a high concentration of low income households, or of students, since neighbouring buildings to the North of the site are predominantly schools and universities. It is therefore unlikely that a community can be formed under these circumstances; it is instead likely that the market value of the development can rapidly diminish. Similarly, in FW, the place is inhabited by the poor with the same consequences on its market value described in MF.

To prevent the vulnerabilities discussed above, the regeneration scheme should be designed at higher levels of performance. This requires a design approach that merges energy efficiency requirements with the built form and the spatial quality of the place, thus operating on building footprints, profiles, and heights so as to strike a balance between environmental and aesthetic parameters. Energy efficiency thus becomes a ‘regulating’ factor that helps moderate building densities and, in doing so, facilitate a sufficient provision of quality open space (with less built area), different building typologies (with all dwellings designed to have a south-facing side), and a different approach in designing urban landmarks that does not necessarily impairs the sustainable functioning of adjacent buildings and spaces.

Building fabric – It is rather surprising that, with an emphasis of the design statement on sustainability, the energy performance of the buildings is largely ignored. Still, design statements do not provide information and make no commitment on this issue. Thus the development, as with the two buildings already constructed, only complies with the minimum standards of Building Regulations. The resilience analysis is inevitably similar to the previous one on this issue. In NSP and PR mandatory requirements for building insulation are very tight, Old building stock not complying with these is retrofitted or demolished if the first option is financially unviable. In MF, inefficient building stock that can offer limited thermal comfort is predominantly occupied by low-income groups, since medium-to-high income groups can effort higher rents and more efficient properties. In FW, dwellings are occupied by the poor and offices rented to small and minor businesses. Concluding, it must be once again reiterated that a higher initial investment on the building fabric can not only provide long-term (and resilient) energy savings, but also contribute to a perception of good quality of the development to future generations.

On-site energy generation - It is important to note that the Masshouse site is unfit for producing any on-site energy because of its location and building density. Such a condition only makes it more pressing to rely on other strategies for attaining the carbon reduction to which on-site generation could have contributed. This only reinforces the need to exceed minimal mandatory requirements to make the development resilient.

6.2.3 – Further findings

As with the previous case study, some issues that emerged in developing the analysis are elaborated to further demonstrate the power of the process. Masshouse was designed with a limited variety of dwelling types, relatively small in size, presumably targeting predominantly occupants that work in the city centre and privilege vicinity to jobs and play, thus singles and couples rather than larger households. In doing so, the development does not attempt to attract a wide range of households, let alone of income groups, which would facilitate the formation of a varied community. It is therefore unsurprising that in its present design, it does not comply with the best practice recommendation for urban development to substantially diversify the provision in terms of types and tenures (Llewelyn – Davies, 2000). The paucity of adjacent open spaces suitable for families and children supports the assumption that Masshouse was designed for a specific small group of occupiers. In turn, such a shortcoming supports the expectation of a limited capacity for future adaptation, reinforced by the evident rigidity of the Masshouse spatial configuration.

The dwelling density of Masshouse is 290 dph. This indicator is above the top range of the benchmark established for an urban context by the Urban Design Compendium (160-275 dph). The high number of units, together with the substantial amount of commercial space proposed, contributes to deliver a very dense urban environment which, as the resilience analysis demonstrates, represents an element leading in some scenarios to the future depreciation of the development. For this purpose, lower densities may be considered. Although this implies lower short-term returns for the investment, it can enhance the long-term good quality of Masshouse in terms of liveability and possibly energy efficiency. It must be stressed here that environmental considerations meet at a higher level, social and economic ones. In other words, the process of privileging environmental parameters to drive the design strategy enables conclusions to be reached that may seem obvious but, although embedded in best practice, ore often ignored to give precedence to aesthetic (i.e. the creation of urban landmarks) and economic ones (i.e. maximisation of financial returns through densities exceeding benchmarks). The resilience analysis unearths such tensions and shows the convergence of energy efficiency with balanced densities and a more liveable composition of the urban space.

Finally, it must be noted that the analysis can be used both as an appraisal system and a design tool. Once an initial analysis is developed, and the conclusions are used for modifying the initial strategy, this can be reappraised to ensure finding ulterior vulnerabilities. In addition, different approaches can be explored to determine the most advantageous outcome for all stakeholders. For example, the option of attaining energy target predominantly through passive solar principles as opposed to building insulation can be compared considering consequences on investments, long-term property values, quality of spaces etc. The unfolding of this exercise generates a range of possible arrangements, each one corresponding to an array of advantages and disadvantages. Depending on the objectives dictated by planning priorities, it will be possible to take an informed decision, in the full awareness of long-term consequences of the options evaluated.

6.3 – Case study in North Yorkshire

6.3.1 Site conditions

The third case study is on a commercial development of about 14,000 m^2 comprising retail spaces, cafes and restaurants, a hotel, and a cinema theatre. The development' s ambition is to kick off the regeneration of the centre of a North Yorkshire town with a population of 18,500. Although rather small this town provides much employment in the area, competing with more important and large cities nearby. The development is located on an urban site adjacent to the current high street, considered outdated and unattractive by the inhabitants of the town and of the region. About 75% of the development is used as retail space. Retail units are rectangular, grouped in two blocks, and sized between 900 to 1,300 m^2. The footprint of most of the units is narrow and long. In order to form the blocks, they are joined on the long side, with only the short side provided with windows. Because of the site layout, most of them are oriented with the longer side laying approximately on the East-West axis, therefore with minimum direct sun access (see Figure 17). The developer's business model is to retain ownership of the development and rent commercial spaces. The development is earmarked for the BREEAM Excellent rating, and its energy efficiency strategies reflect the rating code requirements with a commitment to reduce energy use also through building insulation. Green Leases may possibly ensure that tenants, with internal fit-outs and artificial lighting equipment, comply with the overall development energy and resource efficiency goals. In addition to the measures required for the attainment of the rating, the energy strategy includes daylighting, and passive heating and cooling, thus showing ambitions of best practice that go beyond conventional design and construction approaches. As for the other case studies, the design statement is critically evaluated in its validity against the contextual conditions, and subsequently in its long-term effectiveness.

6.3.2 Resilience analysis

Table 16 summarises the key points that characterise the environmental strategy of this commercial development (step one of the UF method). As for the previous case studies strategies for energy efficiency are a stepping-stone to examining the broader context and all the factors that may undermine their future effectiveness. These are discussed in the following sub-section (step two of the UF method). A list of conditions and their assessment is summarised in Table 17. However, for the sake of brevity and because some of them have been treated at length previously, only a few conditions are discussed here in depth. Finally conclusions and recommendations are provided in Table 18 and 19 that can enable decision-makers, whenever appropriate, to modify and strengthen initial strategies (step four and five). Findings of the resilience analysis are presented contextually to each sub-section under the headline 'recommendations' (step five of the UF method).

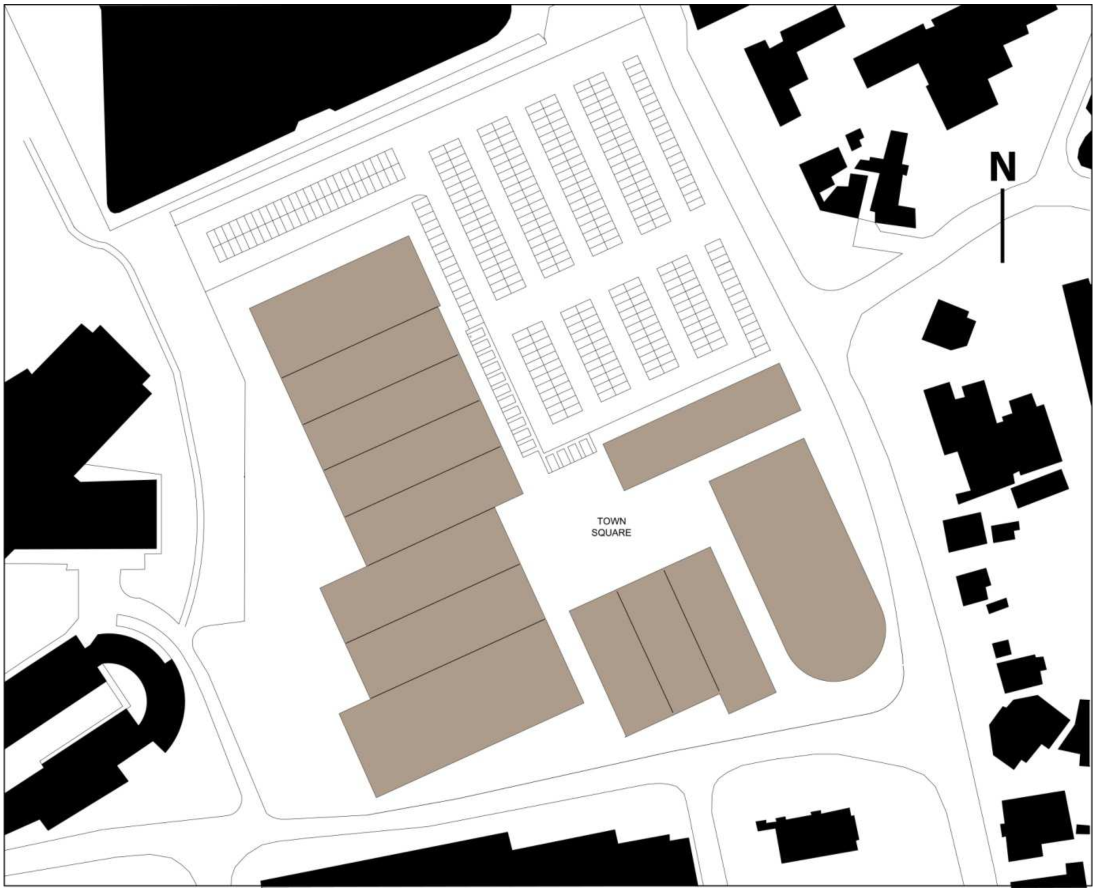

Figure 17 – Masterplan of the commercial development in North Yorkshire

Energy strategy for commercial development (rating BREEAM Excellent)		benefits
Building fabric	U-values exceeding the requirement of Building Regulations. (25% on BR TER – required for BREEAM Excellent)	Reduction of energy use
Daylighting	No performance target specified	
Passive heating	Solar gains through orientation/thermal mass - No performance target specified	
Passive cooling	Natural ventilation utilising prevailing wind	
Renewables	On-site generation meeting 10% energy requirements	

Table 17 – Energy strategy planned for the commercial development in North Yorkshire

Necessary conditions	NSP	PR	MF	FW
Building fabric				
Maintenance	Building components and services maintenance is regularly carried out. However, tight standards are in place. Building stock failing to comply with them is retrofitted or demolished	Building components and services maintenance is regularly carried out. However, tight standards are in place. Building stock failing to comply with them is retrofitted or demolished	Building components and services maintenance is generally carried out. Planning policies are deregulated. Old buildings are kept in use as long as they meet market demand	Basic building components and services maintenance is generally carried out even by the poor. Planning policies are deregulated. The rich keep old buildings in use as long as their perceived quality is high. The poor do not have a choice
Daylighting				
Overshadowing	Right-to-light regulation is in place	Right-to-light regulation is in place	No protection against future development overshadowing existing buildings	Within the enclaves, buildings are well protected against overshadowing. Outside, there is no protection
Light reaching building core	Buildings are not designed to maximise daylight	Buildings are not designed to maximise daylight	Buildings are not designed to maximise daylight. However, daylighting is not regarded as essential for retail spaces	Buildings are not designed to maximise daylight. However, daylighting is not regarded as essential for retail spaces in the enclaves. Outside, the poor cannot afford major restructuring
User behaviour	Artificial light is used only when strictly necessary	Artificial light is used only when necessary because of regulation	No restriction on the use of artificial light	No restriction on the use of artificial light, although the poor use it thriftily out of necessity
Passive heating				
Overshadowing	Right-to-light regulation is in place	Right-to-light regulation is in place	No protection against future development overshadowing	Within the enclaves, buildings are well protected against overshadowing. Outside, there is no protection
Direct sun reaching building core	Buildings are not designed to maximise solar gains	Buildings are not designed to maximise solar gains	Buildings are not designed to maximise solar gains. However, direct sun is not regarded as essential for retail spaces	Buildings are not designed to maximise solar gains. However, direct sun is not regarded as essential for retail spaces in the enclaves. Outside, the poor cannot afford major restructuring
User behaviour	Space heating is used only when strictly necessary	Space heating is used moderately because of regulation	No restriction on the use of space heating	No restriction on the use of space heating, although the poor use it thriftily out of necessity
Passive cooling				
Air ways protected in future building reconfigurations	Building renovation is always carried out so as to retain energy saving features	Building renovation is carried out so as to retain energy saving features because of regulation	No particular attention to retaining energy saving features when renovating buildings	No particular attention to retaining energy saving features when renovating buildings
User behaviour	Cooling is used only when strictly necessary	Cooling is used moderately because of regulation	No restriction on the use of cooling	No restriction on the use of cooling, although the poor use it thriftily out of necessity
Renewables				
Maintenance / Components' replacement;	Renewable generation units are always retained and maintained as long as considered effective. Possibly other forms of generation are more suitable to this development.	Renewable generation units are always retained and maintained as long as considered effective. Possibly other forms of generation are more suitable to this development.	Renewable generation units are seldom retained, especially by those who cannot afford maintenance.	Renewable generation units are sometimes retained by the rich, whilst the poor cannot afford maintenance

*Table 18 – Resilience analysis: assessment of necessary conditions (step three of the UF method). The colour of the text indicates that the energy strategy is: **green** – supported; **orange** – maybe supported; **red** – not supported*

Energy strategy	NSP	PR	MF	FW	
Building fabric	Not resilient because of low U levels	Not resilient because of low U levels	Resilient	Resilient only if the perceived quality of buildings is high	Build with higher levels of building insulation
Daylighting	Not resilient because buildings are not designed to maximise daylighting.	Not resilient because buildings are not designed to maximise daylighting.	Resilient	Resilient	Change configuration or design to allow maximum flexibility
Passive heating	Not resilient because buildings are not designed to maximise daylighting.	Not resilient because buildings are not designed to maximise daylighting.	Resilient	Resilient	Change configuration or design to allow maximum flexibility
Passive cooling	Resilient	Resilient	Not resilient	Not resilient	Protect building features that allow cross ventilation
Renewables	Resilient if effective	Resilient if effective	Not resilient	Resilient for the rich but not for the poor	Other technologies and arrangements may be more resilient than micro-generation

Table 19 – Resilience analysis: final appraisal for each solution (step four of the UF method). The colour of the text indicates that the energy strategy is: ***green*** *– supported;* ***orange*** *– maybe supported;* ***red*** *– not supported*

Building fabric **–** In the BREEAM, the majority of assessment elements is 'tradable' (BRE, 2011). This gives the possibility to select amongst the 48 elements listed those that are more convenient to attaining the intended score. Nevertheless some mandatory minimum performances are required. For example, as far as energy and related CO_2 emissions are concerned, the Excellent rating requires a 25% performance improvement on the building's mandatory Target Emission Rate (TER) as defined in the Building Regulations (BR). There are many factors concurring to the final TER, amongst which building insulation. BR 2010 Part L2A provides a minimum mandatory compliance performance (i.e. limiting building fabric) with the caveat that 'in general, achievement of the TER is likely to require better fabric performance' (BR, 2010) than the mandatory minimum. There is thus leeway for designers and developers in determining the extent to which factors can contribute to attain the 25% TER performance improvement. For example, efforts could focus on energy efficient production of hot water and fixed lighting systems, which are the other two concurring factors. In short, because of the built-in flexibility of the rating system, compliance is possible with only modest improvements to the mandatory thermal transmittance target.

The resilience analysis demonstrates once again that investing on a building fabric that greatly exceeds current Building Regulations' mandatory requirements is a robust strategy. This conclusion has been repeatedly inferred in the course of each of the previous case study thus reinforcing its validity. High performance building fabric can deliver a sustained performance over the lifetime of the development with little maintenance investments. In this light, and considering that all the other energy efficiency options currently planned present many vulnerable factors, it is advisable to invest in tighter levels of building insulation than the ones seemingly necessary for attaining the BREEAM Excellent rating.

Recommendations

- Build to levels of building insulation higher than those required for attaining the BREEAM Excellent rating.

Daylighting – One of the development's design objectives is to provide natural light penetration to 'primary customer zones'. It is unclear, however, if this strategy can deliver energy savings. Retail and restaurant/café spaces, which in this scheme are approximately 75% of the built area, are traditionally relying on artificial light to maintain constant lighting levels in working hours and optimise merchandise colour enhancement. Notwithstanding the actual necessity for natural lighting, the building form of the typical retail unit as currently designed does not allow sufficient lighting levels at the core of interior spaces. Moreover some of the units cannot receive sufficient natural light because in close proximity with other buildings. In some scenarios, size and use of these retail units as currently planned do not meet social and business needs. For example, in NSP (and to an extent in PR), retail patterns are very different from today. In order to reduce car circulation, create local jobs, and support local communities, policies are in place that protect small and local businesses and enterprises. Live/work spaces are in high demand together with small laboratories for handicraft production and sale. These, rather than large retail spaces, compose the new retail landscape. Likewise, in FW, if the development is located out of the rich enclaves, retail units are adapted to dramatically reduced patterns of consumption, since the poor spend only on essential commodities. In these scenarios, the long-term functioning of the commercial development requires high levels of flexibility to reduce the unit size, divide single large units in multiple ones, and, either for environmental awareness or necessity, maximise natural light penetration to all the new small-to-medium units. Given their current particular building form, this could be attained through appropriate interior layout and the creation, for example, of light wells. Clearly, flexibility to changes entails careful consideration at a design stage so as to provide a building structure that allows a variety of future configurations that meet substantially different requirements than those informing the current masterplan. Hence, if natural light penetration is regarded as part of the strategy for environmental efficiency, this must be complemented with building flexibility. For this purpose, building structures must be designed as structural frames (as opposed to bearing walls), since these can allow fast and relatively inexpensive restructuring. Structural frames must also be designed to last. Investments on strong structural elements will enable any future use requiring loads uncommon to retail spaces, and ensure the structure is fit to resisting stronger future climatic events (see Gething, 2010).

Recommendations

- Building form and orientation must be consistent with the objective of maximising natural light penetration;
- Building structure must allow maximum flexibility to interior reconfigurations;
- Structural frames must be designed for higher loads, and building skins and interior partitions must allow fast and affordable reconfigurations.

Passive heating – Heat stored through solar gains is released in evening/night hours, thus being appropriate particularly for patterns of use in residential spaces. Instead, commercial spaces and, to an extent, hospitality spaces (hotel rooms) require a different approach. Nevertheless, since passive heating is claimed to be part of the environmental strategy, orientation and building form are key factors. The rectangular shape of the typical retail unit, with the long sides aligned roughly on the East-West axis, and glazed openings on the short sides, allows limited sun penetration and direct sun available only for limited winter hours. As for daylighting, the possible re-use of the units in some scenarios as live/work spaces, would make a passive solar strategy appropriate for this type of development. It is also important to consider that in scenarios like NSP, PR, and for different reasons FW, many single use developments are transformed into mixed-use. This is the type of development currently regarded as energy efficient and socially sustainable in the UK and other European countries (Llewelyn – Davies, 2000). It is therefore strongly promoted in NSP and PR whereas in FW, the unplanned and unregulated use of buildings outside of the rich enclaves leads to a randomly varying but continuous mix of residential and non-residential spaces distributed across the city. In this light, it would be advisable to modify building forms and orientation of the current masterplan. Alternatively, the same objective could be attained in the future through a complex transformation which would allow sun penetration through the roof, through light wells, etc. For this purpose, as mentioned previously, the building design must allow high adaptability.

Recommendations

- Building form and orientation must be consistent with the maximisation of solar gains;
- The structural frame of the units must be designed to enable enhanced flexibility and transformation, which would possibly allow sun penetration and change of uses.

Passive cooling – The paucity of the design material available does not allow an in-depth analysis on this strategy. Passive cooling relies on cross ventilation, therefore, for example, on stack effects and vents. The interior configuration of buildings, through strategically positioned shafts, can generate air movements. Such a configuration, however, needs to be maintained over time and in spite of future renovations of buildings. In a dynamic market scenario (MF and PR), retail businesses are likely to renovate the premises every five to ten years because of fast cultural and aesthetic shifts, or relocate if different urban locations become more suitable to the company business strategy in terms of customers target and visibility. In this perspective, a business-effective refurbishment can take precedence over spatial arrangements allowing efficient air circulation, thus increasing energy consumption for air conditioning.

Recommendations

- To ensure through effective design that shafts for internal air circulation are protected against future reconfigurations of buildings;
- To ensure through effective design that vents incorporated in shop windows are retained in future refurbishments;
- To ensure that effective user manuals are delivered with lease agreements now and in the future.

On-site renewable energy generation – Planners and developers have agreed on 10% of the total energy use to be supplied through on-site production. At present technologies for on-site energy production are not yet selected. The orientation of retail units and their building form (i.e. pitched roof) are compatible with the use of PV and solar thermal panels. Design documents show that the eventuality of green roofs to reduce water run-off is at present under evaluation. The roof area that can be used for energy production is therefore still uncertain. It must be noted, however, that retail businesses can be highly energy intensive. Consequently the area of PV panels and the related investment) necessary to accomplish the energy target is considerable. Table 20 shows that the totality of the roof area suitable for PV panels falls short of delivering the 10% on-site production to which the developer is committed. It also shows the magnitude of the necessary financial cost.

Retail Unit	roof m^2	area pv m^2	peak hour [Kwh]	expected Kwh (minimum 69 m^2)	expected Kwh (maximum 105 m^2)
U1	20,000.00	930.00	124.00	64,170.00	97,650.00
U2	6,000.00	280.00	37.33	19,320.00	29,400.00
U3	7,500.00	350.00	46.67	24,150.00	36,750.00
U4	7,500.00	350.00	46.67	24,150.00	36,750.00
U5	7,500.00	350.00	46.67	24,150.00	36,750.00
U6	7,500.00	350.00	46.67	24,150.00	36,750.00
U7	10,000.00	465.00	62.00	32,085.00	48,825.00
U8	15,800.00	735.00	98.00	50,715.00	77,175.00
U9	5,000.00	0.00	0.00	0.00	0.00
U10	5,000.00	0.00	0.00	0.00	0.00
U11	5,000.00	0.00	0.00	0.00	0.00
U12 - flat roof	4,200.00	390.00	52.00	26,910.00	40,950.00
U13 - flat roof	3,200.00	300.00	40.00	20,700.00	31,500.00
U14 - flat roof	3,000.00	280.00	37.33	19,320.00	29,400.00
U15 - flat roof	1,500.00	140.00	0.00	9,660.00	14,700.00
U16 - flat roof	1,500.00	140.00	0.00	9,660.00	14,700.00
U17 - flat roof	1,200.00	112.00	14.93	7,728.00	11,760.00
total peak hour	111,400.00	5,172.00	652.27	356,868.00	543,060.00
real performance (0.821)			535.00	less than 10%	less than 10%
Cost (£240/m^2)			1241280		

Table 20 – Limits to energy production with PV panels for the development in North Yorkshire

The relatively short life of PV and solar thermal components may discourage replacements in many scenarios (MF, FW/Hns, and possibly in PR) thus eliminating the expected benefits and the initial financial investment. Investing on renewable generation schemes at a district scale, possibly managed in private/public partnership may lead to more robust energy savings. It is possible also to invest in energy efficient technologies such as source heat pumps or CHP if consistent with the development energy consumption profiles, although the eventuality of future change of uses and fragmentation of the retail units must be taken into consideration.

Recommendations

- To invest in district renewable generation schemes as opposed to micro on-site generation schemes;
- To design heating/cooling energy efficient systems adaptable to future change of uses or the transformation of individual units into many independent ones.

6.3.3 – Further findings

Some of the findings of this case study correspond with those of the first two (e.g. building fabric), thus corroborating them. Others are original and specific to the particular scope of this development, thus further demonstrating the contextual sensitivity of the resilience analysis. For example, since the development's programme is designed in response to the local authorities' objective to kick-start the high street regeneration, the focus of analysis moves towards topics such as the future of the retail landscape and the appropriate typology of spaces that can meet changing businesses' requirements and customers' expectations. In order to be prepared for the unknown, building structures and skins must allow a flexibility that goes beyond current design and construction best practice. This aspect has been debated in the sections 4.2 and 4.3, in which some comments on urban resilience from practitioners are elaborated. Its emergence within this resilience analysis therefore consolidates those intuitions. Following this line of thoughts it is possible to extend the spatial scope of analysis to the open spaces of the commercial development. In particular, the central square, supposed to be the core of the site, appears to be too small if compared to the development's size. One of the local council's concerns is to retain traditional market town urban typologies for the new commercial development, in line with the history of the place. Town squares are central to social encounters; their dimension is usually generous, or at least proportionate to the building masses and institutional importance at its edges. Their configuration and position is key to pedestrian circulation and permeability. The proposed square seems instead inadequate to those purposes and fails being a representative urban space (which would ensure its appreciation now and in the future) and a connective tissue of the many retail units, and of the development with the broader town. It appears to be rather small, excessively shielded by the surrounding buildings so as to be rather invisible, and bordering with a vast car park that can deter social gatherings. It is reasonable to surmise that in scenarios like NSP and PR these features are perceived as obstacles to the good quality of the place and its social sustainability. Moreover, the limited open space available does not allow over-capacity for adaptability to any future changes.

The position and configuration of the car park in relationship to the built area makes it a central feature of the development, thus countering the intention of shaping it as a traditional market place. Instead, in incorporating large parking areas within the shopping precinct and facing shop entrances, it distinctly resembles out-of-town commercial centre typologies. The identity of this place as it is designed may not be supported within the FW rich enclaves, or within the NSP communities. Finally, if surfaced with tarmac, it could excessively retain heat and affect negatively the local microclimate.

A second relevant issue emerging in the course of the analysis concerns the role of the currently most used rating codes, which is one that also emerged during the interviews and that will be further elaborated in the discussion chapter of this thesis. The tradability of the assessment elements comprised in the rating schemes usually allows flexibility in determining the preferred environmental strategy although, as the analysis suggests, this may come at a cost. For example, developers and designers can chose to minimise the importance that building insulation can play in reducing the building's carbon emission whereas the resilience analysis demonstrates its centrality in attaining ambitious target. The role of non-mandatory rating codes as drivers to promote best practice exceeding mandatory targets is currently much debated. One argument supporting tight mandatory targets is that these force designers and the construction industry to innovate, and to use and optimise by necessity technologies that otherwise would not be tested (Gann et al., 1998). A success story demonstrating how ambitious targets can drive innovation is the fast withdrawal of CFC chemicals used mainly as refrigeration fluids that was imposed hastily on industry when the evidence of the thinning of the ozone layer drew interest and preoccupation worldwide. Industries had to comply with legislation and phase out harmful productions in a very short time. Nonetheless, in spite of the initial fierce opposition of markets that feared financial losses in reconverting productions, this happened without negative impacts to business (see Meadows et al., 2004). There is another argument that plays against checklists and assessment criteria, which maintains that these deter innovation since they suggest particular strategies whereas industry should be left free to determine means and modalities to attaining targets as long as these are clearly stated (Vollenbroek, 2002; Gann et al., 1998). The opinions of the interviewees presented here (see section 4.2) pointed at the traps that come with compliance to BREEAM, thus showing an inclination to partially agree with these arguments. Performance targets and guidance for their attainment are necessary instruments to ensure effective performance, although, when too rigid, they stifle innovation and can be used passively. As long as objectives are clearly given (i.e. targets of emission reduction, energy use, etc.) designers can be left free of determining pathways to their attainments.

Chapter Seven - Discussion

7.1 – The case for resilience analysis as an environmental assessment tool

With the case studies presented in the previous chapter the resilience analysis was trialled and demonstrated to possess those requirements necessary to identify resilience, which have been enumerated and thoroughly discussed in chapters three and four. In section 5.3.2, after its presentation, the Urban Futures method (in its modified form called here resilience analysis) was recognised as the one that can meet such requirements. These include:

- To examine resilience holistically and at a system level. This enables an evaluation of the resilience of the entire system as well as at that of the object of analysis (e.g. energy efficiency);
- To broaden the urban system examined so as to include different and nested scales of intervention as well as modifications of the urban system over a sufficiently long period of time;
- To focus on the benefits for which resilience should be sought after (i.e. resilience for what and to what);
- To identify feedback loops and leverage points that can help finalise effective strategies.

The robustness of the resilience analysis as an assessment method was also demonstrated by the convergence of the findings of the three case studies as in the case of the building fabric as a strategy to accrue energy savings. In each one of the three development projects, under different circumstances and from different perspectives, reasons emerged to support a higher commitment for investing in tighter targets of thermal transmittance than the mandatory ones, this being the most resilient amongst the energy efficiency strategies examined. The repetitiveness of such results corroborates this final conclusion. It could be noted that in itself this is an argument already raised by many and supported by much evidence (see Yuzbasioglu, 2010; The Zero Carbon Hub, 2009). Nonetheless, with the resilience analysis, the evidence elicited includes a wide spectrum of short and long-term benefits. These are not exclusively related to carbon emission reduction or pay-back time of initial investments, which are the arguments commonly raised in literature. Instead, they include future property values, the perception of the degree of quality of the development, and more. These are further factors with which a variety of stakeholders involved in the development process (i.e. developers, future occupiers, planning officers, etc.) can easily connect. It must be also noted that these findings are reached through an analytical process that practitioners or developers can undertake as opposed to those gleaned from reports on this issue. Arguably, conclusions reached through an active participation in an assessment process can be more powerful than those grasped through reading reports.

The emergence of a range of disparate benefits comes with the one of trade-offs., defined herein as points where potential conflicts between competing factors are realized within the design process (Lombardi et al., 2011) so as to enable a decision to be taken in the full awareness of inherent advantages and disadvantages. The realisation that the contained investment in building envelopes complying only with mandatory targets can hinder the positive perception of quality and the consequent market value of buildings in the medium and long term future, as mentioned above, was one of the trade-offs repeatedly elicited in the course of the case studies. Another trade-off often mentioned was the one involving solar gains and building densities. The maximisation of one is detrimental to the other. In other words, referring to the analogies between complex systems theory, natural systems, and urban systems discussed here in the chapter three, trade-offs can be viewed as feedback loops (i.e. increase the investment in building insulation - lower the energy use), and the range of benefits mentioned above can be used as leverage points to push the feedback loop towards a desirable state, in which a reduced use of energy is maintained over the life time of buildings. The novelty of this assessment process lies in the possibility of an appraisal method that enables decision makers to acknowledge diverse trade-offs, place them in a wider context, and connect them to a spectrum of environmental, economic, and social consequence. In other words it enables an intuitive complex systems approach to the evaluation of development options.

The resilience analysis is of particular relevance to urban designers, since emerging findings can have implications on the spatial configuration of the place. The embankment in Luneside East is a case in point, in that, as the conclusions of the analysis indicate, it should be retained and not substantially modified as suggested in planning guidance. In a way it could be said that there are urban forms more resilient than others, and that a view to the long-term can help reach decisions on an array of urban physical parameters (i.e. building forms, heights, distances, urban densities, green spaces and their form, etc.) that shape buildings and spaces, which may not have been reached through the conventional design process. This feature distinguishes the analysis as a proper and powerful design tool.

There are other advantages from the resilience analysis that have been abundantly mentioned in the course of the thesis, such as its capacity to be context sensitive. To prove this, at the end of each case study a raft of topics were presented that emerged in the course of each analysis, and that can appear to be only marginally related to the sustainability solutions assessed. Their diversity, however, is not accidental. It reflects the local circumstances, and/or the particular perspective and interests of the partners that contributed to the development of the case studies. For example, in Lancaster, planners involved in the Luneside East analysis were concerned with the social sustainability of the project, and in particular with the integration of the forthcoming community with the existing ones, thus their concern with the embankment and the eventuality that it could represent a physical and visual barrier to permeability. The embankment, however, can have a major environmental impact on the site, because it can be instrumental to its macroclimatic amelioration and because of its potential to protect the right-to-light with consequent energy savings. Thus the discussion steered towards a social and environmental focus, enabling stakeholders to grasp all the trade-offs implicit to design choices.

In the second case study, the focus shifted towards formal design choices because of the particular objective of the city authorities to deliver with Masshouse an urban landmark. Thus the discussion moved towards professional priorities and attitudes, and how these influence the design choices taken in response to the planning guidance. Arguably formal aspects of building and spaces are conduits of socio-political aspirations. They are deemed essential to represent the local ambitions, to contribute to the image of the city, and in so doing, also to gain public consent in the undertaking of such endeavours. They can therefore take undue precedence on other urban parameters, including environmental ones. In highlighting the negative consequences of choices that privilege form, the analysis indirectly promoted innovative design thinking that can reconcile aesthetic and environmental parameters.

Finally, in the third case study the development programme was scrutinised in its potential to meet the local aspirations for a new town centre to be designed in line with the long-standing tradition of a North Yorkshire market town. The partner in this last case study was a developer, hence his interest in developing a design scheme that mediated amongst conflicting requirements such as the aspiration for a representative town market square, the demand for sufficient parking space, the developer's interest in building at high densities, etc. Conclusions of the analysis connected with the developer's interest and gave him arguments, for example, to invest in building technologies and structures different from those initially planned, which can adapt over time and help retain property's market values.

The wealth of issues touched upon in parallel with those strictly related to the main object of examination (i.e. energy efficient strategies) is testament to the flexibility of the analysis and the diversity of topics it is capable of accommodating. More importantly it shows a new alternative approach towards assessment tools, which is no longer constrained by checklists and assessment criteria but favours dialectic reasoning within a structured process. The resilience analysis, in the form presented here, can be considered an assessment tool in its own right, although substantially different from the majority of those currently in use, at least in two fundamental and distinct features. First, it does not deliver certain, unequivocal answers. Instead it induces a process of reasoning to elicit risks, with plausible alternative plans to tackle them. This type of 'strategic evaluation', however, relies on robust evidence provided by scenarios characteristics. Second, whilst the purpose of conventional environmental impact assessments is to quantify environmental efficiency so as to make it demonstrable, the resilience analysis does not deliver the certainty of numbers. It can elicit reasons to attain a higher level of performance without directly indicating a specific target for it as, say, rating codes such as BREEAM and the CSH can do. It can also help identify the most (or a mix of the most) performance effective solution/s within a range of options. Nevertheless, since it does not deliver univocal answers, and since it does not pretend to establish set targets, it is better suited to qualitative rather than quantitative evaluations. Such evaluations, however, are equally sound and demonstrable, although in different ways, than those from rating codes.

By providing quantitative evaluation of building performance, rating systems enable a (maybe imperfect) measurement of environmental efficiency and, to an extent, sustainability as a whole. These numeric evaluation systems allow the reliability and repeatability of their measuring processes. The resilience analysis has demonstrated its power to identify conditions for urban resilience. It can be therefore considered an assessment that can appraise sustainability with a view to its long-term performance: a sustained sustainability. Being an assessment and a design tool, the question must be posed if its structure, its operability, and the evaluations it provides allow an effective integration into practice. The relevance of the analysis from a practitioner standpoint was abundantly demonstrated through the case studies. Nonetheless, is it reasonable to assume that it can be effectively integrated within the design process? Is it reasonable to assume that practitioners can comfortably conflate the environmental accounting of rating codes with the strategic evaluation that the resilience analysis prompts? The two can be viewed as complementary. However is the latter comparable to (or can it be assimilated with) the former?

The contribution of this thesis is twofold: it develops a theoretical discussion about the nature and characteristics of urban resilience, and it proposes a structured approach for facilitating its assessment in a systemic fashion, which is consistent with the theoretical findings. This second contribution is important. Theoretical studies need to be translated into practical applications, and these must be designed to be approachable by practitioners so as to spur innovation and innovative thinking that can be integrated into practice. However, innovative thinking, as well as any form of innovation, can produce change only when it gathers a sufficient rate of diffusion (Winch. 1998). Moreover, in order to be effective and trigger change any innovative approach needs to be codified and integrated within the organisational structure of the activity, profession, or discipline to which it pertains (Winch, 1998). Innovative thinking can be facilitated through frameworks or tools easy to operate. As demonstrated, the resilience analysis can be used as one of such tools although, in order to produce impact, it needs to be recognised as such from a practitioner standpoint, similarly to existing appraisal tools.

In this perspective, the following sections discusses opportunities and challenges to integrate the resilience analysis within current mainstream Environmental Impact Assessments (AIEs), or as a complementary assessment for urban resilience that can supplement and strengthen their potential. First, some of the currently most used methods are briefly reviewed in their capacity of measuring sustainability and possibly urban resilience. This thesis demonstrates that sustainability and resilience are two concepts strictly related and that they complement and reinforce each other. It is therefore necessary to understand if current EIAs facilitate the accomplishment of both and in which way, to subsequently discuss the relevance of the resilience analysis, and the potential for it to complement them. Secondly, the point in time along the sequence of phases of the development process in which the resilience analysis can be more effective is discussed. Whilst EIAs provide assistance on sustainability strategies and environmental performance, other tools provide guidance with regard to the sequencing of the actions comprised in the urban development process. These can help program the most effective timeline for action and managing the relations amongst actors. The RIBA plan of work (2007), for example, allows practitioners to navigate through the stages of the design and construction process so as to master it in a rational and effective fashion. The plan defines stages of the process and, for each one, the actions to be undertaken and the actors that need to be involved. Recently, the plan has been expanded to better integrate sustainability. The Green Overlay (RIBA, 2011) complements the former version with those actions (and their timing) necessary to design buildings with a high environmental performance. Mapped against the sequence outlined within the Plan of Work, EIAs can be carried out at a very initial stage, thus informing the articulation of general strategies to achieve the targets planned. They can also be used to assess the correspondence of the initial design with the real performance, or for monitoring, or auditing.

The following section provides a brief classification of EIAs that can help position the resilience analysis within their landscape.

7.2 – A brief classification of Environmental Impact Assessments

Designing buildings is not an easy task. The professional remit of those involved in the making of the built environment has been constantly evolving over the last century to reflect great changes in design and construction processes determined by technological progress, or by evolving social priorities and dynamics, etc. Buildings are complex and sophisticated objects whose design and construction require sophisticated information in order to select appropriate and cost-effective technologies and materials, coordination skills to integrate inputs from of a range of consultants, and sensitivity to socio-cultural aspects that are key to the their liveability. Over the last decades, sustainability has added a further, significant layer of complexity. Buildings and cities have ‘long life cycles and their impact is felt for generations’ (Fenner and Ryce, 2008). For this purpose, environmental assessment tools can facilitate the daunting task to minimise the high impact that cities can have on the environment. However, since there is not an unequivocal definition of sustainability and of systems for measuring it, assessment methods available are disparate, with different structures, and based on different methodologies.

Rotmans et al. (2000) define EIAs as follows: an "interdisciplinary process of combining, interpreting and communicating knowledge pieces from diverse scientific disciplines in such a way that insights are made available to decision-makers". There is a wide range of these assessments, designed in a variety of formats and addressing a variety of scales and scopes (i.e. urban development, ecosystems, industrial products lifecycles, etc.) that provide valuable aid to professionals in several disciplines, and to governmental and non-governmental organisations. Walton et al. (2005) identify 675 different assessment tools, of which 165 are regarded as relevant to industry and government.

The introduction of the European Commission Directives (European Council Directive, 1985; European Communities, 1997 as quoted in Deakin et al., 2002), in which EIAs are specifically indicated as necessary for delivering high quality urban development and infrastructure, has spurred their use in Europe. Today, in the UK and elsewhere, EIAs are recognised as essential in many fields, including planning and the planning approval process. For example, the UK planning policies recommend developers to carry out this assessment prior to the site selection, since EIAs can enable decision makers to give due weight to environmental factors, alongside with social and economic ones (DCLG, 2000). In the field of the built environment, these assessments have become widespread professional tools either because they can supply technical guidance for complying with mandatory or voluntary sustainability targets or/and because of valuable aid in embedding sustainability within the design process. Most of them provide a list of those issues, with related performance targets, on which it is deemed design efforts must focus. This 'codification' of sustainability has the merit of including within a framework a range of 'sustainability solutions' (i.e. materials, technologies, design principles, or any other strategy deemed to deliver a sustainable performance) regarded as such by professional categories, and national and local authorities. For example, in the UK buildings rated BREEAM are collectively reputed to be designed and constructed with best practice sustainability targets.

The majority of EIAs specifically address a particular environmental, economic or social scope whereas it is recognised that sustainable urban development has direct or indirect consequences on all the three sustainability pillars. For this purpose, Deakin et al. (2002) suggest that currently EIAs can be divided in two groups: those that address environmental evaluation and those that address the social and economic sustainability of urban development, with the former being within the competence of the scientific community and the latter drawing from a variety of expertise within the field of the built environment. In this perspective, they argue for a more integrated approach. Sustainable urban development is encompassing all these three dimensions. How can it therefore be effectively assessed using methods that differ in terminology, metrics, structure, benchmarks, and more? Thus 'the development of new methods that address the broad complexity of the problem continues to be a major research priority' (Deakin et al., 2002).

The multitude of EIAs available with different formats, and the different tools/processes that are designated under this term has led to confusion on their precise purpose. To bring clarity, some scholars have produced a series of studies attempting classifications of EIAs according to their scope and/or their functionality. Fenner and Ryce (2008) separate existing EIAs into three categories: '*knowledge-based tools*' comprising manuals providing information for designers; '*performance-based tools*' which use life cycle impact assessment and simulation tools to calculate several types of performance; and '*building rating tools*' under the format of design checklists and rating systems to assist designers in identifying design criteria and ascertaining the environmental performance. This last category uses lists of elements regarded as instrumental to the environmental performance of buildings, which may also sometimes include social aspects. Such elements can be regarded as indicators of environmental efficiency, with an indicator defined as a type of information that ‘highlights important criteria for measuring’ (e.g. domestic potable water use) (Hunt et al., 2008).

Runhaar et al. (2009), in a study describing tools for planning commonly used in the Netherlands, argue for the distinction between ‘substance-oriented’ and ‘process-oriented’ tools. The former use indicators or other forms of analysis (e.g. ‘performance-based’, rating tools, etc.), GIS computer-based planning support systems, and more. The latter (i.e. focus groups, charrettes, or other techniques aimed at engaging all stakeholders) facilitate the dialogue amongst actors and can be used as a form of building consensus, but do not specifically address environmental issues. The hybridization of these two has produced a third generation of tools. These assist planners in the effort of engaging stakeholders as well as in determining a series of environmental indicators that are pertinent to each particular development, to finally develop an action plan. Runhaar et al. also claim that insofar there is little evidence of a positive change in planning as a consequence of the widespread use of conventional EIAs.

Some assessment frameworks based on the simultaneous appraisal of the three pillars of sustainability already exist. For example, the ‘The Natural Steps’ framework for planning (2012) can be regarded as a hybrid between substance and process oriented assessments. It is an ambitious framework that requires the forming of a work team, the active involvement of communities, and the formulation of a vision leading to the identification of indicators to measure sustainability. Arup’s SPeAR tool is articulated in four sections: Environmental, Societal, Economic, and Natural Resources. Indicators included in each section come from the UK Sustainable Development Indicators listed in ‘Quality of Life Counts’ (DEFRA, 2004) as well as other EU and UN indicator sets (www.arup.com). Similarly, the recently developed BRE’s Green Print for urban development, is a framework for facilitating communities to envision their desired forthcoming urban development through a series of charrettes. Subsequently, the vision is expanded to follow eight streams (Climate Change, Resources, Transport, Ecology, Business, Community, Placemaking, and Buildings). SPeAR and Green Print provide also final scores representing the degree of sustainability of the development.

These assessment frameworks enable stakeholders to appraise the efficacy of the development process in terms of organisational structure and correspondence to the sustainability principles. However, it could be claimed that at that scale of examination the inclusion of social, economic, and environmental factors within an assessment framework is reasonably manageable. Instead, with rating codes substantial difficulties arise. How is it possible to include within their structure, with its high level of specificity, the sheer number of assessment criteria that would encompass the triple bottom line? Nevertheless if both assessment types should complement each other, one appraising the broad planning process, and the other buildings and open spaces, there should be correspondence in their approach to sustainability. Instead rating codes seem to be biased towards the environmental accounting which, although fundamental, is only part of the picture.

In their scoping study which canvasses the opinions of urban decision makers and tool developers with the aim of identifying EIAs’ strengths and weaknesses, Walton et al. (2005) present some relevant, emerging issues. These include:

- The need for an integrated multidisciplinary tool. Given the sheer number of tools available, there is little need of developing others. Instead, it would be necessary to work on a ‘form of rationalisation of the whole tool landscape by bringing the tools together in one place’. Their codification would also be necessary so as to facilitate the identification of the most appropriate methodology for a given assessment context;

- The need for a nesting approach that allows appraisals at different, logically connected levels, each one of which can be unpacked but still clearly related to the others;
- The need for tools that allow the comparison of different ‘actions and scenarios’ as opposed to those that prescriptively suggest the use of specific and discrete solutions;
- The recognition of the role of context in the pursuit of sustainability, reflected in the potential for customisation in order to adjust tools to local needs and characteristics;
- The difficulty of accounting impacts which are often measurable with different units. The disadvantages to live next to high transit routes or in areas prone to flooding, for example, cannot be measured with the same units used to measure energy efficiency.

The opinions summarised above, and the studies on the classification of EIAs, confirm that a perceived major drawback of performance-based assessments and rating tools is their partiality. Only addressing the triple bottom line simultaneously there can be a reasonably reliable assessment on sustainable built environments. Another relevant emerging issue is that, for this purpose, research should focus on refining and aggregating existing tools, thus eliminating redundancies and integrating disparate features. Different metrics, a lack of connection in assessments designed for different scales of intervention, and a participative approach to the process are some of the emerging features envisaged as key to develop a new integrated EIA. Attempting to outline the contemporary urban model that this should be designed to assess, Rotmans et al. (2000) maintain that today the city is made of ‘a number of interrelated stocks and flows. These flows could be tangible, relating to physical or financial flows, but also intangible such as information or knowledge flows. Because the intangible stocks and flows can often not be described in quantitative terms, a qualitative description, using qualitative data is more adequate in these cases’. Moreover, the metabolism of cities is not only determined by physical, biological, and chemical flows but also by social behaviour (see Diamantini and Zanon, 2000). EIAs for sustainable urban development should be therefore modelled on such a conceptualisation of cities.

Mapped against the requirements for improving current EIAs, and against the classification presented above, the resilience analysis can be regarded as one that appraises sustainability performance (in its resiliency) in an integrated fashion (i.e. environmental, social, and environmental aspects). It does so because of the nature of scenarios. Its ‘discursive’ nature lends itself to be used as a process that involves many stakeholders (e.g. workshops, etc.), thus positioning itself amongst those hybrid tools that can reconcile substance-oriented and process-oriented tools. It cannot be classified as an actual rating tool since, as argued at the inception of this section and as elaborated further on, it produces strategic recommendations rather than numeric values, which are more appropriate to measure ‘intangible stocks’. However, it has some similarities with those, in that it can identify assessment criteria for sustainable and resilient performance. It is context-sensitive and offers multiple design scenarios, which are two of the desirable features for a new integrated EIA highlighted in the canvassing study mentioned above. Finally, it possesses features that can circumvent some of the apparent rating codes’ main drawbacks. For example, they are not fit to measure rather intangible factors (i.e. discomfort of living next to noisy places). In this light, it can be envisaged as a tool complementary to rating codes, which could be possibly incorporated to those, thus going towards a rationalisation of the EIAs landscape advocated in the canvassing study. The following section will discuss more in detail the limits of some of the current most used UK rating systems.

7.3 – The case for an integrated rating code

The information produced through environmental assessments is generally regarded as an evidence base, thus objectively recognised as valid. Yet, as stated above, any assessment methodology is designed according to a particular scope, which is reflected in its priorities, and/or the selection of some indicators and the exclusion of others. For example, rating codes predominantly measure environmental performance and only marginally address social factors (Fenner and Ryce, 2008; see also Hunt et al., 2008). An integrated rating code would therefore avoid falling into traps that come with partial appraisals. In other words, it could be said that, inevitably, a specific interpretation of the physical reality (i.e. a model) informs the lens through which events and physical phenomena are read (see Tweed and Jones, 2000). Thus the danger in excessively relying on rating codes to evaluate sustainability lies in an undue entrustment on environmental issues (i.e. the fundamental constituent of their model) to deliver positive sustainable performance.

Other important performance-based tools currently used for environmental assessments equally rely predominantly on the environmental accounting. For example, the Life Cycle Analysis (LCA) methodology enables an understanding of 'the energy use and other environmental impacts associated with all life cycle phases of the building: procurement, construction, operation, and decommissioning' (Bayer et al., 2010). LCA is extremely valuable since it helps identify the impact on the environment of any man-made object as well as the possibilities of reducing it through an optimisation of the production process. The Cradle to Cradle certification created by McDonough and Braungart (2002) aims at eliminating industrial waste through a circular metabolism of industrial processes. Both are very useful methods that help improve the embodied energy of products and processes, and the 'upcycling' of material flows. Nevertheless they do not address other related issues or facilitate any form of alternative approaches to consumption which is in itself a major concern in a world in which resources are finite (for an account of the unsustainability of the global economy cycles see Daly, 1996; Jackson, 2009). The argument made here, however, does not dispute the utility of these methodologies, which are and probably will continue to represent valuable assessment and design tools, but rather suggests that the design of assessment methodologies has so far rarely attempted to face with the challenges of an integrated methodological approach.

In rating codes for buildings, resilience is addressed only indirectly as the capacity of environmentally efficient buildings and urban development to cope with climate change and resources depletion. BREEAM clearly states that buildings attaining Excellent and Outstanding are the best demonstration of their contribution 'to meet the UK's legal obligation on climate change (as defined in the Climate Change Act 2008)' (BRE, 2011). For each one of the categories and elements included in these rating codes, the assessment criteria show a predominant concern for the environmental facet, although some criteria address socio-cultural issues. For example, those listed under 'Thermal Comfort' in the category Health & Well-being, concern the design of thermal zones, the efficient controls based on the occupancy pattern and the type of use, user knowledge of the functioning of the system, and more. Nevertheless, in spite of the efforts to go beyond environmental efficiency, an analysis of all the categories and elements for assessment included in current UK rating codes presented further on shows that the inclusion of social or economic issues is limited only to a few of these, and predominantly regards user behaviour. Instead, as the resilience analysis shows, other socio-economic factors such as long-term maintenance costs, which are not dealt with in codes, are equally liable to undermine performance. Moreover, efficiently designed heating systems can be compromised by the users' perception of comfort, which is, to an extent, culturally determined (see Butera, 2007). Similarly, as many recognise, water efficient and energy efficient appliances, although necessary, do not address the fundamental factor (possibly at the heart of energy consumption) of the multiplication of energy efficient electric and electronic tools that determine a rising energy demand.

As an ulterior demonstration of the partiality of rating codes, BREEAM and CSH categories and elements for sustainable performance have been scrutinised. Table 21 summarises the elements contributing to the final score of the two rating code, evaluating them for their potential to deal with social, economic, and environmental issues. A glance at the Table19 shows that:

- The majority of element listed in the rating codes is not assessed against the triple bottom line and (or) for their capacity to adapt to future unknown conditions of society;
- Energy and water efficiency is predicted only on the basis of the building as designed and not on its long-term performance. A post-occupancy assessment would reveal how much user behaviour impact in the design performance. BREEAM offers the opportunity to audit buildings after completion and occupation. However this form of assessment is not widely used (Fenner and Ryce, 2007);
- Materials, which clearly can have an impact on the local (and national) economy, are rated predominantly for the embodied energy as reported in the Green Guide (which includes only materials tested by BRE, thus locking out many alternatives). There is little attempt to foster the use of locally sourced materials, components, and technologies. This could have evident implications on the economy (and social sustainability) of the local communities and their long term resilience;
- Cycling and walking is addressed only in terms of provision of the necessary 'infrastructure' that can encourage take-up of these activities. Nevertheless, if cycling lanes are not part of a wider efficient network of lanes and, more importantly, if people do not use these lanes because the culture and desire to walk/cycle is not rooted in local communities, they can remain unused;
- The rating of the element 'Site Selection' in BREEAM is assigned on the basis of the selection of previously developed land (brownfield). Although this arguably contributes to an efficient use of land, it is once again the environmental concern that takes precedence. Economic and social evaluations that may justify the selection of land not previously developed, or the selection of one amongst the many brownfield sites available, are not required for the attainment of the score.

BREEAM (new constructions-non domestic)		**CSH**	
Management		**Energy and CO2 Emissions**	
Sustainable procurement	S	Dwelling emission rate	En
Responsible construction practices	En	Fabric energy efficiency	En
Construction site impacts	En	Energy display devices	En/S
Stakeholder participation	S	Drying space	En/S
Service life planning and costing	En	Energy labelled white goods	En/S
Health & Well being		External lighting	En
Visual comfort	En/S		
Indoor air quality	En	Low and zero carbon technologies	En/S
Thermal comfort	En	Cycle storage	En

Water quality	En	Home office	En/S
Acoustic performance	En		
Safety and security	S	**Water**	
Energy		Indoor water use	En/S
Reduction of CO2 emissions	En	External water use	En/S
Energy efficient external lighting	En	**Materials**	
Low or zero carbon technologies	En/S	Environmental impact of materials	En/Ec
Energy efficient cold storage	En	Responsible sourcing of materials – basic building elements	En/Ec
Energy efficient transportation systems	En	Responsible sourcing of materials – finishing elements	En/Ec
Energy efficient laboratory systems	En	Surface water Run-off	En
Energy efficient equipment (process)	En	Management of surface water run-off from developments	En
Drying space	En/S	Flood risk	En/S
Transport		**Waste**	
Public transport accessibility	En	Storage of non-recyclable waste and recyclable household waste	En/S
Proximity to amenities	En/S	Construction site waste management	En
Cyclist amenities	En/S	Composting	En/S
Maximum car parking capacity	En	Pollution	En
Travel plan	En	Global warming potential (GWP) of insulants	En
Water		NOx emissions	En
Water consumption	En/S	**Health & Weell-being**	
Water monitoring	En/S	Daylighting	En/S
Water leak detection and prevention	En	Sound insulation	En
Water efficient equipment (process)	En/S	Private space	S
Materials		Lifetime Homes	Ec/S
Life cycle impacts	En/Ec	**Management**	
Hard landscaping and boundary protection	En	Home user guide	S
Responsible sourcing of materials	En/Ec	Considerate Constructors Scheme	En
Insulation	En/Ec	Construction site impacts	En/S/Ec
Designing for robustness	En	Security	S/Ec
Pollution	En	**Ecology**	
Waste		Ecological value of site	En
Construction waste management	En	Ecological enhancement	En
Recycled aggregate	En	Protection of ecological features	En
Operational waste	En/S	Change in ecological value of site	En
Speculative floor and ceiling finishes	En/S/Ec	Building footprint	En
Land Use & Ecology			
Site selection	En/Ec/S		
Ecological value of site / protection of ecological features	En		
Mitigating ecological impact	En		

Enhancing site ecology	En
Long term impact on biodiversity	En
Pollution	
Impact of refrigerants	En
NOx emissions from heating/cooling	En
Surface water run-off	En
Reduction of night time light pollution	En
Noise attenuation	En
Innovation	
New technology, process and practices	En/Ec

Table 21 – List of the elements assessed in three UK rating codes, examined for their potential of addressing the triple bottom line. In the table En = Environmental; Ec = Economic; S = Social

The list of observations provided above as evidence that UK rating codes rarely address the triple bottom line, and are not designed to analyse long-term performance is by no means exhaustive. As argued before, their structure is perhaps excessively rigid, and promotes an identical approach to all situations. The North Yorkshire case study demonstrates to which extent one of the BREEAM Excellent assessment requirements (25% improvement on TER) can be vulnerable. There, the resilience analysis has produced further 'assessment criteria' that added to those provided by the rating code, can make that particular sustainable performance resilient. The same process can be repeated for other categories of assessment (e.g. waste, management, pollution, etc.). This way, the resilience analysis can be used as a further step that completes the rating codes appraisal procedure.

7.4 – Limits to an integration of rating codes with the resilience analysis

The integration suggested here of rating codes to measure sustainability with a scenario-based analysis to measure resilience has clearly some limits and some advantages. One advantage, which has been abundantly argued in this section, is the capacity of the resilience analysis to complete an environmentally-focused appraisal with one focused also on socio-economic factors. The inherent, related limit consists of the 'open-endedness' of the process that cannot be constrained within a list of given assessment criteria, similar to those of rating codes. Instead it can take towards 'uncharted' territories, depending on the particular focus of the analysis and of those who develop it. In other words, the same solution could require different actions for resilience (i.e. different assessment criteria), depending on each particular site context.

Analysis findings can be of two types: the first consist of the identification of the vulnerabilities/drawbacks of plans examined; the second consists in the ensuing discussion, aimed at researching alternatives for overcoming those vulnerabilities. Understandably, as there will be more than one alternative, the selection of the better suited ones will vary according to the priority, the judgment, and the vision of the stakeholders involved. This flexibility can be viewed as indeterminacy. In spite of the interviewees lamenting the rigidity of current assessment tools, EIAs results need to be reliable and objective, whereas excessive flexibility may leave undue leeway to personal interpretations. Moreover, in order to undertake an integrated appraisal, assessors would need to go beyond conventional computational procedures (i.e. the calculation of TER, water consumption, etc.) and develop a critical examination that, although structured, requires reasoning and a degree of participation unusual if compared with the one required by rating codes procedures.

Another limit could be represented by analysis findings that do not point at numeric values, but rather to qualitative considerations. They also point at the causes generating a particular performance thus offering the occasion to identify leverage points to improve it. This advantage is countered by the lack of numeric values that, ideally, can measure the degree of resilience. The quantitative measurement on which rating codes (or the UK Standard Assessment Procedure - SAP) are based allows reliable, repeatable, and comparable results. These are fundamental to establish and design correct building performance. There is an on-going research and discussion on several issues that concern these rating systems, which will inevitably lead to modifications and improvements of some contended aspects. For example, for the Code of Sustainable Homes, it has been suggested to move away from the metrics used for the energy category (CO_2), to those utilised for the Passivhouse standard ($kWh/y/m^2$) (The Zero Carbon Hub, 2009; see also DCLG, 2008b) since these express directly and more intuitively the rate of the designed energy consumption. Some scholars question (see Downs, 2008) the ultimate effectiveness of EIAs also because of the environmental impact parameters selected. Suggestions for overcoming such shortfalls include the production of minimal impact design alternatives that can be used comparatively. This debate will possibly lead to revisions of current EIA models although, in spite of possible future modifications, the sustainability accounting will probably remain a backbone of rating systems. There have been attempt to use the scenario-based analysis to produce quantitative findings (see Hunt et al., 2012b; Fermani et al., 2012), however these have focused on specific issues such as water efficiency or water supply networks. The excel spreadsheet enabling the multiple resilience analysis presented here, is a further attempt to associate a scoring system to the resilience analysis. This scoring, however, is still rather arbitrary, and more research is necessary to make it reliable and comparable to the existing sustainability accounting models. It can be argued, however, that the very nature of resilience implies preparedness to undetermined, although to an extent foreseeable, future events. In this field, analysis must move towards the territory of ‘suppositions’ and ‘alternatives’, in which rigid scoring systems can be of little aid. Hence, it should be accepted that the measurement of sustainable performance requires strategic evaluation that can make it resilient, which can often be expressed primarily through qualitative evaluation. The lesson learned from the literature review and the interviews to practitioners is that typological and programmatic flexibility can be the cornerstone of a resilient architecture, and that to this purpose preparedness to changes is essential.

The logic of the two assessment models cannot be easily reconciled. If they were merged, assessors would need to develop the necessary sustainability accounting and subsequently the scenario-based analysis. The results of the latter however, may question or contradict those obtained with the former, with evident difficulty in establishing a final rating. For example, in the North Yorkshire case study, the assessor would ensure that conditions for 25% reduction on the TER are met, to subsequently acknowledge that these are not resilient. Summarising, the difficulties for reconciling these assessment systems are many. They include: substantially different appraisal approaches (sustainability accounting versus analytical, non-mathematical reasoning); the possibility of reaching conclusions that subvert the initial assumptions (rigid versus flexible approach); the length of the entire process and the notable commitment required to develop it as well as the understandable difficulty in combining scoring for sustainability with those for resilience.

Finally, a further limit of the scenario-based analysis may be represented by the scenarios themselves, which need constant updating. The original GSG scenarios portray global and regional changes in 2050 and 2100. It may therefore be possible to count on the wealth of information and dataset developed in those studies so as to update and extend the time horizon of scenarios when necessary. To do this, however, substantial research and human effort is needed thus making this task difficult unless dedicated, or existing professional, organisations can manage such a process. This would entail an official recognition of role of urban resilience for the purpose of sustainable urban environments and the validity of the resilience analysis as an important form of assessment. Hence the importance of a sort of partnership with credited organisations/associations working in the built environment sector that can promote and divulge the resilience analysis within their activities.

7.5 –Timing of the resilience analysis within the sequence of the design and construction process

A further relevant issue connected to the optimal use of the resilience analysis concerns its timing within the design and construction process. This process is notably complex, composed of many phases in which several actors are involved in different ways. Lombardi et al. (2011) describe it as an 'event sequence model', in which stages of the development process are managed. The RIBA plan of Work, one of the most used frameworks from the UK practitioners, maps the design process from inception to completion, and actors within each stage are identified. RIBA's is not the only framework that charts this process. Others have mapped, with varying levels of complexity, the sequence of phases, with necessary actions and actors involved (Lombardi et al., 2011). The usefulness of these tools lies in the simplification of a very lengthy and convoluted interaction amongst stakeholders in a progression of phases, within a sort of protocol recognised by all stakeholders. This linear progression of phases, as Lombardi et al. note, entails that at a point in time within the sequence, decisions must be taken that will inevitably open up some possibilities and exclude others. This is because when necessary, some information will be solicited and thus made available that will enable people to take some decisions. If this information is not available at the right time of the process, or if it is partial, decisions taken will exclude eventual, maybe more efficient, alternatives. With a view to sustainability, decisions can unlock or hinder the utilisations of strategies that can maximise sustainable outcomes. This is the case for example, as reported in the paper, of the selection of a pitched roof for a building. Once this roof type is selected, many options to implement green roof technologies will be excluded, as well as a higher yield of rain water which is achievable with a flat roof. Consequently, an efficient phasing of the design process would require that information about green roof technologies and rain water harvesting (cost, appearance, drawbacks, etc.) are made available before the decision concerning the shape of the roof is taken.

In the previous section 7.3 it is suggested that a resilience analysis could constitute an ulterior phase of the UK rating codes' appraisal process. In this phase the selected strategy for rating is questioned in the light of the local conditions, their possible future evolution, and how this can impair the planned building/urban development performance over its lifetime. Depending on the level of definition of the design scheme, the resilience analysis can focus on general features or on more specific ones. It is likely, however, that assessments with rating codes are developed at a design stage in which strategic decisions have been taken and already negotiated with other stakeholders. This would entail developing a design scheme to the point in which building form, materials, technologies, and services are sufficiently defined but may still be modifiable. In this case, against the RIBA plan of work, the resilience analysis should be developed at the end of the 'design development' step, in the Design phase (see Table 20). This could have some disadvantages. A pitched roof for the residential buildings of the development, for example, might have been already negotiated with the planning authorities.

If the resilience analysis demonstrates that the maximisation of rainwater harvesting is necessary for the development's resilience, the developer would have to face the additional hurdle of renegotiating the planning approval and modify building roofs from pitched to flat. Thus, in order to be effectively integrated within the design process, the information about rainwater harvesting should have been solicited and delivered before or during the 'Design Concept' step.

From this discussion two issues stand out. First, any EIA within the sequence of the design process must be developed at a point in time that allows modifications to the building design. If information is delivered too late, possibilities for environmental amelioration may be already locked out. Second, the resilience analysis may need to be developed iteratively. The three case studies presented in this thesis represent a clear case in point as to how differently information delivered at different stages of the RIBA plan of work can influence the final development plan. Table 22 summarises the main findings of the three case studies. Table 23 positions each case study analysis on a phase of the plan of work and attempts to map information that has been delivered too late with consequent unfeasible modification of the scheme. The last column shows the consequences of information delivered at the correct time of the design process (advantage accrued trough the resilience analysis) or too late (the possibility to modify as the analysis suggests is unlikely). In Table 22, boxes with disadvantages are highlighted in grey.

Case study	**Stage of the design process when the resilience analysis has been developed**	**Findings**	**Advantages/Disadvantages**
Luneside East - Lancaster	Pre-planning stage informing planning guidance	Site configuration	Embankments retained in the future design scheme
		Building density	Correct distances between buildings and building heights can inform the design scheme
		Community involvement in renewable energy generation scheme	Developer and local authority can start a process of community involvement as to how invest financial resources for on-site energy generation
Masshouse - Birmingham	After technical design phase for most of the development – after construction for the first phase of the development	Building density	The masterplan has received planning approval. The information is delivered too late
		Building orientation and form	The masterplan has received planning approval. The information is delivered too late
		Range of dwelling type	The masterplan has received planning approval. The information is delivered too late
		Building fabric	Two buildings have been completed. Nevertheless it is possible for the rest of the development to be specified with higher levels of building insulation

Catterick Garrison	During the design development step	Building orientation	The final footprint of the buildings has been already discussed with the local authorities. Probably too late to modify
		Building flexibility and structure	Recommendations can inform the design development
		Building fabric	Recommendations can inform the design development
		On-site energy generation	Other forms of financial investment can be discussed with local authorities

Table 22 – Type of information delivered through the resilience analysis within the sequence of the design process

RIBA Plan of Work				Timing of case studies
Preparation	Appraisal	Identification of client's needs and objectives, business case and possible constraints on development.	Business justification	
		Preparation of feasibility studies and assessment of options to enable the client to decide whether to proceed		
	Design brief	Development of initial statement of requirements into the Design Brief by or on behalf of the client confirming key requirements and constraints	Procurement strategy	**Lancaster case study: Resilience analysis at the end of the design brief phase can allows its modification so as to give guidance on design strategies for resilience**
		Identification of procurement method, procedures, organisational structure and range of consultants and others to be engaged for the project.		
Design	Concept	Implementation of Design Brief and preparation of additional data.	Design brief and concept approval	**Cetterick case study: Resilience analysis at the end of the design concept stage has locked out changes regarding the building forms and building density. It has however delievered important findings to design building striuctures and envelopes more flexibly and with higher building insulation.**
		Preparation of Concept Design including outline proposals for structural and building services systems, outline specifications and preliminary cost plan.		
		Review of procurement route.		
	Design development	Development of concept design to include structural and building services systems,updated outline specifications and cost plan.		**Masshouse case study 1: Resilience analysis at the the design development stage has locked out changes regarding the building forms and building density. Higher building envelopes efficiency is however still possible.**
		Completion of Project Brief.		
		Application for detailed planning permission.		
	Technical design	Preparation of technical design(s) and specifications, sufficient to co-ordinate components and elements of the project and *information for statutory standards and construction safety*.	Detailed design approval	.

Pre-Construction	Production information	Preparation of production information in sufficient detail to enable a tender or tenders to be obtained.		
		Application for statutory approvals.		
		Preparation of further information for construction required under the building contract.		
	Tender documention	Preparation and/or collation of tender documentation in sufficient detail to enable a tender or tenders to be obtained for the project.		
	Tender action	Identification and evaluation of potential contractors and/or specialists for the project. Obtaining and appraising tenders; submission of recommendations to the client.	Investment decision	
Construction	Mobilisation	Letting the building contract, appointing the contractor.		
		Issuing of information to the contractor.		
		Arranging site hand over to the contractor.		
	Construction and practical completion	Administration of the building contract to Practical Completion.	Readiness for service	
		Provision to the contractor of further Information as and when reasonably required.		
		Review of information provided by contractors and specialists.		
Use	Post Practical completion	Administration of the building contract after final inspections.	Benefits evaluation	**Masshouse case study 2: Resilience analysis at the the post completion stage can be used only to be aware of the future challenges that the constructed buildings will have to face with.**
		Assisting building user during initial occupation period.		
		Review of project performance in use.		

Table 23 – Timing of the resilience analysis of the three case studies within the RIBA plan of work, with related advantages and disadvantages

Tables 22 and 23 show how relevant findings developed through the resilience analysis are, and how timely or untimely is the delivery of the information for the purpose of taking an informed decision. More in detail:

- The resilience analysis on the Lancaster regeneration site can provide information at a pre-planning stage and enable the articulation of a design brief informed by resilient strategies. However, this is an early stage in which rating codes assessments may have not commenced yet. Thus, the resilience analysis should be performed independently from them. Alternatively, a rating code including the measurement of resilience must be formulated in a way to include a preliminary assessment at the Preparation stage of the Plan of Work;

- The North Yorkshire resilience analysis, instead, was developed at the end of the concept design stage, in which possibly the environmental strategy to meet assessment criteria are already defined. Whilst some initial decisions might already have been negotiated with local authorities, and a process of renegotiation may be regarded as excessively time consuming from the developer standpoint, the level of detail reached at that stage of development of the design scheme allows a richer evaluation and more specific findings. Possibly, the timing of the North Yorkshire analysis is more in line with the current timing for rating codes. Nevertheless, initial decisions that may have influenced the very nature of the development, the configuration of its open spaces, and the density of built areas have been locked out;
- Finally, and understandably, the Masshouse resilience analysis provides little help for improving the resilience of the development, although, to an extent, can be considered 'educational'. It provides interesting insights as to how formal and environmental parameters can conflict and it suggests that privileging the latter can result in a quality of spaces which is not solely based on aesthetics but on more long-lasting factors (i.e. optimal natural light, sufficient provision of, and sufficiently illuminated, open spaces, etc.). By validating or contradicting initial sustainability ratings, this 'post design' assessment can therefore help refine design procedures or, whenever possible, provide clues as to whether possible future risks can be avoided through, say, alternative approaches to building uses and management of the properties.

As stated before, an iterative resilience analysis would allow developing information that can initially inform the design brief, and subsequently help finalise the design concept. However, in the light of an integrated tool to assess sustainability and resilience, this discussion points at the design stage as the best point in time to carry out the assessment.

In exposing merits and limits of currently most used assessment tools and in comparing these with the assessment model of the resilience analysis, this chapter argues that both are complementary albeit of difficult integration. Whilst the latter provides robust environmental accounting based on the buildings as designed, but little insights on the social and economic sustainability issues, the latter looks at the long-term performance in an integrated fashion but does not provide quantitative evaluations, let alone univocal answers. Nevertheless this chapter has demonstrated that an integrated approach in assessing sustainability is necessary and that the resilience analysis offers a structured system for this purpose. Integration between these two forms of appraisals is therefore desirable although more research is necessary to reconcile the substantially different evaluation models.

Chapter eight - Conclusions

By bringing together the points made in the course of the research, this final chapter summarises its key findings and demonstrates in which way the stated objectives of the thesis are met. It concludes with a brief account of the challenges encountered in the course of the investigation and with an outline of new possible avenues of research.

Rapid environmental, social, and economic changes that characterise contemporary society offer a pressing rationale for this investigation on urban resilience, defined herein as the connotation of a sustainable urban system to resist, and continue to function in the face of, external disturbances (i.e. change). The aim of the investigation is twofold: to contribute to the urban design debate by bringing clarity on this concept that has been extensively used and interpreted in different fashions over the last decade; and to develop and trial professional tools to help design resilient cities. Objectives of the investigation include: a thorough literature review of those studies on resilience aimed at professionals working in the built environment sector; interviews with practitioners supplementing and completing this review; the identification of a methodology to test the resilience of urban development (informed by the findings from the review and the interviews) as well as its modification in order to specifically address the evaluation of buildings and open spaces; the trialling of the methodology on three case studies; and finally a discussion of the findings and on the validity of this scenario-based analysis as an environmental assessment tool in its own right. What follows is a more detailed summary of the most relevant issues that emerged whilst attaining each one of the objective listed above and the conclusions drawn.

8.1 – Summary of the findings on urban resilience

Literature review - The urgency of developing urban strategies for coping with changing environmental and socio-economic conditions has inevitably taken the resilience debate to the centre stage. The literature review on its interpretation and significance highlighted how broad is the range of urban issues studied from a resilience perspective and how compartmentalised these studies are. Five categories were considered that are directly pertinent to the urban context, namely: resilience to natural hazards; resilience to man-made hazards; resilient communities; resilience to climate change; and resilience through adaptability. Some of them clearly intersect or even overlap. Yet, these are presented or discussed separately and with little attempt to connect and integrate where possible. Moreover, the literature examined showed a predominant concern to associate resilience with environmental and man-made threats, relegating to backstage the dangers implicit in rapid social, cultural and economic shifts of society (and requiring high levels of adaptation of the urban fabric). Drawing from ecology studies and complex systems theory, some important analogies with urban systems were brought to light that can offer a helpful conceptualisation of urban systems and with it some important principles. Such principles help go beyond the compartmentalisation with which resilience has so far been treated in literature and offer a model with which it can be analysed through a complex systems approach. These principles include: to envision the urban context as a system in which environmental, social and economic factors interact; to examine for this purpose a sufficiently large spatial and temporal scale; to evaluate resilience strategies of the entire system as opposed to single parts thereof; and to utilise feedback loops and leverage points so as to strengthen the system's resilience. The city is made out of material and immaterial flows, inter-dependent and intertwined (Rotmans et al., 2000). As Mumford (1961:85) states: 'the city is not so much a mass of structures as a complex of inter-related and constantly interacting functions'. In this perspective, it would be unthinking to address, say, only material flows or even each flow independently. It can be concluded that guidance on resilience should be joined-up more efficiently, bringing together climate change, the adaptability of the urban fabric, the flexibility of building uses that can support resilient communities and economy, etc., and eliciting those interrelationships that are so important to envisioning the urban system as a whole.

Interviews with practitioners - The literature reviewed comprises much guidance to practitioners. Thus interviews with practitioners were important for providing insights as to how effective this guidance is and to which extent it helps understand and integrate resilience into practice. Opinions canvassed confirmed that resilience is differently perceived and interpreted amongst practitioners. There is moreover a tendency to regard it as an issue predominantly dealt within specialist sectors (e.g. security, flooding, etc.) albeit recognising it as associated with the longevity of the built environment at large. In that perspective, practitioners interviewed were aware of the limits of current design and construction practice, which is more concerned with the design and delivery of buildings rather than their long-term performance. Some possible approaches to circumvent such an attitude were mentioned, some of them innovative, and the necessity of tools fit for identifying resilience strategies was highlighted. The rigidity of current assessment tools was also noted, one of the causes being their quantitative model of evaluation which is believed to stifle alternative approaches to design and construction. Moreover, their checklist-based format was deemed to facilitate the attainment of sustainability solely through 'environmental accounting', thus eschewing more integrated avenues. The interviews helped recognise those features that must connote a practitioner-oriented approach to identify resilience, which include: the necessity for a qualitative assessment that does not hinder innovation, and the need for an integrated assessment tool that can encompass also the social and economic urban dimensions.

Conceptual approaches to plan for uncertainty - The research in literature of a conceptual approach suitable to plan urban development with a view to the long-term shows that conventional urban planning often relies on tools that are not fit for such a purpose. These include trends and projections on the basis of which forecasts that will inform urban development plans are formulated. It is a linear mode of thinking with a presumption that the present will unfold following patterns of trend extrapolation. Arguably this simplification of reality is necessary to form an initial picture in which forces that can influence the lines of evolution of cities are identified. Nevertheless, as many argue (Myers and Kitsuse, 2000; Hillier, 2011), such an approach is not suitable for the contemporary condition of society, which is extremely volatile and dynamic. Another approach is possible, based on a multiple view of the evolution of present conditions. By focusing on the forces that can determine change, and by ascertaining the plausible directions of evolution resulting from different interplays of such forces, it is possible to trace a map of alternatives, which can be used as a design and/or planning tool. It can be concluded that as resilience is about responding effectively to uncertainty, scenarios are tools fit for such a purpose. They enable a scanning of the risk horizon in a systemic fashion, since their narratives can capture society's dynamics in all its many facets. Scenario-based methodologies are currently used in many sectors to explore strategies for coping with uncertainty and future challenges, although a scenario-based tool to appraise urban development for a practitioner audience is much needed.

Adapting existing tools to analyse resilience - The Urban Futures method was identified for this purpose, although two important limits were ascertained that required modifications. Firstly, the Urban Futures method is designed to appraise individual options whereas urban designers need to consider many simultaneously, in the same way as rating codes assess many categories within the same framework. Secondly, scenarios required a further level of definition so as to integrate and detail some characteristics of relevance to urban designers and planners. Consequently, such characteristics were developed by the author through consultation of relevant literature. Moreover, a multiple analysis was attempted to evaluate simultaneously a range of energy efficiency measures for buildings and an Excel-based interactive tool was developed that can examine diverse solutions together. Both attempts show that the multiple analysis produces a series of findings with ensuing recommendations, which can be used to compose the map of possibilities mentioned above, and elucidate the systemic nature of the urban context. In its modified form (called here resilience analysis) the method was tested on three case studies.

Case studies - The analysis focus of the case studies was on energy. The holistic nature of the scenario-based method, however, allowed the exploration of socio-economic, policy, cultural, and behavioural factors directly and indirectly connected to energy strategies. It also spurred the emergence of other urban design parameters that can be influenced by the enhancement or the attenuation of such strategies. From this exercise three conclusions stand as emblematic of the essence of the resilience analysis and thereby of the approach necessary to designing resilient cities. First, the resilience analysis does not deliver an unequivocal answer but rather a series of possible avenues leading to the design of a strategy for resilience. It is clearly a consequence of an analytical approach based on multiple perspectives in order to deal with long-term uncertainty. Second, the measuring of resilience may be better suited to deliver qualitative rather than quantitative evaluations. Finally, the resilience analysis is context sensitive because it focuses on conditions to retain the long-term functioning, which are inevitably dependent on the evolution of the local situation responding to more general pressures. These are therefore three features inherent to urban resilience that set the direction to a new attitude for planning and designing resilient cities, which cannot rely solely on 'sustainability accounting' but must reinforce it by probing in a systemic fashion the consequences of design choices.

Advantages and shortfalls of the resilience analysis – On the basis of the three case studies, advantages and shortfalls of the resilience analysis were discussed and, more importantly, its characteristics compared with those of current most used UK assessment methods, namely BREEAM and the CSH. Limits of the resilience analysis include: the difficulty to measure resilience quantitatively (as opposed to qualitatively), which would enable the evaluation to be regarded as reliable and repeatable through an established numeric procedure; and the multiple findings as opposed to an univocal outcome resulting from the rating code procedure. These limits however, are also its strengths since they allow the high level of flexibility in determining design strategies, which was one of the features practitioners believe current EIAs lack. It was noted in the course of this research that many frameworks to embed sustainability in urban development result with the definition of targets which are inevitably static, crystallised at a point in time. As society moves forward, these targets will move and a resilient built asset must adapt accordingly. The resilience analysis can help addressing these dynamics. The timing for developing the resilience analysis within the sequence of building design and construction was also discussed, showing the advantages and disadvantages of undertaking the analysis at an initial design stage, at a final concept design stage, and at a detailed design stage.

The exploration of multiple avenues, the acknowledgement of the dynamicity of the urban context, the necessary trade-offs amongst a multitude of factors are expected to foster a different mindset in those involved in the making of cities. The undertaking of this alternative approach can be facilitated by the resilience analysis if used as a design tool. The discussion chapter outlines possibilities and challenges this may entail. It evaluates the differences between current rating codes, as the most used assessment tools amongst practitioners, and the resilience analysis, with the former biased towards environmental efficiency appraisal and the latter attempting to transcend it so as to integrate the long-term and historical shifts within the evaluation process. The two approaches are different and at the same time complementary. Integration is invoked although substantially different structures make it difficult. Ultimately, the necessity of a new fully-fledged integrated design tool is recognised in order to facilitate practitioners to a transition towards a new approach to designing cities, with the resilience analysis representing an initial although promising step forward.

8.2 – Challenges encountered in the development of the investigation

Challenges encountered in the course of the research were many and of different nature. What follows is a brief account describing the most relevant ones.

A major challenge was represented by the inter-disciplinary and experimental nature of this research, which requires the utilisation and interlocking of several methodologies from disparate fields of knowledge. Clearly, the exploration of new approaches to research comes with the difficulties of developing a coherent construction of a new methodological sequence, and establishing connections amongst disparate methods of investigation. It also comes with the further burden to acquire information on methods that do not pertain to the comfortable terrain of the discipline within which the thesis is developed. A case in point is the selection of content analysis for the interviews, which requires consultation with social scientists, the study of textbooks, and mental elasticity to undertake research in unknown territories. Ultimately, the harmonisation of the several methodologies resulted in much time allocated to discussion with supervisors, colleagues and other experts in order to ensure the consistency of the research progress. In turn this resulted in a formative process, since it required dialogue amongst experts from different disciplines, and a fruitful exchange of views that unlocked new research attitudes and perspectives.

The development of the scenario-based can pose difficulties for those who are inexperienced. Although the UF methodology (and the resilience analysis) is designed to reduce its complexity so as to make it manageable to a wide professional audience, difficulties in understanding its logic and dynamics still exist. As a result there can be resistance in willing to engage with it for many reasons. First, it does not match with the conventional perception within the professional domain of an environmental assessment method, which is often based on checklists or other rigidly structured procedures. Second, the consultation of scenarios and characteristics can be laborious and it certainly requires several attempts before its inner workings can be demystified. Finally, there is resistance amongst practitioners to accept future urban scenarios as a valid tool for risk assessment. This is possibly linked to the entrenched attitude to measure environmental performance (and any other type of performance) through numeric evaluation, as discussed at length in section 7.3. It may also be linked to the tendency to regard scenarios as predictions of the future of society. Those who engage with the scenarios can therefore become excessively involved with the narrations to the point of regarding them as actual forecasts, whereas, as illustrated in chapter five, they are merely a tool to explore long-term consequences of choices. Such a response to the use of scenarios was noticed by the author and other members of the team in different occasions during activities of dissemination of the research. It was also noticed by the author during consultation with experts.

Possibly as a consequence of resistance to innovative methods of analysis, or more generally innovative concepts, there were difficulties in finding companies within the construction industry (or even architectural/urban design firms) prepared to trial the methodology on one of their projects. Thus the research for a third suitable case study was not simple. Companies can be unwilling to experiment new tools or approaches whenever the advantage that these can bring is unclear. Although substantial attempts were made to focus the resilience analysis on those particular issues that may be of interest to an enterprise in the construction sector (i.e. long-term property values, etc.), the tendency to resist experiments and innovation can still be strong.

The non-liner development of the investigation also posed a substantial challenge. Possibly there is a degree of ‘messiness’ in all scientific and academic research. The demonstration of the original hypothesis or research question may require probing several avenues before finding an effective direction, or it may require returning several times on assumptions that proved incorrect. However, the particular history of this investigation resulted, to an extent, in articulating the rationale for an empirical investigation that had already started. The resulting process was at times confusing, and it required flexibility and patience to overcome obstacles as well as many reviews of the initial intended objectives. What follows is a brief summary of more practical challenges encountered in the course of the investigation.

A selection of literature on categories of urban resilience was carried out, thus excluding some. In itself, operating a selection when discussing resilience can be a controversial strategy, since it counters the idea that this can be grasped only holistically, at a system level. The exclusion of literature on resilient infrastructure, or on resilient economy, for example, can be debatable since the built environment surely encompasses such aspects (see Rogers et al., 2011). Notwithstanding the importance and possibly the urgency of an exhaustive literature review on all the dimensions directly and indirectly connected with urban resilience, in the opinion of the author the final decision to narrow the scope of research did not impair its robustness. Although it was a decision dictated primarily by the necessity of delimiting the scope of investigation to match it to the time line of this thesis, it allowed a more in-depth analysis of the resilience categories selected, and it did not impede reaching some valid and general conclusions. By the same token, the decision to develop case studies focusing exclusively on the energy efficiency strategies could appear, to an extent, arbitrary. This particular focus was selected because regarded as pertaining predominantly to the field of building’s environmental efficiency, thus appropriate to demonstrate whether and how there is interdependence with social and economic factors. It was also decided to keep the same focus for all case studies so as to compare results. Arguably, the analysis of other sustainability options of a diverse nature would have further tested the potential of the resilience analysis. However, this would have required developing other case studies thus excessively extending the time for this research.

The decision to limit the number of interviewees to eleven was also predominantly dictated by time issues. As a consequence, and as argued in chapter four, the number of interviews does not allow any generalisation although the particular professional position of the interviewees leads the author to surmise that, to an extent, opinions expressed capture the common feeling of the professional category. Arguably a wider series of interviews would be necessary to provide a robust understanding of the way resilience is regarded and interpreted in practice. It could be also argued that a literature review could in itself provide a sufficient basis for the theoretical investigation of this thesis, and that interviews do not add to it findings that can be of theoretical relevance. It must be noted however, that the opinion of experts in the field of the built environment facilitated transferring theoretical findings into practical applications, thus introducing the empirical investigation of the thesis. Therefore this initial canvassing should be envisaged as a contribution that helped the investigation in two ways. First it helped identify some features that possibly practitioners would expect an assessment tool to possess. Such features include: a less prescriptive structure and a focus on qualitative, as opposed to quantitative, evaluation. Second, as a collateral contribution, some novel aspects of resilient buildings were highlighted that point at new directions in designing and represent the outline of a future research agenda. These include: the relationship between shifts of styles and building obsolescence, and a lifecycle analysis scope broadened to include the decommissioning of buildings and infrastructure.

Another difficult choice was the one related to the selection of case studies, which privileged, to an extent, homogeneity of features (i.e. mediums sized developments as opposed to individual buildings or large scale developments). This decision enabled a comfortable comparison of results to the detriment of the trialling of the full potential of the resilience analysis on diverse cases. All these decisions indicate that the second part of the thesis, in which the identification of strategies for resilience through case study analysis and from a practitioner's standpoint has been developed, must be considered an initial attempt that necessitate further investigation. By the same token, the discussion of the resilience analysis as an assessment tool in its own right must be regarded only as an initial outline of a future research agenda. It demonstrates and promotes the use of integrated assessment tools, and recognises the limits of current rating systems and those of the resilience analysis. More investigation is necessary, however, to ascertain how these can be overcome.

8.*3 - Further Research Opportunities*

Given that urban resilience is a very topical subject, its nature, definition, and boundaries are at present continuously debated and changing. The recent first International Conference on Urban Sustainability and Resilience organised by the Centre for Sustainability and Resilience at the University College London (see www.usar-conference-2012.org), for example, included sessions on food and the city, the role of open spaces in urban resilience, resilient urban transport systems, social capital and adaptation, behaviour change, and more. The widening of the horizon of urban resilience studies only demonstrates its relevance to the debate on sustainable cities and the necessity to encompass and integrate all aspects of the urban environment within its scope. The emerging strands of discussion within the conference also pointed at gaps in the existing guidance for urban resilience here reviewed, some of which overlap with those debated in this thesis, namely: its ambiguous connection with sustainability, its sometimes diverging interpretations, and the difficulty of translating theoretical findings into practitioner-based approaches.

The resilience of food systems, for example, has been much investigated in the UK (see HM Government, 2010; Foresight, 2011). The integration of food production within urban design and planning as a strategy to build resilience against a future of resource scarcity, however, is only at its infancy (van der Schans and Wiskerke, 2012), although some studies are available that investigate the impact this practice would have on the urban environment and the advantages that would bring to its resilience (see Viljoen, 2005) Likewise, the contribution of an enhanced green infrastructure to urban resilience and to a wider resilience of socio-ecological systems has been mentioned in the course of this investigation (Pickett et al., 2004; Folke, 2006), and would require further attention. Still an exhaustive review of these new emerging topics could open new perspectives to resilience studies and, more importantly, could help understanding their role within a truly integrated design process that looks at the long-term evolution of cities.

The power of the resilience analysis as an assessment tool in its own right was demonstrated. It is consistent with the model of resilient city that has been outlined in this thesis. Still a brief comparison with current mostly used assessment tools identifies some contentious issues that need to be resolved. Its difficulty in producing quantitative evaluation in a context in which sustainability is predominantly measured in its environmental efficiency can be envisaged as a drawback by the audience it addresses. More effective arguments must be developed that support the value of qualitative evaluation. For this purpose, a more effective integration of qualitative and quantitative evaluation should be developed. Additionally a numeric measurement of resilience could be attempted. This issue requires much investigation if the analysis of resilience is to be integrated into practice.

Finally, it must be stressed once more that the relevance of the concept of urban resilience is also a consequence of the awareness that short-term choices cannot be sustainable. Thus research and design efforts must focus on alternatives to conventional methods of urban planning and design that shift the emphasis on the long-term consistently with the intergenerational obligations inherent to the sustainability discourse. Much research exploring structured approaches to design has been developed recently, thus demonstrating a strong interest in this issue. Tony Fry, for example, in his recently published book "Design Futuring' (2009), provides the rationale as well as a design methodology to cope with long-term changes. He maintains that ' while the inability to project our action in time seems to be a structural limitation of our mode of being, overcoming this condition and acquiring much greater futuring capability will become an increasingly vital factor for securing our ongoing being'. For this purpose 'futuring scenario building is the key methodological tool of designing from the future to the present'. 'Unless this is done, later events can make earlier decisions redundant or expose them as inappropriate'. In line with this attempts that tries to break the mould of a possibly innate attitude to think for the here and now, the ultimate purpose of this thesis is to contribute to a paradigm shift in planning and designing sustainable and resilient cities.

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Appendix 1

Interviews with practitioners

Categories	Questions for interviewees
Individual and collective meaning and interpretation of resilience	1 - Do you think resilience is a familiar concept in the planning and urban design field? How do you think it is currently interpreted? How do you interpret it?
	2 - Do you think that in current practice the notion of resilience is also associated with one of longevity of buildings and of the built environment at large?
	3 - Given your interpretation of resilience, could you specify how such a concept is addressed in the planning/design process, and with what tools? Could you also specify how do you address resilience in your profession/practice?
	4 - There is an assumption, in many disciplines, that resilience is a positive quality. It implies that what is planned needs to last and perform well for as long as its physical form lasts. Do you think this is achievable as far as the built environment is concerned?
Applicability/measurability	5 - Do you think the long-term effectiveness of what we plan could be achieved through the application of a set of principles, or guidelines, that can inform the initial phase of the design/planning process? - (Qualitative approach)
	6 - Conversely, do you think that a long-term effectiveness can be best achieved through a value-based approach? For example, by establishing performances that should be maintained over the life time of the built environment (e.g. a level of energy efficiency, buildings adaptable to a given number of uses, percentage of open/green spaces available per inhabitant, etc.)? - (Quantitative approach)
	7 - Do you think that resilience is measurable? If so, how and with what (qualitative or quantitative) indicators?
	8 - Do you think resilience (as for the definition stated above) as an indicator could (and should) be integrated in assessment tools, or rating codes, such as Code for Sustainable Homes, BREEAM, or Green Print?
Scale	9 - Do you think the nature of resilience changes depending on the scale considered? If so, could you define how?
	10 - Do you think resilience is a concept applicable to a single intervention, or at a building scale, or at an urban development scale, or at a larger scale, or at all scales?
Sustainability and urban resilience	11 - Do you think resilience and sustainability are distinct or related issues? Could you define their relationship?

Interviewee n 1
Climate and Sustainability Manager for a big City Council

I deal with the green infrastructure of the city and adaptation; I am involved with major developments, policy formulation and implementing new programmes and initiatives.

1 - It is not particularly understood. Resilience is not a major criterion for assessment and most major developments only have to meet a fairly narrow set of criteria. Some of these have to do with design quality and quantity of provision (e.g. homes, infrastructure, etc). The main emphasis is on working to a timescale and budget. Urban development is mostly designing for today not the future, with the exception of some BREEAM builds.

2 - No, it is about fit for purpose over a period of time. The emphasis is on current deliverables, on assessing its immediate application not its performance over time. The built environment is assessed against Building Regulations or other legislation that has little consideration for the future. The city passes the responsibility to the developer, it's at the developers risk and most developers are not the owners; we all are – a complete flaw in the planning process at the moment! Highways are a major pressure in the city and risk assessments have a narrow, local scope, failing to consider the new planned infrastructure as part of a network, and as such with liable to take or to add pressure on the entire system.

3 - West Midlands Sustainability Index and the PPSs/PPGs cover some aspects connected that can produce resilience. Climate change is forcing professionals to lengthen (say 20 to 30years) the time-horizon of risk analysis and to accept academic guidance (as there is little professional guidance available), which has shifted the goal posts again.

4 - No, it must connect with other infrastructure and also question how it connects to people.

5 - Yes, it would be a linear progression in relation to scale. The more you intend to change the more that needs to be considered.

6 - Yes, I would say it is achievable. We have historic developments that despite being designed more than 200 years ago perform well today with some small alterations/adjustments. The solution is not to tie it down to a numeric factor and must be more flexible, so that strategies can build in flexibility.

7 - It's surprising that some of the worst performing buildings in the city have been built in the 1980s. We need a qualitative measure, although in reality you need a bit of both. However the number should not be fixed, solutions should not be tied down to numeric outcomes. Feedback loops should allow knowledge to be updated.

8 - There is a risk of locking yourself into numbers for example the green provision is still based on a playfield act from 1926. Numbers are moving. It is more important to relate to people and social needs.

9 - Yes, but perhaps not sufficient in their own right. Rather than indicators that measure resilience, current indicators should incorporate and be corrected through their resilience factor.

10 - Yes, possibly as an industry standard test where resilience becomes the end goal.

11 – Maybe we should focus on delivering resilience rather than sustainable development, which policy makers still do not fully embrace. It is also seen as the preserve of the few, whereas the outcome affects everybody. Resilience, instead, could be a concept that industry and developers could easily understand: it can deliver quality.

Interviewee n 2
Architect: Designer, academic, and consultant

Chartered Architect, key role in RIBA, currently Course Director of the Postgraduate Diploma in Architectural Practice in a leading UK university, she is also a partner in an architectural and planning consultancy specialising in unusual rural casework.

1 - Resilience is confused with longevity which it shares many concepts. Flexibility within the Built Environment has been around since the 1970s and a view to change within the life of buildings, the longevity of buildings in terms of a low carbon economy. Resilience means different things to different people, i.e. resilience to climate change, protection of flooding and defence. Using the word ‘resilience’ implies defence ability. Resilience is also looked at from a social stand point.

2 - Yes, Michael Gove doesn’t invest in good design and therefore urban developments will have a shorter life. In current practice we design for a design life of 20 years, it is a concept related to insurance and performance of material. However the most durable being stone, concrete have had damaging consequences on the environment, on the carbon footprint, and the future usage of the building.

3 - We need to ask do we want longevity?; should we recycle buildings into something new?. Buildings are capable of being reworked, stripped back to their frame to provide space for many uses, i.e. the Angel building in Islington, retail warehouses,.. should there be an intention to live forever?, a design life of 400 years, where these parameters are worked for historical environments such as the college in Oxbridge. Some building technologies are more suited to be recycled and therefore they can be recycled and perform well in terms of longevity (concrete frame). The profession needs to consider the building in parts where some could last and some are unlikely to last and each one should be designed consequently.

4 - It would be very useful to give people the tools to design at all scales. One thing that resilience cannot stand is fashion. Buildings that were believed to have been resilient have failed on fashion. There are two things working against architects when considering the design life of buildings, one is the annual economic cycle and the other the 5 year political cycle, as with Climate Change are predicting future usage. What is needed is tools that will set the bar, to sort what can be achieved in the next 5 years and what is to be considered in the subsequent years. A tool could show the carbon emission and show what the options are and specify the appropriate building technologies.

5 - It is important to consider that decisions taken at one scale will have an impact on the longevity of classes of use.

6 - Unless it is legislated for it’s not done. Maybe the question should be turned around because the performance of the buildings’ needs ends sooner than its physical form. The changing needs of society and the environment impacts change in and conflict of use. There is a need to define the degree of flexibility. Developers have been trading for land and land is expensive and they need to get a return, industry is caught up in its own trap! We expect considerably resilience from our housing stock in spite of that we have here in the UK the

smallest housing sizes in Europe (Housing Campaign, RIBA (Mayor of London, size standards made compulsory) 80% of housing is already built and difficult to adapt, 20% of trading is in land not housing and is run by Quantity Surveyors. A tool to assess performance of housing stock is needed.

7 - I've fallen out with quantifiable approaches, you cannot quantify some environmental elements they are a given, it is a Capitalist approach where the value of good design is quantified and therefore you can save money for not doing it! Beauty cannot be defined in terms of quantity; it is inherent need in human nature. One can't imagine allocating a prize to measure environmental benefits.

8 - It is a bit of both (quantitative and qualitative).

9 - Concepts are fragmented, there needs to be a tool for decision making to assess the longevity, it's whether you can convert people to your understanding of resilience.

10 - PFI has in built resilience to 25 years however didn't produce good architecture although it was driven by resilience.

11 - Sustainability is environmental resilience and we can make statements about achieving it but we are a long way off a quantitative approach.

Interviewee n 3
Director in a big design practice; experience in teaching urban design; delivering CPD for RIBA

Architect working independently. Previous work experience include: twenty years as a director in a big practice; work for government sectors; teaching in urban design courses; participating to international workshops and editing papers related to the workshop outputs; collaborating with RIBA and delivering CPD for them.

1 - It is familiar with those who work in security, for example counter terrorist advisers for buildings and building procurement. I am specialised in law courts. Many design aspects of these buildings need to comply with security issues. Buildings are designed to have elements of high resilience that have not been designed specifically for that purpose (fire resistance etc). I am interested in risks and I consider resilience as risk management in the wider sense. But mainly it is difficult to discuss with other people about resilience in relationship to changes that can happen thirty years away from now. Buildings may not last that long.

2 - The interpretation is of longevity as an attitude to adaptation. The opposite attitude is: 'if it doesn't work get rid of it'. Longevity from a sustainable point of view is good. I lived in a council flat. Now that building block has been pulled down. I live now in a Victorian house that has more than 120 years.

3 - As a designer you have to think in terms of building elements which need continuity and others that need change. For example, there are elements in law courts that are designed to be safe and are very fixed (e.g. custody wards). Other parts of the building may need changing and they often do so. So it is in hospitals. In buildings you can have both extremes.

4 - It is applicable and must be consistent at all scales. But I think it is particularly relevant at an urban scale because it relies on context. You can have a resilient building in a neighbourhood that is not resilient, and in this case the resilience of the building can be undermined. This brings up the question of brief. Briefs of individual buildings do not usually

address the relationship with the urban context. However, it would be difficult to contribute to the resilience of the area through the resilience of the building only.

5 - It must be. We now build buildings far from coasts because of flood risks. Buildings can be designed to be sustainable, but if they are built at sea level or if they can be supported only by specific socio-cultural contexts, they will not be resilient.

6 - Yes, although the concept of ‘long-lived’ must be defined. There are places where building obsolescence is artificially determined by rising land values.

7 - When there are no guidelines, chaos ensues. If goals must be achieved that go beyond the private interest of clients and developers, then guidelines are necessary. In Netherlands, political will made sure that guidelines for flood protection were agreed, and mechanisms to protect them regardless of the alternation of parties in power were put in place so as to protect those guidelines into the future.

8 - Yes. Quantitative objectives are part of the picture, since you need to attain good standards of environmental efficiency.

9 - Probably it is possible to devise a scoring system, although it may come with threats. It is possible to formulate specific questions and give a score according to the answer. For example: can business be carried out in the building if there is no power for up to three days? Can the building resist to fire? Can the building survive in absence of trade? Scores given to all these factors can then be added and the level of resilience determined. However it is important to consider the type and quality of intervention. You can protect buildings with barbed wire fencing or design in elements that fulfil the same objective through soft features (e.g. landscaping etc). A security feature at Aston stadium consists in an art installation preventing cars to reach the stadium. Scoring systems can be of help but nobody wants to end help with buildings like concrete blocks because of security reasons. It is essential to think of the context.

10 - Yes. In general, it is good to raise awareness on resilience amongst professionals. Sustainability or even accessibility should be principles that need to be integrated in all aspects of the practice. So it should be for resilience.

11 - These are two different concepts. I think resilience is integral to sustainability. Resilience leads to a smaller ecological foot print of buildings. Saving money and resources is sustainable.

Interviewee n 4
Architect directing own practice and working in urban design schemes, also overseas

I am a Chartered Architect and Director of Urban Synthesis Ltd, presently working on master planning projects in China and in East Europe. The way China operates is very much economic-driven. In China master planning is brief-driven and not design-driven; the client brings in consultants to deliver the brief. We are attempting to introduce mixed-use developments, although this concept is not embedded in policy, and therefore recognised as an option. I could see tools for assessing sustainable urban development being used either to assess initial briefs, or to assess technologies for brief implementation.
1 - In the UK the concept of resilience is familiar although is confused with the one of sustainability and/or robustness. It is perceived as something that has much more to do with technological and much less with socio-economical issues. I think the emphasis should shift

from the environmental to the social, the cultural. It has to do with adaptation. There is a bias of ‘being green’ which is used as a political issue.

2 - Current practice has a green bias. Wider issues are not considered.

3 - As designers we can be specific on what we deliver. Other practices will look at resilience in different ways. There is often a whitewash approach to resilience that doesn’t take into account local diversities. In China we are attempting to retain communities by enhancing local resources to meet local expectations. Instead, the traditional planning approach would have wiped out everything to rebuild it new. The UK has a different approach. In China, we have even attempted to introduce the concept of urban farming, which was accepted, for an urban development adjacent to a rural area. One needs an understanding of the local conditions and the brief should be set accordingly.

4 - I think it is applicable at all scales. Even a tree can transform a place and recoup a community cohesion making it more resilient. For example, a tree was planted in an open area with a seat around it, that simple tree has attracted elderly people, they gather around it. Now that open space is often populated and very popular. This was very symbolic and at very little cost, it changed the social dynamics of the place.

5 - It changes according to scale, although connected at all scales. In fact, the complexities become greater the larger the scale becomes.

6 - If you analyse local conditions and you let those issues drive your design process, than you probably can deliver resilience. You still need to tick all the boxes and make sure that your design is environmentally sound. However, looking at the local context and answering to those needs may result in resilient environments (i.e. Villa Bordeaux). At the same time, it is essential that the planned urban development meets also the political and economic agenda in order to be accepted and brought forward. Resilience is not permanence; the urban environment needs to adapt to change. Victorian buildings are resilient because able to adapt and still retain their historical presence.

7 - I am diffident of quantitative approaches.

8 - Having enough time for analysis a qualitative approach can be developed and detailed in a quantitative assessment. For example in our Chinese master-plan that includes urban farming principles, we have assigned 30m^2 per person of green land for cultivation. Clearly, having time and resources, this standard would have been tested to make sure it meets the real needs of people. I believe though that bad design comes when there is an overreliance on quantitative approaches.

9 - You cannot measure it when you try to embed it. You can only measure it in hindsight.

10 - I think BREEAM is nonsense. It is a political tool and can be tweaked as you like. It produces big reports that add value to the project. Contractors have learned how to manipulate rating systems. CSH in principal is better but falls in the same trap of generalisation. Codes should be used not only as quantitative standards.

11 - I think they are the same, although not strictly referring to environmental aspects. My understanding of sustainability does not have an environmental emphasis, however in current practice it does.

Interviewee n 5

Head of an organisation promoting good design in the built environment

Chief executive of an organisation promoting the quality of the built environment and facilitating cross profession, cross developer discussion through initiatives such as public lectures and design reviews.

1 - Resilience is becoming a more familiar concept, not sure it is understood or that I necessarily understand it. I think it is interpreted from another word, the ability of the physical form, a place to last over time, to succeed, to flourish. I think this is set in the context of extreme events, i.e. financial crashes, extreme weather conditions and climate becoming more fashionable.

2 - The term is more commonly used in a societal context, rather than longevity, however it can be used to think of both, the physical form.

3 - It is addressed as a process of future proofing, thinking about change and risks that may arise. I think today we look at more extreme events than we did in the past. I think we are raising a debate not necessarily under the banner of resilience, for example, through our Talking Cities lectures, Mary Rowe and David Engwicht. They are about the form of resilience that is saying we can take action, that we have a model that rather than large amounts of public money which would make this happen, finding other ways of progress. As regard with Design Review, resilience has come up and panel members have raised questions regarding changes in the weather, financial.

4 - At all scales, I think it is less significant at a smaller scale; future transport for example cannot be dealt with at a scale of a single building. Certain decisions are relevant at a single intervention, at a larger scale you would need to look at all the scales.

5 - At a larger scale you would need to look at design decisions that will impact the local, integrating solutions at the larger scale also requires different types of decisions to create something that is adaptable.

6 - This is a complex question. There is a lot of discussion to the extent that we can accept the temporary (area in Brooklyn, containers like Gabriele Wharf in London). Understanding the concept of resilience is not about building to last, but I think the urban form because of its cultural power, is important. The retail core of Coventry, a comprehensive redevelopment was undeliverable as it failed to connect with existing street patterns and circulation, cultural importance and memory. When it comes to the urban form stable with gradual evolution is what is needed. If all structures were temporary it would feel like we were living in shanty towns. The more robust the urban form the more successful the temporary. Different timescales apply to different buildings, one would expect a cathedral to be robust, it is all about the different timescales.

7 - I think things are always useful, partly because not everyone can always be skilled and/or educated to the same level. It also provides a frame of reference, a common language. By Design was published 12 years ago yet it still provides a frame of reference. It helps to structure your thinking, not necessarily building from them but it fosters discussion. However it is no substitute for good design, for good practice. People who look at it and then use it for self-criticality to justify their schemes are just ticking the box.

8 - Quantitative tools can be useful, especially when talking about things that are technical in nature. When you talk about % of green space per habitant, you must factor in quality, choice and preference. Given that in Birmingham the percentage of green space is high it

does not perform well. I suppose if you can come up with numbers there is always a power in numbers however not everything that can be counted counts and not everything that counts can be counted!

9 - Yes, I think we have to strive to measure it. It is an overarching concept with many dimensions, you have to break it down, you could find ways of measuring them, and in some cases they are a starting point for discussion. It is all about a variety in choice and sometimes there are reasons why something has a low score. There's always got to be a get out clause!

10 - Resilience is a way of thinking about things and like sustainability there are indicators and maybe some indicators are the same, some that we are already using but about other things. It's a different angle, different prisms of looking at things. However there is a danger that quantitative indicators can oscillate cultural acceptance.

11 - The English language has lots of words that say the same thing, but the argument is that they are not really the same. I think they evolve different things. Sustainability is about not messing up the future when Resilience is about coping with the future.

Interviewee n 6
Project architect id design company, mainly working in architecture

Chartered Architect. Project architect mainly working on individual buildings. Clients include public and private sector. Currently working for a charity as a client, with which is possible this client to engage with sustainability issues.

1 - Resilience is not a concept that we are familiar with. It may have an understanding within a larger urban setting. My understanding of resilience is future proofing a range of different things, such as economic, user requirements, how clients will use it, materials, strategy for construction i.e. load bearing or frame construction. I interpret future-proofing as the ability to be relevant for a long time. It is about educating the client, making them understand how quickly the brief and their needs can change. We are revisiting a scheme only 3 years after completion due to a need for changes in layout. Often, the client has no understanding of how these things work. A building is never static. A building should change throughout its lifetime. I sometimes work on refurbishment projects, in which you have to work with all sort of structural and contextual constraints that make you think of how adaptability could be achieved better. Resilience is about flexibility to change.

2 - Yes it is. You end up with different clients with different expectations of timescales. For example, the building we are working on at the moment is community-owned; it is therefore possible to think about it over the long-term, and we consider in any design choice the flexibility of architectural features. Different building components have different timescales; it is also about envisaging the organisations' needs.

3 - It is addressed within a decision making process, in our practice we rely on shared knowledge and do not really use checklists. It depends on the expertise of the client and its request to comply with standards such as BREEAM. BREEAM is all to do with funding, it is time consuming and so much of it is pointless and doesn't necessarily deliver sustainability. It delivers an engineered design, which leaves nothing left for architects to design. The agenda now is much wider than the one pictured by BREEAM.

4 - At all scales. It is applicable to scale, cost and the duration of the project, and making an informed choice. Although there can be a risk of designing buildings that are too resilient.

5 - It is all about context, we are quite an intuitive practice. You need to spend time to understand the correct context in each project. Once this happens informed choices can be made. Unfortunately there is rarely enough time to dedicate to the study if the context.

6 - I do not necessarily think it is positive. I'm not sure I agree with that. Resilience is not really about endurance, it is not just about longevity. It is about adaptability. One can argue that old churches are still standing, but if they are not used it is because they are not adaptable. Warehouse buildings for example have proved to be resilient in that they were made to high quality and adaptable over a long period of time. Maybe resilience is not always necessary and we have to accept that buildings can be demolished. Instead, urban fabric needs to be more permanent.

7 - Yes it can be achieved through a set of principles, but it should not be such a linear process. The danger with sets of principles and guidelines is the sheer preponderance that stops you thinking. Design is an iterative process. It is more to do with a set of pointers than answers.

8 - I think you need to do what is appropriate at the time. As buildings need to become more energy efficient we are looking at passive measures, orientation, maximising solar gain. The question is when do you apply these things? We bring in sustainability consultants who work with the client on building technologies, this is very much a scientific approach and it works.

9 - I am not sure whether you would be able to measure it in advance. This is an economic question: what is the life time cost? The retail buildings in the city centre that have adapted over a number of years justify their life time costs. So this is evidence that could justify higher initial investments. It could be an interesting approach.

10 - I'm not sure that it could as an integrated tool. I am not sure how compliance could be demonstrated.

11 - I'm not sure that they are different. Sustainability covers a wider concept, resilient buildings should be sustainable because they last longer and therefore have a reduced carbon footprint. It is about a rational use of resources.

Interviewee n 7
Architect with long experience in procurement in the government sector. Experience on building industry standards

Chartered Architect, working for 18 years in the government sector, particularly procurement, home office projects, estates, DGI, design reviews, construction. Sitting on a cross-government committee, CLG, working on area plans, conservation, streetscapes, defence, court services. Experience on building industry standards.

1 - Resilience could be determined through life cycle cost, a life cycle cost approach. In design reviews I always ask 'what is the design life and for is it for?' For example, infrastructure (M&E) is always 100 years or more. I would see resilience as relating to robustness, the value of elements, life cycle doesn't just mean physical but also the adaptability, change of uses, the social user requirement, the broader cultural issues, its physical fitness, systems resilience and usability. The word resilience in the environment, where I tend to work it tends to be just physical. But I would think in terms of system's resilience.

2 - I would say both. However, different sectors can develop these things in different ways. Yes, but one of the problems is that they all have different viewpoints. Life costing has the word cost in it, that is high jacked by quantity surveyors. Private finance initiatives (PFIs) are major contracts where you might think of life cycle approaches, structures documents, not architectural they are very technical and not design soft, [there are some interfaces].

3 - The post occupancy evaluation (POE) looks at softer issues. While life cycle methodology is reliable, solid, and consistent, it doesn't look at social issues and it would be interesting if those were integrated in the classic LC analysis. It would be also important to integrate soft issues. The British canal offices, Associated Architects are looking at costing and resilience, trying to reconcile some of the hard issues using a systems approach, but this is woolly, it's always vague. Another examples working from first principles is school design, open space plans to create learning environments. BDP created workspaces applying the same concept. These methodologies are also useful for outdoor spaces. There is a cultural change in efficiency thinking about flexibility and resilience, (Brigit Hardy, OGC, Francis Maud, Working without Walls).

4 - It should be holistic, buildings are powerful structures, political. Issues should be transferable at all scales as some of the principles stay the same. The problem I think is always one of hierarchy, professionals taking a leadership role, facilities management (PFI). There is also an issue of definition of success, which varies depending on buildings and places (how do you judge the success of a reactor or of a public space). How do you judge the performance of a place, the public realm? How do you judge longevity? The trend in the public sector is deskilled clients, clients are making poor decisions.

5 - It is about money and investment, cost and value create problems. Sometimes it doesn't take into account the value and its cost and how it can contribute.

6 - Yes, scaleability, it must do, it costs more at a larger scale and therefore corners are cut. There is not enough time for designers to assess risks or assess how it will perform in the future. We live in a virtual age, mentally, socially, culturally, people want change and they want it quickly. The built environment is expensive and a valid long term solution is really tricky. We are spending money and making decisions now when we don't know where we are going to be in 5 years. Built assets and infrastructure are expensive still need flexibility. Flexibility and permanence can be conflicting, and resilience entails acceptability in relationship to cultural values that change. Cultural meaning is juxtaposed with quite arty sculptures.

7 - They should be integrated (qualitative and quantitative)

8 - Yes, it can be but you need to look at the market, what will it add? The built environment is always a compromise between quantitative and qualitative, hard and soft aspects, it always needs a balance. You can value costs and there are many methodologies for this purpose. Also, I would not use the term scientific, but technical.

9 - It is measurable, reconciling the hard and soft measures, some of it managing fickle perceptions.

10 - In principle yes, an assessment but these things flow into one another, the blurriness of the interfaces.

Interviewee n 8
Planner, working with local council as site manager, previously working for HCA

Major site manager in the Physical Regeneration Team at Newham Borough Council. Currently working on a number of large derelict sites to be developed, dealing with potential investors/developers and linking all stakeholders (developers, community groups, council, etc) in order to enable and facilitate the regeneration process. Previously working for the Homes and Community Agency on some development schemes taken to completion.

1 - Sustainability has been superseded by resilience, which has been the new buzzword for a couple of years. Now practitioners are talking of resilience, but I think these concepts are two of a kind. It is, unintentionally, familiar in current practice and CSH and other tools are dealing with it, although it can be rather intangible. We are running a competition for temporary activities on a site that will be regenerated, to trigger community engagement through art installations, music festivals. There is a resilience agenda behind this because the community engagement will then lead to the final, permanent development of the area. There is a predominant lower income community here and it is important to tackle this in a moment when things are changing very fast. There seemed to be a recovery but now the building industry is struggling again with change.

2 - No I don't. The Homes and Community Agency tried to promote this concept with the London Design Guide. But the building industry resists changing standards or any novelty, fearing that it could have negative financial impacts on their investments. Standards such as Building for Life are resisted by the private sector.

3 - It is addressed through Code for Sustainable Homes, Lifetime Homes, etc. However, such tools can become a tickbox exercise. So maybe the concept of resilience needs to be addressed at a grassroots level if it has to reach communities. Instead, there are conflicting messages coming from local authorities.

4 - At all scales. But it needs to cascade down consistently. This can happen only if responsibilities are taken at a top level, and a clear message is delivered. Many instruments nationally and locally have been established to attract investors to developing brownfields: Enterprise Zones, Business Rate Relief, superfast broad band connection, etc. But initiatives such as LEP proposed by the Mayor of London are going against the local interest. Money streams coming from these regeneration processes should be reinvested locally to produce jobs.

5 - In a world where messages and actions were consistent, resilience would not need to change depending on scale. As thing are now, resilience changes. The building industry agenda develops according to the context, and their strategies are determined by the logic of financial return. So they consider resilience depending on constraints.

6 - We have evidence around that it is achievable. Historical buildings are there to witness. However, it is difficult to answer now since only in ten or more years time there will be evidence. I have my concerns that we didn't learn any lesson from the 50s and 60s, especially when it comes to density and ghettoes.

7 - It can and it has been done. But it also depends on how much it is left to interpretation. Professionals attaining to guidelines can deliver good design if they deem important to comply, but they may not. In fact my experience in the Homes and Community Agency is that compliance to non mandatory standards rarely happens. In the Enterprise Zone

documents there are no guidelines or principles to attain to, and the GLA doesn't seem to be willing to include them. These will be detailed only at a later stage, while I wonder if they should be included upfront.

8 - It is an interesting idea. If the scientific approach effectiveness could be demonstrable and show that benefits can be delivered, then I would definitely support it. There is the risk, though, that quantitative indicators become another standard, another tickboxing exercise, and another potential problem.

9 - I think it is, Although Qualitative benefits may be harder to measure. You can measure success through factors such as reduction of fuel bills, jobs created, the rate of retention of people locally, etc. People move out once (and if) they have a better job. I see qualitative indicators as mainly referring to sustainable communities: a condition for which people live, grow, and are retained in the same area.

10 - Given the fact that we are all prone to economic fluctuation, it would make sense to integrate resilience as an indicator in these tools, although I am not sure how it can fit with the local agenda.

11 -They are one and the same.

Interviewee n 9
Academic working in Property, Planning and Construction

Professor in Property, Planning and Construction. As an institution that teaches planning in the built environment we are thinking about training the planners of the future. Our time is spent on developing a curriculum covering all aspects of planning, the natural environment definition of what we consider countryside.

1 - I'm not sure it is a familiar concept to planners; it is certainly familiar in the academic field, potentially overused. In our practice it is currently emerging, I have very rarely heard the word used. Resilience is a buzz word, academics are using this new term (a bit like fashion) sustainable development has become overused. However, there is a danger of misinterpretation in that it refers to something being able to cope with external changes, being able to bounce back to its original state, it is not about springing back to where you were but going a different route, maybe that offers more than sustainability.

2 - It's what I would call one of the ingredients. To achieve resilience you would want some longevity. Old buildings, monuments and statues which need constant repair are not resilient and therefore longevity is not always positive. Resilience should have positive outcomes.

3 - Nothing would be resilient without buy-in, I mean it is more than participation; it is about the next level up, community, starting from the beginning. At present the participatory process is too far down the process. We use a spatial planning toolkit, Strategic Environmental assessment. We look at economic, environmental and social aspects together and assess whether they are pointing in the same direction. The bit where I see the difference is social learning, an understanding and learning from where you've gone, and that is shared and built upon further progress on a different trajectory, the experimental side, I call it adaptive management. How you react to an unforeseen event, being proactive and factor in social learning adaptive management.

4 - I favour the landscape scale, which is flexible and fluid enough dependant on the purpose. A post office service would not be resilient if it didn't factor in the countryside; we impose

artificial boundaries and should start looking at natural boundaries, water catchment scale for example. We should be operating at a larger scale, which distils down to a smaller scale. For a village hall to be resilient, the wider context should be considered.

5 - Resilience is one of these umbrella terms which can be used to a variety of scales and objects. The danger of working at a smaller scale means missing out, you don't recognise the wider system. It will change, you should have fluid scales without barriers.

6 - It needs to last, endure and perform well. Yes as long as we are happy using the term built environment, if we look at what makes a resilient city, we may not have cities at all, we may want to look at the natural environment, ecosystem. It can exist without having a physical form, like the internet, a metaphysical form. There are other dimensions to take into account, sensory and perceptual form, which can be overlooked.

7 - The starting point is a vision, a vision which is developed by a range of stakeholders not a lowest common denominator, where principles can be taken from it. Yes, you've got to have a vision, we've got to get away from the economic focus. You have a vision, then a set of principles and having got that you need benchmarks in order to test its performance. A major culture change is needed in the decision making process.

8 - Mixed methods seem to work best.

9 - Resilience is as much part of the process of developing the indicators, you can assess not measure. Indicators are essential, both quantitative and qualitative, and also the process of identifying the indicators. We value what we measure instead of measuring what we value.

10 - I certainly would like to see those codes reappraised, embedding the concept of resilience, design tools to be changed.

11 - The bit I saw different is that you can go back. Resilience for me is a subset of sustainability, a strand under the umbrella of sustainability.

Interviewee n 10
Architect and urban designer providing policy and design advise

Architect and an Urban designer providing policy advice as well as urban design and architectural advice in the built environment.

2 - I think resilience as a concept is not as well known or understood as it should be within the field, whereas the concept of sustainability tends to dominate the discourse.
In my opinion, resilience in the built environment would allow for flexibility and adaptation over time as environmental conditions and user requirements change. In this the concept of resilience differs from the concept of sustainability, which – applied to design – is often understood as a fixed and permanent condition.

3 - I don't really know.

3 - Resilience is very difficult to address in the planning/ design process, because it requires thinking beyond the brief for the project´s current timescale. For example, a resilient building would be able to accommodate changes of use, changes of configuration, changes of technology etc.
However, flexibility would be a key feature – e.g. in housing design this could mean designing rooms with space standards sufficiently generous to allow for various uses. I wrote

a paper about the flexibility of housing in Berlin which indicates how generous space standards allow for flexibility and adaptation over time. You can access the paper here: http://www.architecture.com/Files/RIBAProfessionalServices/ResearchAndDevelopment/Symposium/2008/DominicChurch.pdf
I try to find out as much as I can about the concept of resilience and try to act as a facilitator of knowledge sharing and best practice.

4 - As a concept, I have heard resilience referred to in terms of resilient urban environments more often than I have heard reference made to resilient buildings. I think resilience as an objective can be applied at various scales, even though the design characteristics leading to resilience may be different according to scale.

5 - I think that this would be linked to time-scales. Resilience relates to the lifetime of the thing in question. Large scale structures (e.g. Regional or Metropolitan systems) tend to be characterised by long timescales and comparatively slower rates of change and adaptation (e.g. decades, years, in some very rare cases perhaps months). Hence resilience would be to do with facilitating greater gradual adaptability at that scale over a long timescale.
Small scale structures (e.g. machinery and technology) tend to have relatively short lifetimes and are characterised by a relatively fast pace of change. Resilience in this context would be to do with prolonging the lifetime of the thing in question as well as the ability to change and adapt it.

6 - A resilient structure may outlast the physical form as envisaged by the original designer. The Coliseum is a good example of a resilient design. Over the centuries this typology, developed by the Romans, often played host to very many different uses. Frequently, the physical form of the Coliseum changed over the years, as elements were added or removed. In some cases, the structure became nearly completely subsumed in the urban environment (there is a famous case for this, I forget in which city. Let me know if you need help finding the example).

7 - Possibly, although I would view these principles as rather simple and generic rather than highly detailed and rigid.
For example, I think that relative simplicity could be an advantage. Functional concepts and systems which are comparatively simple allow for easy adaptation.
Another feature could be the choice of materials, structure and technology. For example, timber, stone, or brick structures could be easy to adapt and modify in nearly any context, whereas “high-tech” solutions such as glass, metal and concrete could be more tricky to adapt, depending on the design. It may be that later users no longer have the know-how or the physical means to make changes to a more complex structure.
In terms of the creative vision, a resilient design should be strong enough to survive a bit of knocking about. For example, together with my brothers and sister I inherited a house my father designed and built. We had to make changes to it, because we could no longer afford heating it as it was. The changes we made were fairly fundamental and we were very worried that we would destroy the vision and spirit of the house. In the end this did not happen, and the atmosphere of the house seems to have grown stronger despite the obvious changes.

8 - I think that this type of approach could become redundant very rapidly if any of the contextual parameters change (and there would be very many of these). For example, there would be no point in working out how fuel efficient a gas-fired heating system should be if there is no more gas available.

9 - I think it is very hard to measure resilience, as it is a concept inherently about change, much of which will be unforeseen and unpredictable. However, it might be possible to measure the degree of similarity with certain characteristics which have proved to be highly resilient in the past.

10 - I don´t see resilience as such a fixed item, which could easily be plugged in to existing tools or methodologies. On the other hand the value and viability of such tools could be tested in terms of the extent to which they facilitate greater resilience.

11 - I think the difference is in the perception of what the term communicates. The term resilience suggests a condition of ongoing adaptability and permanent mutability, whereas the term sustainability seems to suggest something which is achieved once and then relatively static.
A sustainable design, once perfected, might never change. On the other hand, a resilient design may change very significantly over time.

Interviewee n 11
Architect with a sustainability agenda, working in building industry

Architect and partner of a small construction company specialized in residential and in sustainable construction

1 - I can associate three meanings at resilience:

- Buildings or urban physical capacity of last: based on material and design quality;
- Urban system Capacity to meet system needs in a long last;
- Urban system and building capacity to meet environmental changes.

2 - I think that nowadays is only associate at building longevity at least here in Italy; Government and local authority aren't planning the urban fabric with a long vision. It's more likely they have been putting tonnes of restrictions to the "private" leaving to us the responsibility. We are doing our best to give a high quality product: resilient in many aspects.
We are really glad to see that people are concerned about what they want: client is becoming more and more demanding. That means they what a better environment.

3 -

- By studying and analyzing environment changes;
- By studying population moving and habit/custom changes;
- With an active behaviour ➔ by educating persons;
- By studying how new materials meet the new environment.
- By studying population moving and habit/custom changes;
- By studying how new materials meet the new environment.

4 - I think that resilient should be apply at a large scale (urban or region scale) with different standards since the environment is very different.

5 - Environment changes in a different way so the resilience changes differently.

6 - Resilience is a large concept. I think we have to study more and more: we need information, data, resources, practical experiment....! But I think we have to start on something: as far all the system chain work together as resilience will perform better.

7 - I think Yes! First step has to be: studying, analysing and giving principles and guidelines for planning process. It will be improved by feedback corrections.

8 -We have to be more concerned to establish performances. But this has to be the second step.

9 - Yes it can be measured!

Qualitative indicators:

- Type of technical solution used: is it in the guidelines the solution used? Is it the right solution for this location and situation? (Klima house has thermal bridges guidelines)
- Thinking of problems during the design process that could come out during the construction stage.
- Is there a report on habitant mitigation? It has been used?
- Is that design solution come out by studying habitant customs? Every place and population has different needs.
- Etc..

Quantitative indicators:

- Consumption of Kcal/mq
- Parking system (parks/inhabitant)
- Green spaces
- Children spaces
- Km of bicycle-lane
- Summer insulation standards(different from winter insulation standards)
- etc

10 - Yes I do! Probably it will effect on the current tools.

11 - I think there is a relation because resilience effects on sustainability as it effects on the life cycle of an urban system or building.
Resilience is a wider concept of the sustainability.

Appendix 2

Tables of resilience analysis on energy efficiency strategies

Building envelope		Market Forces	Policy Reform	New Sustainability Paradigm	Fortress World/Haves	Fortress World/Have-nots
Necessary conditions		**Market logics determine occupancy tenure and building lifetime through market values**	**Mandatory standards for building fabric are tighter**	**Mandatory standards for building fabric are very tight**	**The rich demand a high building standard**	**The poor occupies low market value properties**
Basic maintenance of some building components	BR 2000	? Basic maintenance for building components is usually provided. However, building stock with low insulation may be depreciated in a future where high building specs result in added commercial value	X Basic maintenance for building components is usually provided. However, building stock with low insulation may be substituted because of tighter building standards	X Maintenance is regularly provided. However building stock not complying with tight energy efficiency requirements is upgraded or substituted	X Maintenance is provided by the rich. However, building stock built with poor specs may be left to the poor	? The poor can provide only limited maintenance
Legislation		√ There are no mandatory standards for buildings	X Mandatory standards for building fabric are tighter	X Mandatory standards for building fabric are very tight	√ There are no mandatory standards for buildings	√ There are no mandatory standards for buildings
User behaviour		X Low environmental awareness may result in low energy savings regardless of the level of insulation	√ Incentives and metering lead to positive results although environmental awareness is still low	√ Collective shift to environmental awareness leads to responsible behaviour	X Low environmental awareness may result in low energy savings regardless of the level of insulation	√ Responsible behaviour dictated by necessity
	CSH level 3	? Basic maintenance for building components is usually provided. (However, building stock with low insulation may be depreciated in a future where high building specs result in added commercial value))	X Basic maintenance for building components is usually provided. (However, building stock with low insulation may be substituted because of tighter building standards)	X Maintenance is regularly provided. However building stock not complying with tight energy efficiency requirements is upgraded or substituted	? Maintenance is provided by the rich. However, building stock built with standard specs may be left to the poor	? The poor can provide only limited maintenance
		√There are no mandatory standards for buildings	X Mandatory standards for building fabric are tighter	X Mandatory standards for building fabric are very tight	√ There are no mandatory standards for buildings	√ There are no mandatory standards for buildings
		X Low environmental awareness may result in low energy savings regardless of the level of insulation	√Incentives and metering lead to positive results although environmental awareness is still low	√ Collective shift to environmental awareness leads to responsible behaviour	X Low environmental awareness may result in low energy savings regardless of the level of insulation	√ Responsible behaviour dictated by necessity
	CSH level 4	? Basic maintenance for building components is usually provided. However, if high insulation relies also on mechanical ventilation, its maintenance may be neglected by those who can't afford it	√ Maintenance is usually provided because of incentives and tight regulation on energy use	√ Maintenance is regularly provided. However building stock not complying with tight energy efficiency requirements is upgraded or substitute	√ Maintenance is provided by the rich	? The poor can provide only limited maintenance. Mechanical ventilation would not be repaired when necessary
		√ There are no mandatory standards for buildings	√ Compatible with mandatory standards	? Maybe compatible with mandatory standards	√ There are no mandatory standards for buildings	√ There are no mandatory standards for buildings
		X Low environmental awareness may result in low energy savings regardless of the level of insulation	√ Incentives and metering lead to positive results although environmental awareness is still low	√ Collective shift to environmental awareness leads to responsible behaviour	X Low environmental awareness may result in low energy savings regardless of the level of insulation	√ Responsible behaviour dictated by necessity
	CSH level 5+6	? Basic maintenance for building components is usually provided. However, if high insulation relies also on mechanical ventilation, its maintenance may be neglected by those who can't afford it.	√ Maintenance is usually provided because of incentives and tight regulation on energy us	√ Maintenance is regularly provided.	√ Building stock with good specifications and a high levels of insulation is usually retained and valued	? The poor can provide only limited maintenance. Mechanical ventilation would not be repaired when necessary
		√ There are no mandatory standards for buildings	√ Exceeding mandatory standards	√ Compatible with mandatory standards	√ There are no mandatory standards for buildings	√ There are no mandatory standards for buildings
		X Low environmental awareness may result in low energy savings regardless of the level of insulation	√ Incentives and metering lead to positive results although environmental awareness is still low	√ Collective shift to environmental awareness leads to responsible behaviour	X Low environmental awareness may result in low energy savings regardless of the level of insulation	√ Responsible behaviour dictated by necessity

Sun access	Metrics	Market Forces	Policy Reform	New Sustainability Paradigm	Fortress World/Haves	Fortress World/Have-nots
Necessary conditions	WPSH	Sun access is protected only if it result in added value to properties	To an extent solar access is protected through planning policy	Solar access is considered of high importance for any energy efficiency strategy	Sun access is considered important as it provides amenity	Provision of sun access is not a priority for the poor
Overshadowing	5%	**?** Sun access is protected only if it result in added value to properties	**X** Protection of minimum levels of sun access is provided through planning policies. However, this degree of sun access may be considered too low	**X** Protection to sun access is provided through planning policies. However, this degree of sun access is considered insufficient	**X** Protection to sun access is guaranteed within enclaves as it provides a pleasant environment. This level of sun access may be too low.	**X** No protection against overshadowing provided
Maintenance (if solar gain relies on airtightness)		**N/A** No substantial solar gains come with this minimum level of sun access. Thus no particular maintenance is required	**N/A** No substantial solar gains come with this minimum level of sun access. Thus no particular maintenance is required	**N/A** No substantial solar gains come with this minimum level of sun access. Thus no particular maintenance is required	**N/A** No substantial solar gains come with this minimum level of sun access. Thus no particular maintenance is required	**N/A** No substantial solar gains come with this minimum level of sun access. Thus no particular maintenance is required
User behaviour		**N/A** No substantial solar gains come with this minimum level of sun access. Thus no responsible behaviour is required	**N/A** No substantial solar gains come with this minimum level of sun access. Thus no responsible behaviour is required	**N/A** No substantial solar gains come with this minimum level of sun access. Thus no responsible behaviour is required	**N/A** No substantial solar gains come with this minimum level of sun access. Thus no responsible behaviour is required	**N/A** No substantial solar gains come with this minimum level of sun access. Thus no responsible behaviour is required
	20%	**?** Sun access is protected only if it result in added value to properties	**√** Protection of minimum levels of sun access is provided through planning policies	**?** Protection to sun access is provided through planning policies. However, this degree of sun access is considered insufficient	**√** Protection to sun access is guaranteed within enclaves as it provides a pleasant environment	**X** No protection against overshadowing provided
		N/A No need to rely on mechanical ventilation since solar gains would be limited	**N/A** No need to rely on mechanical ventilation since solar gains would be limited	**N/A** No need to rely on mechanical ventilation since solar gains would be limited	**N/A** No need to rely on mechanical ventilation since solar gains would be limited	**N/A** No need to rely on mechanical ventilation since solar gains would be limited
		N/A No need to rely on user behaviour since solar gains would be limited	**N/A** No need to rely on user behaviour since solar gains would be limited	**N/A** No need to rely on user behaviour since solar gains would be limited	**N/A** No need to rely on user behaviour since solar gains would be limited	**N/A** No need to rely on user behaviour since solar gains would be limited
	30%	**X** Protection of sun access is given only to attain amenity of the place, and add value to properties. This level would exceed such an objective.	**?** Protection of good levels of sun access is provided when possible, as there is a tension between high densities required in planning policies	**√** Protection to sun access is provided through planning policies.	**√** Sun access is protected within enclaves, as it is considered important to the quality of the place	**X** No protection against overshadowing provided
		? Maintenance is provided only by those who can afford it	**√** There are incentives in place to help with maintenance	**√** There are incentives in place to help with maintenance	**√**Maintenance is provided within enclaves	**X** Very little maintenance is provided
		X Behaviour not informed by environmental awareness may result in low energy savings	**√**Energy consumption is reduced compared to current levels because of technology improvements and regulation for energy efficiency	**√** Users are informed and behave responsibly	**X** Behaviour not informed by environmental awareness resulting in low energy savings	**√** Users may behave responsibly because of necessity
	50%	**X** Protection of sun access is given only to attain amenity of places, and add value to properties. This level would exceed such an objective	**X** Protection of high levels of sun access may not be provided as it would entail lower densities	**?** Protection of high levels of sun access is provided when possible	**√**Sun access is protected within enclaves, as it is considered important to the quality of the place	**X** No protection against overshadowing provided
		? Maintenance is provided only by those who can afford it	**√** There are incentives in place to help with maintenance	**√** There are incentives in place to help with maintenance	**√** Maintenance is provided within enclaves	**X** Very little maintenance is provided
		X Behaviour not informed by environmental awareness may result in low energy savings	**√** Energy consumption is reduced compared to current levels because of technology improvements and regulation for energy efficiency	**√** Information is provided to facilitate behavioural change	**X** Behaviour not informed by environmental awareness resulting in low energy savings	**√** Users may behave responsibly because of necessity

Daylighting	Metrics	Market Forces	Policy Reform	New Sustainability Paradigm	Fortress World/Haves	Fortress World/Have-nots
Necessary conditions	Vertical Sky Component	Right to light is protected only if it result in added value to properties	Right to light is protected through planning policy, although market logics lead to development reducing very high levels of light penetration to existing buildings	Right to light is protected although urban densities required could result in some flexibility towards developments that may slightly reduce light penetration to existing buildings	Natural light penetration is considered important (and it is protected) as it provides amenity	Natural light penetration is not a priority for the poor
Overshadowing	>27%	**?** Right to light is protected only if it results in added value to properties. Properties with low levels of natural light that are kept on the market for low-income groups.	**X** Planning policies protect light to light. However, building stock with low light penetration may be demolished	**X** Planning policies protect light to light However, building stock with low light penetration will be demolished	**X** Right to light is guaranteed within enclaves. However properties with poor natural light are demolished	**X** No protection against overshadowing provided. Nevertheless, properties with poor natural light are normally occupied but the low-income groups because of necessity
User behaviour		**N/A** No need to rely on user behaviour since low levels of natural light penetration require high use of artificial light	**N/A** No need to rely on user behaviour since low levels of natural light penetration require high use of artificial light	**N/A** No need to rely on user behaviour since low levels of natural light penetration require high use of artificial light	**N/A** No need to rely on user behaviour since low levels of natural light penetration require high use of artificial light	**N/A** Artificial light use is reduced because of necessity
	27%	**?** Right to light is protected only if it result in added value to properties	**√** Planning policies protect light to light.	**?** Planning policies protect light to light However, this level of light penetration may still be considered insufficient	**√** Right to light is guaranteed within enclaves.	**X** No protection against overshadowing provided.
		X Because of poor awareness of environmental issues people continue to use artificial light even if not strictly needed	**?** Information is provided to facilitate behavioural change. However, there is a general resistance to change	**√** Users are informed and behave responsibly	**X** Because of poor awareness of environmental issues people continue to use artificial light even if not strictly needed	**√** Artificial light use is reduced because of necessity
	<27% >40%	**X** Right of light is given only to attain amenity of the place, and add value to properties. However, this level of penetration would exceed the objective of providing good quality living spaces	**?** Planning policies protect light to light. However, market logics impose a flexible approach towards very tight standards, and very high levels of light penetration may be reduced by new developments	**√** Protection of right to light is provided through planning policies.	**√** Right to light is guaranteed within enclaves.	**X** No protection against overshadowing provided.
		X Because of poor awareness of environmental issues people continue to use artificial light even if not strictly needed	**√** Energy consumption is reduced compared to current levels because of technology improvements and regulation for energy efficiency	**√** Users are informed and behave responsibly	**X** Because of poor awareness of environmental issues people continue to use artificial light even if not strictly needed	**√** Artificial light use is reduced because of necessity
	40%	**X** Right of light is given only to attain amenity of the place, and add value to properties. However, this level of penetration would exceed the objective of providing good quality living spaces	**X** Planning policies protect light to light to an extent. However, market logics impose a flexible approach towards very tight standards, and high levels of light penetration may be reduced by new developments	**?** Protection of right to light is provided through planning policies. However there may be tension between highest levels of light penetration and building densities required	**√** Right to light is guaranteed within enclaves.	**X** No protection against overshadowing provided.
		X Because of poor awareness of environmental issues people continue to use artificial light even if not strictly needed	**√** Energy consumption is reduced compared to current levels because of technology improvements and regulation for energy efficiency	**√** Users are informed and behave responsibly	**X** Because of poor awareness of environmental issues people continue to use artificial light even if not strictly needed	**√** Artificial light use is reduced because of necessity

On-site renewable production Necessary conditions	Metrics	Market Forces	Policy Reform	New Sustainability Paradigm	Fortress World/Haves	Fortress World/Have-nots
	Percent of on-site energy demand	Strong reliance of technological progress for energy savings	Policy imposes high energy efficiency and stimulates through incentives responsible behaviour	Shift of values results in low energy use	The rich lives in enclaves that necessitate a degree of self-sufficiency	The majority cannot afford maintaining equipment for on-site production
Maintenance and components' replacement	0%	**N/A.** However, building stock is valued for its appearance and construction quality. On-site renewable is not a necessary requirement	**N/A** Planning policies make a quota of on-site renewable production mandatory. Building stock that does not conform to regulation is upgraded or demolished	**N/A** In planning policies a high quota of on-site renewable production is mandatory. Building stock that does not conform to regulation is upgraded or demolished	**N/A** However, in a world of constant social unrest, self-sufficiency in resources is viewed as necessary. Thus, on site production is valued by the rich	**N/A** However, the poor could not afford maintenance and components' replacement
Legislation		**N/A** No mandatory standards provided	**X** Planning policies make a quota of on-site renewable production mandatory.	**X** A high quota of on-site renewable production is mandatory.	**N/A** No mandatory standards provided	**N/A** No mandatory standards provided
User behaviour		**N/A** Energy use increases	**N/A** Energy consumption is reduced compared to current levels because of technology improvements and regulation for energy efficiency	**N/A** Energy use goes down reflecting a changed attitude towards energy use	**N/A** Energy use increases slightly	**N/A** Energy use decreases by necessity
	10%	**X** Maintenance and components' replacement is implemented only from those who can afford it. Single ownership (versus community generation units) are preferred as this reflects and individualistic vision of society. This makes it more difficult to invest on renewable.	**√** Incentives are in place to facilitate maintenance and components' replacement	**X** Maintenance is regularly carried out. However, as in planning policies a high quota of on-site renewable production is mandatory, building stock that does not conform to regulation is upgraded or demolished	**√** Maintenance is regularly carried out	**X** The poor cannot afford maintenance and components' replacement
		X No mandatory standards provided. However unregulated development overshadows many roofs	**√** Planning policies make a quota of on-site renewable production mandatory.	**X** A high quota of on-site renewable production is mandatory.	**√** No mandatory standards provided	**X** No mandatory standards provided. However unregulated development overshadows many roofs
		X Energy use from centralised generation systems increases in spite of renewable generation	**√** Energy consumption is reduced compared to current levels because of technology improvements and regulation for energy efficiency	**√** Energy use goes down reflecting a changed attitude towards energy use	**X** Energy use increases slightly	**√** Energy use decreases by necessity
	15%	**X** Maintenance and components' replacement is implemented only from those who can afford it. Single ownership (versus community generation units) are preferred as this reflects and individualistic vision of society. It is unlikely that high investments for such a level of generation can be supported	**?** Planning policies make a quota of on-site renewable production mandatory. Incentives are in place to facilitate maintenance and components' replacement. However this percentage may be above mandatory requirements	**?** Maintenance is regularly carried out. However, as in planning policies a high quota of on-site renewable production is mandatory, building stock that does not conform to regulation is upgraded or demolished. Community ownership facilitates the independent management of units	**√** Maintenance is regularly carried out	**X** The poor cannot afford maintenance and components' replacement
		X No mandatory standards provided. However unregulated development overshadows many roofs	**?** Planning policies make a quota of on-site renewable production mandatory, although this percentage may be above mandatory requirements	**X** A high quota of on-site renewable production is mandatory.	**√** No mandatory standards provided	**X** No mandatory standards provided. However unregulated development overshadows many roofs

		X Energy use from centralised generation systems increases in spite of renewable generation	√ Energy consumption is reduced compared to current levels because of technology improvements and regulation for energy efficiency	√ Energy use goes down reflecting a changed attitude towards energy use	X Energy use increases slightly	√ Energy use decreases by necessity
	20%	X Maintenance and components' replacement is implemented only from those who can afford it. Single ownership (versus community generation units) are preferred as this reflects and individualistic vision of society. It is unlikely that high investments for such a level of generation can be supported	X Planning policies make a quota of on-site renewable production mandatory. Incentives are in place to facilitate maintenance and components' replacement. However this percentage may be above mandatory requirements. Also urban densities recommended may conflict with large roofs surface covered with PV panels.	√ Maintenance is regularly carried out.	√ Maintenance is regularly carried out	X The poor cannot afford maintenance and components' replacement
		X No mandatory standards provided. However unregulated development overshadows many roofs	X Planning policies make a quota of on-site renewable production mandatory, although this percentage may be above mandatory requirements	√ A high quota of on-site renewable production is mandatory.	√ No mandatory standards provided	X No mandatory standards provided. However unregulated development overshadows many roofs
		X Energy use from centralised generation systems increases in spite of renewable generation	√ Energy consumption is reduced compared to current levels because of technology improvements and regulation for energy efficiency	√ Energy use goes down reflecting a changed attitude towards energy use	X Energy use increases slightly	√ Energy use decreases by necessity