RESPONDING TO THE BUILT ENVIRONMENT CHALLENGES: DESIGN FOR ADAPTATION

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ABSTRACT

The current building stock in the UK only vaguely fits the evolving needs of businesses and users. This leads majority of existing buildings to be demolished, renewed, refurbished or redundant. However, maintaining a redundant building stock is economically unviable and a socially unacceptable solution, as these buildings generate no income while the building owners are responsible to pay taxes for the buildings. Also, scrapping and rebuilding relatively young buildings is neither economically nor socially desirable and does not correspond with the demand for durability and sustainability. Therefore, to survive a more complex array of needs, modern buildings are required to be designed to improve space, environmental and safety standards and adapt for potential change situations. In this sense, adaptable buildings focus on potential bespoke solutions that are flexible for varying customer needs. Buildings with adaptable potential may survive in the immediate future; however, the traditional maladaptive buildings will remain as redundant stock unless they find a correct use. This paper investigates the design strategies for adaptability in middle range buildings (4-12 storeys) while explaining the capacity of adaptable buildings to respond to the built environment challenges. A comprehensive literature review was undertaken to identify the strategies and design parameters for adaptability in buildings, and eleven interviews were carried out among the construction professionals to identify the practicality of promoting adaptable building strategies within the UK construction industry. NVivo-10 software was used to analyse the empirical data, and the results explained market demand, user requirement, stakeholder awareness and challenges like cost, risk, technology and existing planning policies are the key issues that need to be addressed when promoting adaptable buildings.

Keywords: *Benefits and Challenges; Built Environment Challenges; Design for Adaptability; Strategies and Parameters; Sustainability.*

1. BACKGROUND

The built environment challenges appear in the areas of ‘environment considerations’ (Geraedts, 2008), ‘innovations in technology’ (Flanagan and Tate, 1997; Nutt, 2000), ‘planning and policy issues’, ‘social requirements, ‘political forces’ (Gann and Barlow 1996) and ‘economic considerations’ (Arge, 2005; Douglas, 2006). Recent consideration has been given to identify how the new building stock could be adapted for 21st century challenges (Henehan and Woodson, 2003; Sheffer and Levitt, 2010). This requires an understanding of the extent of changes required to the existing building stock and the lessons learnt for designing new buildings to survive future markets. To respond these macro level challenges, buildings need to change in terms of the ‘function’ they house, the ‘capacity’ to achieve the performance required for the population they hold and the ‘flow’ of reacting to internal and external environmental forces (Slaughter, 2000). Buildings that are unable to survive with the aforementioned challenges would become prematurely obsolete or require substantial refurbishment or demolition.

The existing building stock is an important physical, economic, social and cultural capital to any nation (Kohler and Hassler, 2002). However, building obsolescence seems as one of the critical dilemmas

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associated with the existing building stock. The strategies of 'adaptive reuse' (Kincaid, 2000) and 'brownfield developments' (Silverthorne, 2006) are discussed in the literature as better means for using existing buildings in a sustainable way. Itard and Klunder (2007) explain that building transformation, if structurally possible, is a much more environmentally efficient way to achieve the same results than demolition and new construction. In a way, reuse benefits are seen as not only a lower cost option for the typical end-user, but also in the value of retaining the style and character/heritage of buildings, the solid build qualities and the appropriateness of their location (Ball, 1999). The UK government legislation (e.g. landfill tax) and policies (e.g. Strategy for Sustainable Construction 2008) encourage building owners/clients to rethink the possibilities and potential avenues for reusing space (adaptive reuse) while extending the functional lifespan of their buildings. In addition, the government is seeking alternative strategies to minimise the building redundancy while promoting optimum use of the existing building stock in urban centres; it encourages conversion of redundant office and retail space into leisure, service and/or residential uses rather than demolition and renewal (Davison *et al*., 2006). Nevertheless, the conversion processes might be neither economical nor practical in many circumstances; therefore, there is a real need to design new buildings for potential adaptations.

Even though there are number of ongoing discussions on promoting adaptable buildings a very few applications could be identified within the UK construction industry. Therefore this paper aims to investigate what adaptable buildings are, their design considerations, benefits and challenges, which of course would help relevant authorities/stakeholders to support in their decisions. However the study focused on middle range buildings (4-12 storeys) as they represent the highest percentage in the building stock.

2. RESEARCH METHODOLOGY

Data were collected from an extensive literature review and eleven semi structured interviews. Literature review was focused to identify the design strategies and parameters for adaptable buildings. Semi-structured interviews were used to understand the need and practicality/challenges of promoting adaptable buildings within the UK construction industry. The interview questionnaire was piloted with three academic members of one of leading higher education institutions in the UK for feedback on clarity and readability. The selected interviewees were from architecture, quantity surveying, structural engineering, planning and policy development disciplines and their lengths of experience varied from less than 10 years to more than 30 years, demonstrating a good spread of experience. The collected data were organised manually by coding text and breaking it down into more manageable pieces. Moreover, NVivo 10 software was used to further code those data to create nodes.

3. NEED FOR DESIGNING BUILDINGS TOWARDS FUTURE POTENTIAL ADAPTATION

As an innovative solution to many of the above problems, consideration is now being given to exploring the possibilities of integrating adaptable potential in new buildings. The term 'adaptation' often appears in the manufacturing industry, although recently it has also emerged in the building industry as an innovative strategy for minimising the premature retirement/redundancy of buildings. Many of the manufacturing products are industrialised, produced on a mass scale, short in lifespan and highly focused on customer flexibility compared to construction products (Hashemian, 2005). These adaptable techniques from the manufacturing industry could perhaps be exploited to a certain extent in construction practices when products need to show similar characteristics, like flexibility, customisation and adaptation. The importance of 'adaptable buildings' in construction businesses has been recently discussed by many authors, particularly with regard to various facets of building adaptations, such as 'technical and functional performance of adaptable buildings' (Gann and Barlow, 1996; Slaughter, 2001; Kendall, 2003; Larssen and Bjorbery, 2004), 'stakeholders' motivation and benefits' (Arge, 2005; Kalita, 2006), 'regulations and policies' (Kincaid, 2002; Adeyeye *et al*., 2010), 'sustainability' (Kincaid, 2000, Thomsen and Flier, 2009) and 'risk' (Remoy and Voordt, 2007).

4. ADAPTABLE BUILDINGS

This paper explains 'adaptable building' as an innovative strategy for designing new buildings towards future adaptations. It extends the economic and functional lifespans of buildings (Douglas, 2006). Specifically, adaptable buildings can be defined as 'dynamic systems that carry the capacity to accommodate a set of evolving demands regarding space, function, and components' (Adaptable Futures, 2012). A maladaptive building is one that cannot match the new demand placed upon it, whether it is technically unviable or cost-inefficient. The line between the two can often become blurred and depends on a set of exogenous and endogenous demands that can be determined through careful evaluation. Correspondingly, open building design (Habraken, 1980; Kendall, 1999) provides a similar conceptual philosophy but falls short of providing clear criteria for evaluation, focusing primarily on the separation of long and short-term components. The literature reveals adaptable buildings as a nascent but strong and practical solution to defeating the problem of building redundancy (Douglas, 2006; Kronenburg, 2007; Adaptable Futures, 2012). However, the critical challenge to building designers/owners/ developers is the inability to prepare for unforeseeable futures, mainly because of the difficulty in predicting future uncertainties, risks and the costs of changes (Ellingham and Fawcett, 2006). Property developers are more concerned with the returns on their investments in adaptable properties; however, economic evaluation for adaptable buildings needs to be conducted to provide the needed 'hard' evidence to show that these buildings provide a more economically sound answer than a typical fit-to-use solution. Thus, there is a need to respond to the increasing pressures of rapid changes in user needs, technological shifts, altered working and living patterns and other forces that render buildings obsolete before the depletion of their service lives (Fernandez, 2003).

4.1. DESIGN STRATEGIES

In specific to this study the 'Strategy' means how the building endures change over time (Adaptable Futures, 2012). In a way it is a plan of action designed to achieve a long-term or overall aim (Oxford Dictionary, 2010). 'Adaptability' has different meanings for different interest groups. Table 1 encapsulates the variety of strategies that were discussed in the literature to define adaptability in the built environment. These strategies 'can effectively reduce life cycle costs by allowing a timelier and less costly response to a dynamic environment, which adds costs measured in terms of money, time, and complexity' (Ford and Garvin, 2010, p.54). Among these terms, 'adaptability' and 'flexibility' are often engaged to bring a similar kind of meaning. 'Adaptability' is used to explain macro level issues like 'capability of social uses' and 'flexibility' is used to address micro level issues like 'capability of physical changes' (Groak, 1992). By contrast, Schneider and Till (2005) define 'flexibility' as a common term to represent the capability of buildings to accept both different social uses and physical arrangements. Beisi (1993) argued that providing adaptability is not a one-time strategy but should guarantee the long-term possibilities of use. The strategies of durability and design for disassembly are closely related to adaptability, which in different forms enhance long-term environmental performance (Russell and Moffatt, 2001).

Table 1: Design Strategies for Adaptability

Author / year	Generality	Flexibility/Versatility	Elasticity/Extendable/ Expandable/Scalable	Convertible	Dismantlable/ Separable/ Partitionable	Disaggregatable	Prefabrication/ Standardisation	Overcapacity	Movable	Rearrangeable	Reusable/Recyclable	Refitable	Multi-functional	Integratable	Universal	Modularity	Ejectable	Exchangeable
Gann and Barlow (1996)							•	•	•	•								
Blakstad (2001)		•	•		•								•					
Robertson and Sribar (2002)			•		•						•			•				
Arge (2005)	•	•	•													•		
Douglas (2006)		•	•	•	•	•												
Verweij and Poelman (2006)			•															
3DReid (2006)		•	•	•					•		•	•						
Geraedts (2008)		•	•		•				•	•					•		•	•
Pati *et al.* (2008)		•	•	•														
Gijsbers *et al.* (2009)		•			•		•		•									

Having considered aforementioned design strategies and available terminologies for adaptability in buildings the following frame-cycle (refer Figure 1) was developed by the Adaptable Futures research team.

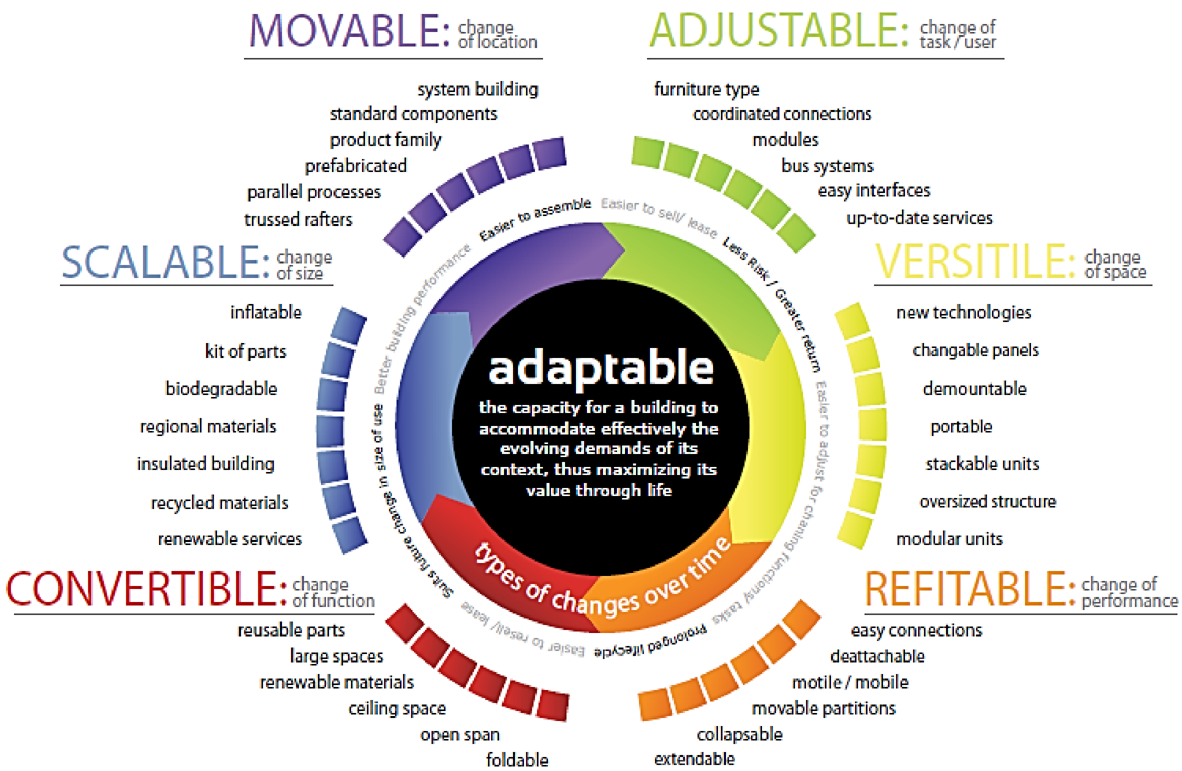

Figure 1: Design Strategies for Adaptability in Buildings (Frame-Cycle)
Source: www.adaptablefutures.com (2012)

The frame-cycle considers six main strategies and their associated sub-strategies. The ‘adjustable’ strategy relates to the ability of buildings to change their tasks. This considers alterations of furniture type, coordinated connections and module systems. ‘Versatility’ explains the ability to change the internal space of a building. The strategy takes into account up-to-date service systems, changeable panels, demountable/portable and stackable units, oversized structures, modular units and easy connections. ‘Refitability’ elucidates the ability to change building components, which considers detachable, degradable, mobile, movable and collapsible components. The term ‘convertible’ determines the ability of buildings to shift between different uses/functions. This requires internal and external alterations to buildings. Considerations are given to managing large spaces, renewable materials, ceilings and open spaces to facilitate those uses. The ability to change the size of the building is reflected by ‘scalability’. ‘Extendible’, ‘elasticity’, and ‘expandable’ also have similar meanings to scalable. This considers such alterations as reusable components, renewable services, recycled materials, insulated buildings and kits of parts. The ability to change location is explained through ‘movability’. This encourages system buildings, standard components, product families, and prefabricated and parallel processes. However, semantic permutations/dependencies between some of the aforementioned strategies create difficulties in clustering them into specific individual categories. For example, design for potential change of use (convertible) connects with the scalable and refitable aspects of building components. Brand (1994) provides strong evidence that buildings are not just static objects but that they are dynamic. There is, for instance, a model (shearing layers of change) of the way a building tears itself over time. Hence, designing a building to adapt to a potential change of use means allowing its hierarchical layers to change; each in its own time scale. Most importantly the consideration should pay for identifying the critical design parameters when designing buildings towards potential adaptation.

4.2. DESIGN PARAMETERS

Literature reveals different design parameters for adaptability in buildings (refer Table 1). One or few of those design parameters might be influenced when designing buildings to accommodate aforesaid strategies. From a web-based survey among 32 architects, Manewa (2012) identified the parameters like plan depth, floor to ceiling height, structural design, fire safety design, services system, and building size, height and proximity are the influential parameters for change of use (convertible). There are buildings with adaptable features; however, it is uncertain whether they fully match the performance of their new purpose-built facilities because of their restrictions as regards to layout and height (Douglas, 2006). Gregory (2006) states it is significant that the buildings best suited to adaptation are those with the most generous ceiling heights. For example, ‘the inherent flexibility of many of the Georgian and Victorian domestic buildings has been very influential in the development of ideas of adaptability in new work, especially housing and industrial buildings’ (Farrell, 1979 p.59). Moreover, Kincaid (2000, p.158) explains that ‘too much floor to floor clearance is wasteful in both the long term and short term; too little is always wasteful in the long term as use changes, and in the short term hostile to energy use and people’.

Moreover, Douglas (2006) and 3DReid (2006) discuss the influence of storey height in building change of use scenarios. In addition, Saari and Heikkila (2008, p.240) explain that the ‘long-term adaptability of old industrial properties has been particularly good thanks to high floor heights and long spans and their conversion to office and residential use has been possible and relevant in several recent construction projects’.

Table 2: Design Parameters for Adaptability

Author/ year	Floor to ceiling height/ Storey height	Technical span	Structural load	Building orientation	Space/Area/Volume for system zone	Building height	Building width	Building size	Floor plan	Availability/Elevator/Vertical circulation	Location/Site condition	Floor systems/Raised floors	HVAC system & distribution	ICT service	Plug & play elements/ Interchangeable components	Ceiling zone/Soffit quality	Organisation of space	Separation of functions/ Decoupling	Fire sprinkling changes/ Fire safety design	Plan depth	Structural design/Slabs	External façade/Cladding design	Acoustic/Noise insulations	Physical access/System access flexibility/Proximity	Interior walls (movable)	Electricity supply	Central corridors	Inter-system interaction	Intra-system interaction	Internal layout/Layout predictability	Flow	Core design	Partial/Phased demolition
Gann and Barlow (1996)						•	•						•						•	•	•	•	•	•						•			
Ratcliffe and Stubbs (1996)	•																																
Keymer (2000)					•										•									•				•	•	•	•	•	•
Heath (2001)	•																			•	•						•						
Larssen and Bjorberg (2004)	•	•	•		•					•	•		•	•							•				•	•							
Arge (2005)	•	•					•					•	•	•	•	•	•	•	•														
Richter and Laubach (2005)												•	•						•		•	•		•									
Verweij and Poelman (2006)								•	•																								
3DReid (2006)	•									•		•				•			•	•	•	•		•									
Gijsbers (2009)	•				•						•			•				•						•	•			•					
Rawlinson and Harrison (2009)	•	•		•			•			•			•			•				•	•			•									

Moreover, Kaputsyan (1974, p.280) identified storey height as a significant economic parameter whilst emphasising that the 'economic level of mass-scale housing construction for a specific period is stimulated by the standard requirements, thus formulating such economic parameters as the upper limits of the floor space of flats, the height of a storey, the number of lifts and the like'. Hence, storey height was considered in this study to be a significant design/economic parameter for change of use in buildings. Higher storey heights increase the flexibility of buildings. Having identified the influence of 'floor height/storey height' in building change of use, it is necessary to explain how this parameter could affect the economic considerations of buildings. Lau (2001) identified 'floor height/storey height' as one of the marketable factors that clients/owners most often consider when buying or leasing a space.

4.3. SUSTAINABLE CONSIDERATIONS

Sustainable buildings have the in-built ability to adjust to changing circumstances and technologies, without excessive waste and conflict (Kendall and Ando 2005). In its simplest form, sustainable futures are ones in which the basic means of human livelihood get easier, human opportunities become richer, and nature's diversity is more sustained and not only in the rich parts of the world (Holling, 2000). In this sphere, adaptable buildings can be defined as 'dynamic systems that carry the capacity to accommodate a set of evolving demands regarding space, function, and components' thus maximising the through life value (Adaptable Futures, 2012).

'Sustainability' has been an important element of all real estate developers' agendas, regardless of time and market perspective (Arge 2005). If buildings were designed for potential adaptations, it would be possible to successfully respond to the aforementioned built environment changes. On the other hand, sustainability will be a major criterion in judging future buildings and their installations. Among the factors that play a role here are savings in base materials, minimising waste production, ease of dismantling, adaptability and deposit money arrangements. Flexible buildings and installations that are readily adaptable to changing conditions respond to this trend (Geraedts, 2008). Buildings designed to maximise the potential for adaptation to accommodate different uses are required, together with appropriate transportation and communication infrastructures (Gann and Barlow, 1996). 'The construction industry must respond by creating new buildings that are adaptable, allowing their operating facilities managers to readily respond to changing space use demands throughout their life' (Webb *et al*., 1997, p.318). A building that is 'unfit for purpose' leads to it being redundant in its functional tenures. In this light, either design for adaptations (DFA) or design for short lifespans can be considered. However, the latter is not always appreciated in the sustainable agenda as many of the construction materials are economical in long structural lifespans, although reusable solutions have not been very well practised in the construction history recently. Hence, this paper promotes the potential for extending the functional lifecycles of buildings through DFA as opposed to designing for shorter lifespans. However, the future-proof endeavour seems complicated and risky because the decisions taken today need to be justifiable tomorrow, and perhaps these decisions may only vaguely fit tomorrow's requirements. In this regard, spending too much over budget for an unattainable target could also be considered a waste.

5. RESULT AND DISCUSSIONS

Eleven interviews were carried out among the construction professionals to identify the practical considerations of promoting adaptable buildings within the UK construction industry and they were analysed through NVivi-10 software. Tools in NVivo can be used for a variety of purposes, for instance models can be used to explore ideas as well as to present them to others (Wiltshier, 2011). A model was used to reflect on initial nodes and determine possible issues on promoting adaptable buildings within the UK construction industry (refer Figure 2). The results revealed that the buildings which are designed to enable future change represent a good long term investment however it is less practical to design one building to respond to all the aforementioned changes. In fact, the buildings which respond to pre-designed changes will bring 'value for money' and also 'improve the sustainability' in long term. To promote adaptable building within the UK construction industry, consideration should be paid on issues such as of market demand, user requirements, stakeholder awareness, cost and risk factors, and also available government initiatives for promoting adaptable construction.

The interviewees further stated that a typical commercial developer will initially raise finance for a development to pay a consistent yield on their investment over a 25 - 30 year period. By increasing their upfront costs on a development to provide the flexibility for a future 'non-specific' change they will be increasing their investment. Then it will take longer to repay which is a risk. As there is no certain plan for the future requirements there is no guarantee that their investment is a profitable one. Therefore, a more robust methodology is required at the beginning of the project to help developers'/clients' investment decisions. Developers are in business to make money to maximise return on every lowest spent. Therefore in reality they would accept to incorporating features in their buildings that tick the eco/sustainability box, but mostly provided it does not cost anymore. Therefore to have a market where design for future adaptability, the current entrepreneurs need payback in their lifetime, not in the future. However there are no concessions to achieve this. The whole structure of business, company or national, is run on achieving the yearly financial targets. There is little investment for a sustainable future no matter what most companies may expound. Moreover, if the government incentivised developers (through tax relief or grants) to consider this in their developments it could lead to better sustainability/environmental improvements. However, in real terms in depends on the location, for instance if a building is proposed to design for multi-use a city centre will realistically always be prioritised for commercial use. The Government could lead an initiative in their Public Sector Construction Programmes for specific areas they wish to regenerate strategically.

In a way, more buildings would be adaptable if there were 'legislation/regulation', 'increase in building values and rents', 'change in planning rules', 'greater standardisation', 'change in industry mind' and, most importantly, 'clarity over cost/benefit' and 'greater use of lifecycle cost'. In addition to economic considerations, the benefits to society at large (the neighbourhood) and the environment were also noted.

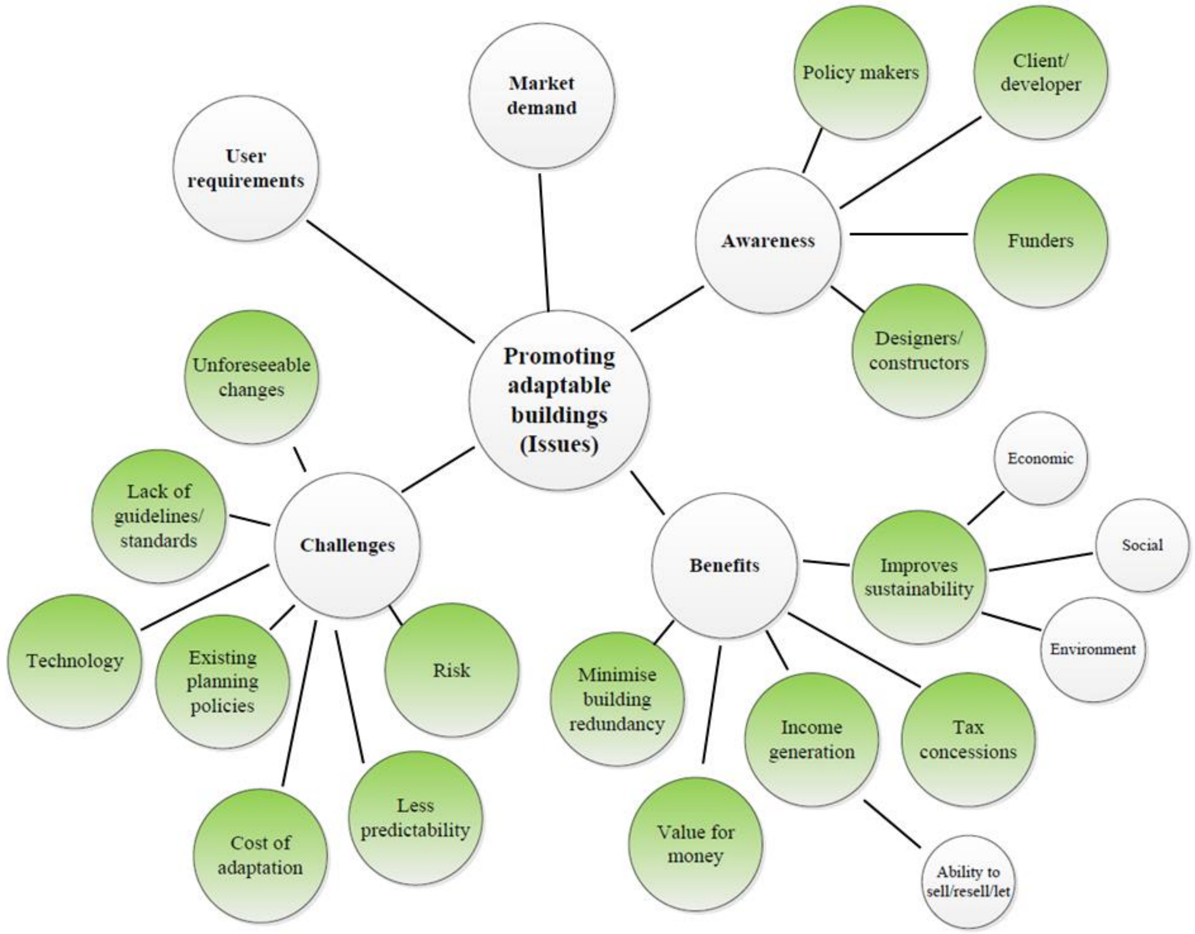

Figure 2: Issues Associated with Promoting Adaptable Buildings in the UK Construction Industry

6. CONCLUSIONS

Social, economic, political, environmental, technological, physical and legal factors demand built environment changes. However, the existing building stock lacks adaptable performance and vaguely responds to these challenges. As a result, the existing building stock has a tendency to remain redundant or is scrapped and rebuilt. In a way, adaptive reuse empowers a 'new life' into existing buildings; however, physical, economic, environmental and policy constraints appear to be the major difficulties in continuing such adaptations within existing buildings. Therefore, design for adaptation is considered as a means for empowering adaptable potential in new buildings to respond to the built environment challenges. This process (DFA) considers the lifecycle extendibility of buildings, which takes into account different adaptable strategies, design intelligence and design parameters for improving adaptable potential in new buildings. These adaptable strategies are able to provide reasonable design solutions to micro and macro level changes.

From the empirical investigations it was identified three key entities which are user needs, market demand and stakeholder awareness are required to be balanced to achieve a successful adaptable product. However, there are few challenges. Existing planning and policy issues appear to be major constraints to designing buildings for potential adaptations. Even though the exogenous demand arises for implementing adaptable strategies in built environments, a lack of owner/developer motivation tends to cause them to disregard these adaptable concerns in their brief. Existing design practices also need improvements to encourage adaptable potential in the new building stock. The expected benefits from adaptable buildings would be the motivation factor to promote adaptable buildings within the UK construction industry. The key benefits like value for client's investment, income potentials, tax concessions, remedy for redundancy and ability to improve sustainability are highly acknowledged. Whilst a plethora of literature exist on the importance of the need to either design with adaptability in mind, or making the existing buildings adaptable, the focus is mainly on the features of the building (product) such as scalability, convertibility, etc. However, given the complex stakeholder engagement, information intensity, process complexities etc, it is necessary to develop an appropriate environment which facilitates the development of adaptable buildings. Therefore, this study will further look in to how adaptability can be empowered in terms of incentives, processes, stakeholder engagement and technology (especially the rapidly developing information technology enabled tools such as Building Information Modeling - BIM) leverage. It is expected that the outcome will contribute to the achieving the broader sustainability agenda in the built environment.

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