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SUSTAINABLE IMPLICATIONS OF BUILDING REUSE AND ADAPTATION

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ABSTRACT

Built environment products and processes are now biased more towards profitable markets while giving sustainability the first priority in achieving the same. Consequently, value has become one of the main concerns while seeking various cost reduction methods through sustainable implications. Building reuse is one distinctive way that reflects the aforementioned sustainability in multiple ways. The existing building stock in the UK does not support sufficient flexibility that can be used for future adaption. Demolition of those buildings and construction of new builds does not seem to be an optimum solution, unless it helps increasing the building redundancy. Thus, an effective and achievable solution is required to address this problem. Apparently, design for adaption and application of adaptable features from the initial stage of every new build seem to be the most sustainable way that can be endorsed with sustainable, flexible buildings that last long and resist the future potential changes.

The research has exploited qualitative methods to explore the aforementioned problem. The research itself is based on a case study of Liverpool City Centre. Ten Structured interviews were conducted to identify the sustainable implications of building reuse and adaptation while an Archival Analysis was undertaken to identify the patterns of building change of use and their ability to reuse. The findings illustrate that economic factors have immensely influenced towards building reuse and adaptation. The research findings would also help different stakeholders to make decisions on how reusable features could incorporate within the new building designs through sustainability.

Keywords: *Adaptation; Building reuse; Sustainable implications.*

1. INTRODUCTION

1.1. BACKGROUND AND RATIONALE

Reuse can be explicated as the second hierarchical level of popular waste reduction methods; 3Rs of lean construction (reduce, reuse, and recycle) (Craven, 2012). When it comes to building reuse, although it takes long planning process, it finally saves buildings from demolition and gives significant benefits in social, environmental and economic perspectives (Douglas, 2006). Not only that, but also it has the potential to serve end users rendering a higher aesthetic value (Wolstenholme, 2009). Brownfield reclamation is another term that can be used to describe building reuse leading to land conservation and the reduction of urban sprawl (Craven, 2012). However confusion about the equality of renovation and facadism on building reuse is still on the contrary (Egan, 1998). But as per the general sentiment, it has been identified that it is a historic building preservation other than tearing. If buildings are capable of reusing without rebuilding, all costs related to rebuild can be saved leading on to a positive direction of economy (Couch & Dennemann, 2000). Building reuse conspicuously illustrates the magnitude of building adaptability and convertibility (Carlson & Gardner, 2011).

Adaptability is the capacity of buildings to give occasion to ponderable change. Over the lifecycle of a building, change is inevitable, both in the social, economic and physical surroundings, and in the needs and expectations of occupants (Russell & Moffatt, 2001). The concept of adaptability can be categorized as;

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- Flexibility, or enabling minor shifts in space planning;
- Convertibility, or allowing for changes in use within the building; and
- Expandability, (alternatively shrink-ability) or facilitating additions to the quantity of space in a building.

These can be achieved through changes in design and the use of appropriate technologies and materials. Ultimately, it gives a matured solution for most of the prevailing issues and challenges in construction industry over demolition and new constructions. A building that fails to survive upon the modern trends and demand while being inefficient both in technically and economically can be termed as a 'maladaptive' building (Russell & Moffatt, 2001).

Since environment, technological innovations, planning and policy issues, social requirements, political forces and economy are considered to be the predominant issues and challenges of construction industry; The buildings that fail to persist upon these issues and challenges would have to be converted by means of refurbishments otherwise would be demolished before they become waste as null and void (Kay, 2012). Most of the historical archaic buildings that currently exist can be considered as results of such conversions or refurbishments that were capable enough to exert with reuse. Majority of listed buildings in United Kingdom evidently prove this fact (Couch & Dennemann, 2000).

Buildings can be made adaptive and reusable by making changes in few different aspects such as; function that the building services for, volume which the building serve for certain amount of heads (population) and the sequence of hold that reins against internal and external forces. This can simply be termed as function, capacity and flow (Slaughter, 2000). Thus, the building can be adaptively reused for a purpose other than which it was built or designed for. Usually in a refurbishment, only the necessary sub-elements are replaced while the main structure/ shell is remained with minor or no changes. Therefore the durability of the focal structure is inevitably important (Russell & Moffatt , 2001).

In collateral to the rapid movement, aged buildings become maladaptive and unsustainable while reusing of them has had to deal with issues in terms of historic building conservation and heritage policies (Feildon & Bernard, 2003). Consequently, building's change of use has become one of the major issues in existing building stock in UK property market (Liverpool City Council, 2012). The information gathered in a recent research on building use change and its impacts have concluded highlighting the complaints on symptoms of "sick building syndrome" as a result of failure to adaption and continuation with those failures (McLennan, 2001). Demolition and building new doesn't seems to be economically viable and environmentally sustainable solution anymore (Douglas, 2006).

Nevertheless it is important to preserve those historic buildings as much as possible where 'reuse' is the distinctive approach to preservation of historic building and as well as preservation of existing resources. For, historic buildings represent the importance of social, cultural, environmental, economic and political perspectives of a nation (Feildon & Bernard, 2003).

1.2. AIM AND OBJECTIVES

The aim of this research is "to identify the sustainable implications of building reuse and adaptation'' through the objectives of identifying the pattern of building change of uses, investigating the factors that influence the aforementioned changes, exploring the adaptable potentials of those buildings and finally through identifying the triple bottom lined sustainable considerations of building reuse.

2. RESEARCH METHODOLOGY

The research is soundly based on a single design which is a case study design that enquires how functional changes of buildings have occurred over the past century and it ultimately urges the demand for adaptably designed buildings that resist potential future changes. Consequently, the case study promenades the functional change of built environment with respect to macro level.

The research process is designed with the aim of answering the research objectives (Naoum, 2012). The table below encapsulates the adopted research methods and the relevancies of them with each objective achievement.

Table 1- Research Objectives and the Research Process

Research Objectives	**Adopted Research Methods**							
	Literature Review	**Informal Discussions**	**Archival Analysis**	**Semi-structured interviews**	**Web based discussion threads**	**Case study**	**Secondary data Analysis**	**Desk study**
1. To identify how the uses and functions of buildings have been changed over their lifecycles (pattern of building reuse and change of use);	√	√	√	√		√		
2.To investigate the factors that influence for building reuse /change of use (reasons behind those changes);	√	√		√	√	√	√	
3.To explore the adaptable potentials of those buildings;	√	√			√		√	√
4.To identify the economic, social and environmental considerations of building reuse in terms of sustainability;	√	√		√	√		√	√

2.1. PHILOSOPHICAL POSITION OF THE RESEARCH

The study identifies 'building change of use' as one of main reasons for building obsolescence and investigates the potentiality of reusing existing buildings and its impacts towards sustainability. The study falls under applied research category which conducted as explorative research tradition, based upon 'pragmatism'. Nevertheless, explanatory descriptive traditions were also adopted in achieving third and fourth objectives. Since the study needs a clarification of sustainable parameters of building reuse including a cost-benefit analysis, an evidence-based, practical procedure was undertaken as an 'applied research'. Several approaches were used to collect data such as archival analysis for the case study, literature review, semi-structured interviews and secondary data analysis whilst the Triple Bottom Line (TBL) considerations for adaptability were identified through a desk study (Dainty, 2008).

Coordination all these ultimately endorses a new set of knowledge connecting the theoretical insights into practical context with empirical verifications.

Since the study has exploited multi method approach to collect data, '***pragmatism paradigm'*** is the chosen philosophy in this study.

It is the **Inductive theory** to be employed in this research. The theories are derived from the aforementioned observations and explorations (Creswell, 2009). The application of **Constructivism** is to be taken with the inductive approach through qualitative methods. By the means of constructivism a theory can be formulated going through observations (Creswell, 2009).

As per the research aim and objectives ***qualitative*** is the best fit approach in collecting data placing the investigation under ***qualitative mono-design*** (case study).

2.2. CASE STUDY DESIGN

Case-based empirical study is used basically to form new fiction and establish theories or to confirm and expand the existing theories (Yin, 2003). Within the scope and delimitations of this study, a ***single longitudinal case study*** design is used to study functional changes of buildings in macro level which enables to extract the essence of an in-depth analysis.

The case study contrived to show that the building functional changes actually occurs over a particular period of time is, the Liverpool city centre. How that change effects on the overall sustainability is studied after identifying the factors behind those changes. Liverpool is a cultural city that comprises with an extensive heritage value with number of listed buildings that were reused from 17s. In that case the selection of Liverpool city centre represents the typical factors that were required to accomplish the objectives. The Liverpool city centre was chosen as the case study to thorough the consecutive pattern of functional change of buildings over past 100 years. The chronological trend enables to understand how uses of buildings have changed in a formal manner. The archival analysis morphologically allows witnessing that in macro level.

The unit of analysis is 'buildings' in which the trend of changes are studied confined by middle range (4 -12 storeys) buildings. This unit of analysis was chosen because of the ease of comparability with the previous investigations where the unit is placed at the same level as those which are already placed in existing research phenomena.

The findings are finally interpreted with descriptive explanations derived from the comparing and contrasting strategy. In congenial to sustainability agenda the impacts of TBL sustainability are investigated in depth. In order to generalize the findings, semi structured interviews were used as a supportive tool.

Archival Analysis within the case study design

Analysing historic data immensely supports in achieving research goal with evidence (Hall, 2010). As per Creswell (2009), the difficulties of archival analysis are, ethical approval to access archival data because of security and copy right reasons, format and quality of stored data (i.e. micro films, manually drawn maps) and technical deprivations. Thus, for this research, archival data catalogues for the past century was used obtaining the legal permission to access and extract the data with copyright permissions from Liverpool Record office, Liverpool city council and Liverpool Central library.

Both Goad maps and street maps were used in this case study. However, functions of buildings were not always displays in historic maps. As a solution for that, the micro films of Liverpool street directories were referred to identify the functions of each building. Street directories were gazette only after 1971 therefore one difficulty was there to identify the functions of buildings before 1971. For that, a comprehensive literature search was carried on. Some points were clarified via informal discussions with a development control of Liverpool Record Office.

2.3. DATA COLLECTION METHODS- STRATEGY OF INQUIRY

2.3.1 Primary data collection methods

Conducting Interviews was the predominant primary data collection method of this study. Participants were selected in multi-disciplinary fields related to the building reuse (ex; architecture, engineering, planning, policy making and regulations, sustainability, procurement, construction management, facility management, quantity surveying and academician). Knowledge of the participating residents and experts can be relied upon the subject area as they can be considered as witnesses for the functional change and people who have practically experienced the change over time (Flick, 2006). A semi-structured questionnaire was employed as an instrument for data collection in this empirical study.

The audio clips were then transcribed and those were analysed via qualitative data analysis (QDA) computer software package NVivo. The data analysis was then used to develop a grounded theory. Grounded theory is a theory that was derived from data, systematically gathered and analysed through the research process.

2.3.2 Secondary data collection methods

An extensive literature review is speculated all over the research supporting each and every part of it. Initially, this was used to manipulate the formerly researches undertaken on the same area to perceive the basement for the study (Naoum, 2012). The reliability and relevancy of those were secured as all the secondary data sources were obtained through Liverpool John Moores University electronic library catalogue databases plus the university libraries, learning resource centres and Liverpool central libraries. The most of the secondary data sources were extracted from university learning resource centres while the sources from central libraries were obtained from the official membership of the respective libraries.

The archival records, historic maps, special books and documents were obtained from the Liverpool Record Office archival unit. Micro films were another good source of data for preserved archival records which were again available at Liverpool Record office.

A thought process review with related literature is illustrated in Figure below.

Figure 1- Funnelling of thought process to determine topic

Apart from that, already collected data are properly refined and categorised as their relevancies and information are produced that can use as inputs to the analysis by a 'desk study' (Creswell, 2009).

Numerous documentary data were used for this investigation. Archived reports, statistical records, building regulations, use class warranties; sustainability agenda, listed building consents, planning permission guides, etc. were some of them.

Documents/audio-visual materials are also employed as data taken from record office. Historical data, ownership transfer, tenant change, functional changes are examined through the data collected from Liverpool Record Office. The archive catalogue and relevant documents obtained from the Archaeological Department are also to be used in the research.

3. SCOPE AND DELIMITATIONS

In terms of 'use', the life span of a building can be prolonged with the features made in the initial design stage. Considerations on the construction stage are not covered by the research.

The research observation case study itself is practically and theoretically limited to the Liverpool city centre- L1 zone where the resulting outcomes are considered as a representative of the adaptive building reuse in aggregate of United Kingdom. The study is focused on the sequential changing pattern of reused buildings over the past 100 years where the selected case studies; buildings are precisely focused on the change of use. In that case, four number of use denominations; commercial, residential, office and retail are focused by virtue of similarity in their use, design, procurement and economic deliberations.

The selected case study is consisting of buildings that are limited to 3 – 12 stories (middle rise range) because the more the high rise, more tendencies to allocate higher design loads on foundations and different design parameters for adaptability. Very High-rise and buildings with two or less stories structures or buildings were not considered. Listed buildings are also not covered within this research scope. Majority of buildings in the selected cluster for the case study however are retail and office buildings.

4. LITERATURE REVIEW

4.1. RATIONALE

Over the last two decades, sustainable development and corporate social responsibility were two of the main discourses driven by global pressures. On the other hand, the global economic crisis is another hot topic widely perceived as the biggest barrier for the performance of afore-mentioned two factors. The UK construction industry frequently attracts hostility among the local community and general public due to its disruptive impact arising from the built environmental activities (Moore & Rydin, 2008). In that case the development of sustainability and CSR has been the best response being a solution for global warming and financial crisis as well. Since transition of economies is somewhat beyond the control of individual perspective, every organization should have a strategy to respond the challenge of meeting ethical, corporate social responsibility and sustainability-related responsibilities in recessionary times (Pitt, et al., 2007).

The current global economic downturn provides a unique opportunity to re-assess the sustainability of construction projects and develop more innovative practices (Hobbs & Mansour, 2009). With the recent declining economy and the dynamic regression of land markets people started to think that the trend for

green is dying, but projects that promote reuse have proved that greener buildings have been a perfect solution endorsing more for less cost supporting the economy as well (Hobbs & Mansour, 2009).

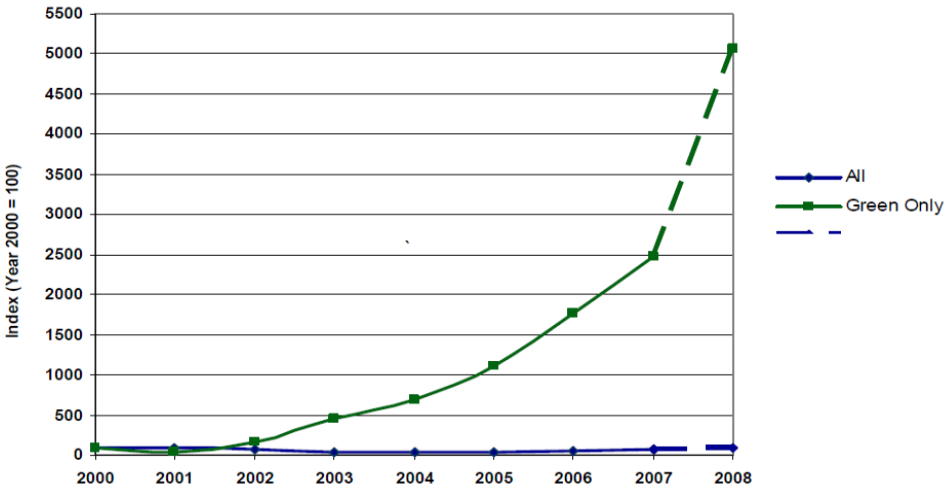

Figure 2- Green vs. non-green buildings growth in Europe

Source: RREEF Research, 2009

Despite this economic down turn, a tremendous growth in sustainability proves the greater potential for green buildings and sustainable solutions in the near- and long-term.

Hence, reuse of buildings and designing buildings that are endorsed with adoption potential are generally less cost consuming than conventional new buildings in terms of cost saving, good will of environment and greater demands with higher rent premiums for such properties (Murphy, et al., 2010). In fact, that can be a competitive advantage for global economy.

Construction industry is a major contributor for the pollution not just in the UK but also in the worldwide environment (Nieto, 2009). Built environment activities uses approximately 6 Tonnes of material for construction each year for every woman, man and child in UK (DTI, 2006). DTI further revealed that construction sector generates 92 MT of wastes per year, of which 13 MT are unused raw materials (Cabinet Office UK, 2011). Apart from that, 90% of non-energy materials extracted in the UK are supplied as construction materials and, the construction, occupation, maintenance of building and consumes 42% of all energy and generates around 50% of all UK carbon dioxide emissions, thus contributing to climate change. The construction industry is also a major consumer of natural resources causing natural material depletion. Being some of the impacts cause by construction industry in UK, have deleteriously effect on every aspect of the environment. In that case, it is undoubtedly proven that built environmental activities hold major part of the responsibility for most of the dangerous consequences cause lately.

4.2. EXISTING BUILDING STOCK

The contemporary built environment facilities are always a representation of a local cultural capital plus social, environmental and economic status of a particular area. However failure to withstand and adapt the TBL changes is a major reason to decrease this value of existing building stock. This has practically proven since majority of existing buildings built in mid-eighties are designed focusing on a single function within the intended life span. In that case the existing building stock has now faced drifts of challenges that include;

- Having buildings with long lifecycles but they are used for functions with short life cycles;

- As some stocks no longer meet current requirements, huge amount of vacant building stocks have been generated evoking an issue of building redundancy;
- Rapid change of user demands has become higher than the possibility for the existing buildings to be adapted in accordance with the changes;
- Tremendously biased trend for sustainable development in the built environment

These challenges conspicuously show that the existing building stock has got a greater need of a positive change. The buildings and their elements should be modified in terms of function, capacity and flow (Slaughter, 2000). The table below shows the ways that buildings can respond to the typical changes

Table 2- Responses of buildings to changes

Type of Change	Category	Responding Factors
Function	Upgrading existing functions	Higher performance levels that require different components/ processes
	Incorporate new functions	New facility performance objectives that require new components/ systems
	Modify for different functions	Different objectives from change in usage class that require different components, systems and/ or processes
Capacity	Change in loads/ conditions	Higher expected performance under specific load conditions
	Change in volume	Increased requirements for operable space per usage class
Flow **CIOB Subsection**	Change in environmental flows	Higher/ different performance requirements for internal or surrounding environmental conditions
	Change in flow of people/ things	Different performance requirements for passage, movement or organization of people/ things within/ into the facility

Source: (Slaughter, 2000)

The existing building stock is mostly accordance with the current framework for change of use in planning that is contained in the Town and Country Planning (Use Classes) Order 1987 (as amended) and the Town and Country Planning (General Permitted Development) Order 1995 (as amended) (Research Limited, 2012). Therefore any modification that is executed should undergo these congenial planning acts. However, upgrading maladaptive buildings to fit intended adaption is not always economically viable and technically justifiable. On the contrary, demolition may also not sustainable. Apparently, buildings designed for a single function is also somewhat practical economic solution in most business case scenarios (Jiune, 2011).

4.3. A NEED TO DESIGN NEW BUILDINGS FOR ADAPTION

The remedy for aforementioned issues and challenges are not only for existing building stock, but also for the buildings to be designed. Failure to design adaptable buildings will definitely result huge amount of obsolete buildings and ultimately increases building redundancy. Since the current building stock slightly facilitates this fact, an eager need has been evolved to design buildings for adaptions. The inflexibility of the original design seems to be the main cause for this, leading the buildings to be remaining vacant, demolished or reused with major renovations (Jiune, 2011). Having a stock of excrescent buildings is a threat to the growth of economy as the owners are bonded to pay taxes even though they do not emanate income and as well as a detriment for the social enhancement. On the other hand, overthrowing and constructing new builds is neither economically nor socially acceptable and does not consort with the sustainability too (Manewa, 2012).

Buildings designed to maximize the potential for adaptation confessedly accommodate different uses that are required in accordance with the change of market, cultural and political trends (Webb, et al., 1997).

4.4. BUILDING REUSE/ ADAPTATION AND THEIR SUSTAINABLE IMPLICATIONS

Certain built environmental communities define Adaptive Reuse (AR), or Re-use, as "the process that adapts buildings for new uses while retaining their historic features." (Davison, et al., 2006) A more accurate definition to AR is given as prolong the period from cradle-to-grave of a building by retaining all or most of the structural elements and as much as possible of other elements (Latham, 1994). In that case, it is not only the buildings of historic significance can be infused with new life but also the sundry buildings (Barlow & Gann, 1996).

In modernity, the aspiration to preserve historical buildings emerged in many Western countries out of various romanticist, nationalistic, and historicist streams (McLennan, 2001). Today, the exigent factor of extending the life cycle of a structure has been one of the major goals of sustainability too. Being a solution to building redundancy and sprawling, it immensely preserves virgin materials while conserving energy as well (Pirlon, 2004).

Advantages of building reuse

Most of the historical buildings are located in the centres of cities and in collateral to city developments these buildings remain as heritage-listed buildings adding a societal value (Feildon & Bernard, 2003). Adaptive reuse helps to extend this value. Another fact that clearly stands out is old buildings are often made of specific construction techniques and materials that the modern industry lacks of. In that case, the majestic nature of these buildings can be used to enhance the attractiveness towards clients as per the requirements of new tenants (Couch, 2003). Apparently, the savings in terms of cost, energy and environment and the contribution to overcome the global issue 'climate change' is the biggest benefit that can be gained as a result of building reuse (Hall, 2010).

Table 3- Summary of different benefits of Adaptive Reuse

Category	Description
Archaeological Motives	Architectural evidence for present and future generations
Aesthetic Appreciation	-Visual Amenity; the subjective enjoyment society experiences from

	its visual environment, its complexity and richness -Regional and particular character: reuse reinforces local identity -Cultural value: adds to richness, eclecticism, serendipity in built environment
Economic	Assess if cheaper than demolition, long term energy savings waste management cost of demolition
Function	Creative programming of existing building
Psychology	Involves the poorly studied psychological experience relative to drastic change Vs. gradual evolution of the built environment
Environmental	Retention of the original building's "embodied energy", lower greenhouse gas emissions. Reuse of buildings usually involves a saving of approximately 95 per cent of embodied energy that would otherwise be wasted
Social	Maintain the heritage significance of building increase liveability; provide the community with new housing and commercial property opportunities.
Promoting innovation	Emerge creativity in engineers, designers and architects

Source: Latham, Creative Re-use of Buildings I & II. Donhead, Dorset, 2000**.**

Barriers to adaptive reuse

The biggest barrier for adaptive reuse is the unsuitability and unsustainability of some old buildings and sites (Couch & Dennemann, 2000). In that case, the costs for modifications can be higher than a new build. Unviable circumstance that does not suit the current building codes is another fact. (Ex: the contamination of asbestos in old sites). Difficulty in obtaining planning permissions including planning and policy issues is also can be defined as a draw back for AR.

Sustainable considerations of building reuse

The balance between environmental health and economic health is secured by the means of energy efficient designs and materials (Kesik, 2013). Communities always have much to gain from historic buildings as adding value to their lives through pursuit of sustainable development. Avoiding the wasteful process of demolition and new constructing admittedly saves energy while benefiting the social advantages of recycling (Pirlon, 2004). Sometimes, adaptive reuse is the best way that the building's structure is cared in order to gain better use of the building itself. Where a building can no longer function with its original use, a new use through adaptation may be the optimal way to preserve its heritage significance while contributing to sustainability. However, some governments have made policies when adapting heritage buildings to minimize the impact on the heritage value as follows;

- Discouraging "facadism"- removing internal parts and retaining its facade
- Behest the new work to be contemporary and not to be poorly imitated tasks that makes harm to the original historic formation
- Recommending a new use for the building that is compatible with its original use.

Reuse of materials and resources, lesser energy involved, need of lesser labour and machine power certainly impact on a country's economy by minimising the expenditures on new builds (Simons, 2009). The monetary funds reserved for new constructions can be saved therefore.

5. CASE STUDY

Qualitative data are basically analysed to distinguish between several themes and disclose the substances that are consisting of expected characteristics that addresses the set objectives (Kirk & Miller, 1986)

Data is **primarily** collected by aforementioned case study observation and interviews. Thereupon, the collected data is analysed and interpreted through following types of analysis methods.

Table 4- Research Objectives and the Research Process

Strategy of inquiry	Research method	Supplements
Case study	Archival analysis, content analysis	Manual
Semi- structured interviews	descriptive thematic analysis	NVivo.

The selected cluster for the cases study is the Liverpool City Centre focusing on a macro level diagnose.

5.1. HISTORICAL CONTEXT OF BUILDING CHANGE OF USE IN LIVERPOOL

Liverpool is a city which is incorporated within the Metropolitan County of Merseyside with a wealth of historic value goes 800 years back since it's founded and recorded as borough in 1207 (Webb, 2007). Liverpool has the greatest density of Grade- I listed buildings outside London and whole famous sky line.

5.2. CASE STUDY INITIALIZATION

Single case study was studied to explain the typical changes of buildings over a period of 100 years. The city of Liverpool focused on the change of use of buildings within a relatively larger geographical area (macro level).

Though number of factors act as obstacles, economic matters and planning and policy issues are considered to be the most likely limitations to implement building reuse and change of use solutions in the built environment. It is important to reuse buildings in a city like Liverpool which has historic/character value of buildings so that the historic buildings are preserved for more generations ahead; as well as the culture and heritage is also preserved. Thus, this study was designed to explore all three TBL factors including economic and political considerations for building reuse.

Over the last 50 years Liverpool has undergone more economic restructuring and urban change more than any other city in Britain. For whilst Liverpool represents an extreme case with respect to the rate of urban change, economic, social and environmental pressure compared to those found in other cities (Couch, 2003). Liverpool city Centre has had to adapt more than most, its hand being forced by an enormous economic decline back in the years, post war period (Wilkinson, 2011).

The area selected for this study is the triangle surrounded by Paradise Street, Church Street and Hanover Street. The reason the select this triangle was this was the popular 'Paradise Triangle' that was

a core zone pinpointed labelled as the 'principal development area' (Littlefield, 2009). Historical Street maps, Goad plans, street directories were used to capture the changed occurred to buildings over last century. Maps were analysed (archival analysis) to identify the changes and the reasons behind those patterns. Changes are clearly noted in the matrix of a chronological order classifying the building uses as social, commercial, industrial, residential, leisure/ recreational and open / vacant. Residential included detached and semi-detached houses and apartment blocks. Commercial comprised offices, banks, public houses, hotels and retailers. Industrial included buildings for manufacturing and warehouses. Social covered schools, churches, clubs, hospitals and buildings that were built for the purpose of maintaining community wellbeing. Leisure included parks and other recreational facilities. The highlighted changes were mainly in terms of use and size. However, this study predominantly focuses on the change of 'use' compared to other types of changes. Functional transformations are investigated through a typo-morphological analysis.

The reachable historic maps and archival documents/ micro films were collected from Liverpool Record Office (archaic maps and records) and Liverpool central library (recent maps not older than ten years). Thus the archival analysis is to realise the macro level of building chronological change.

Historic maps to a scale of 1'' = 88ft/ 1:1000 for the years 1795- 2012 were used to study the pattern of building use change over the years. Among them a critical functional changes were identified in years 1880, 1924, 1988, 2004 and 2010 which are illustrated in the figure below. The factors behind these transformations were also studies with the investigation of remaining maps. Direct visit observations were also made to clearly identify the transformation from the older building to the current status. The buildings with no change are indicated in grey colour.

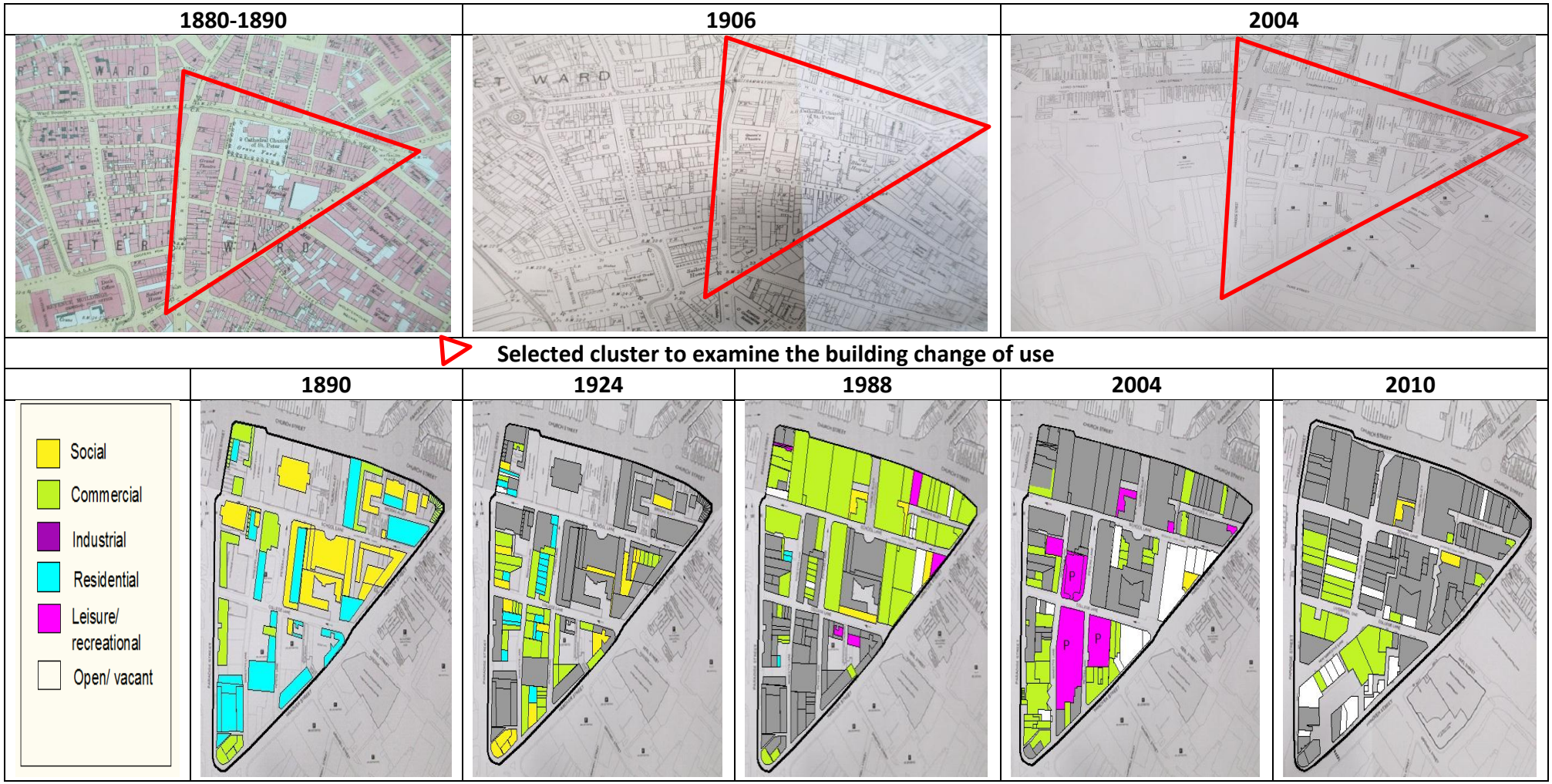

Figure 3- Macro level change of use in buildings

Source: Old ordnance survey maps, Street maps and Goad plans of Central Liverpool, Liverpool street directories; Liverpool Record office, Archival

5.3. ANALYSIS FOR THE CASE STUDY

Figure 2- 1765

Many of the agricultural fields and bare lands were developed for new buildings and their associated infrastructure networks. The city was not much packed but the commencement of few industrial buildings and residential buildings has been occurred. Compared to the other typologies, social buildings were the majority (Routledge, 1988). Few semidetached houses were built along Manesty's Street and School Lane. Few commercial stores also can be seen which were connected with the shipping industry. A scattered appearance of buildings has been there in this era. The St. Peter's Church, Bluecoat and a pub house can be identified as social buildings.

Figure 3- 1890 (Base plan)

The number of buildings within the cluster has been increased taking the advantage of bare lands. This was the era where Liverpool suffered from high population. As a solution, more semi-detached houses, terrace houses were built with lesser facilities. The number of pubs has also been increased with the development of Cain's Brewery business. Few commercial buildings have built, yet fully connected with the shipping industry. The bluecoat charity school was converted in to a hospital. Grand Theatre was made at the start of the school lane converting the pre-existed semidetached houses.

Figure 4- 1924

Many changes have occurred at this time. Few buildings which were used to be residential were converted in to commercial (Research Limited, 2012). The impact of world war is also immensely effected the functional change of buildings. A considerable spatial expansion can be seen to make residential buildings to fit for the demanding population. Few hotels were also built. The blue coat hospital was again converted in to a school of architecture. The athenaeum remains with several inner renovations.

Figure 5- 1988

Many changes have occurred at this time. The Parish church has been demolished and many commercial buildings have built. Residential areas have been utmost reduced and they have been converted in to commercial areas. More space has been allocated for commercial buildings, enabling the city to take the place of a commercial hub by this time. Post war rehabilitation can be seen in positive perspective. Many extensions and new construction have been undergone. Few vacant spaces can be seen as obsolete buildings as a result of war damages. This was the time when unemployment rate was highest of 26% (Couch, 2003).

Figure 6- 2004

More ground and underground parking area were created. The vacant area has been increased. More retail stores were created with extensions and reuse of existing buildings with conversions (Royden, 2012). The blue coat building has been further refurbished to have few retail spaces too. Most of the retail buildings were carried on with the same function but with a change of owners (i.e. C&D store was then owned by NEXT and HMV). The old John Lewis was moved to the corner of the triangle.

Figure 7-2010

Many changes were undergone since 2004 to 2010 with the Paradise Street development which were not externally visible because of the façade retaining but numerous internal changes (Madsen, 2009). A remarkable growth in commercial, social and open spaces can be identified in 2008. Since city Centre is a commercial hub, more than half of the area is converted in to commercial space while the remaining is comprise with social and open spaces (Moscardini, 2008). Residential spaces are very few which were also owned by Liverpool city council. The area which was vacant still remains same while adding more vacant area proving the problem of 'building redundancy' in the city.

By 1888, all functional categories were appeared to be in L1 area. With an in-depth analysis, the cluster seems to have started to commercialise from 1980 onwards. A major redevelopment can be seen by 2006 with the Paradise Street development (Reid Architecture, 2005). Apparently, residential buildings

were totally shifted away from the cluster and more commercial and social buildings were accommodated. The residential buildings' failure to contribute to the city economy most of them were required to convert in to office or public house spaces. The dramatic growth in population has immensely impacted on this. This is the key factor identified as a driver for most of the spatial expansions, sustainable persuasions, social and wellbeing improvements. Apart from that, political and legislative changes, sustainable concerns and trends, change of user demands time to time have also impacted on these changes.

The establishment of bank in early 19s shows the stability of city in terms of monitory transactions. HSBC and Lloyd's banks are vital among them. A huge contribution to the economy has been made by the three anchor stores of the city which were chronologically sentenced to different changes since early 80s. However it seems that many buildings have reused over and over again for different purposes while few has demolished and few remain redundant too. The adaptability of them was positive in to a certain extent unless the rate of replacement and refurbishing is not exceeded 50% of the entire work (Parker, 2012).

Additionally, a growth in social and leisure buildings within the cluster also can be seen. With all these, it is notable that the shipping industry of Liverpool continued from the beginning apart from few pauses in early 18^{th} and 10^{th} centuries, which is another key contributor to the city attractions as well as economic stability. Thus, economic, social and environmental considerations are identified behind these changes and they can be assisted when DFA and the process of reuse.

6. INTERVIEWS

In addition to archival analysis of building change of use 10 interviews were undertaken among the academics and professional experts to identify the impacts of those changes. Interviewees were asked to respond to a set of structured questions and the data was analysed through NVivo software. A summary of interview data is included in the conclusion.

With the case study, it is conspicuous that many changes have occurred over the past 100 years with respect to social, industrial, residential and commercial buildings. Those changes can be small with additional improvements (no functional change), large changes with major refurbishments (no functional change), large changes (functional change) or demolition. It also identified that the possibility of converting old building to newer building with a functional change or same use is in a higher rate. Evidences were given that successfully undergone through such processes. Population growth, manufacturing and industrial growth, rate of higher education, recessions have highly impacted on these generic changes. Planning and policy matters also highlighted among them. Eventually, it can be concluded the case study by asserting that, building change over time practically occurs and the functional change is prominent among them. Some aged buildings are comprised with a higher potential to adaptability.

The first objective was to identify how the uses and functions of buildings have been changed over their lifecycles (pattern of building reuse and change of use). The case study research design employed in the study has conspicuously identified that the building change has occurred in past 100 years with a determination of the pattern of change in macro level. The second objective was to investigate the factors that influence for building reuse /change of use (reasons behind those changes). The same case

study analysis has been capable of identifying the factors behind those changes linked with the historical context and background to the case study. Secondary data analysis helped to generalise the findings. Growth of population, education status, policy and legislative matters, interference of government, recession and growth of other sectors (industrial, commercial and educational) over the last century were the closest reasons behind these.

Exploring the adaptable potentials of the aforesaid buildings was the third objective and a comprehensive narration was given on adaptable buildings and their implications toward practical application while exploring the adaptable potential of the buildings within the selected cluster (case study) in order to achieve that. The supportive arguments were given by different participants in interviews. Different time periods during the last century proved the current need for designing new buildings towards potential adaptations. Whilst, improving the possibilities for extending the functional lifespans of buildings were deeply discussed with the incorporation of both secondary and interview data.

The final objective was to identify the economic, social and environmental considerations of building reuse in terms of sustainability. Data collected from interviews immensely contributed to identify the TBL sustainable considerations of building reuse while existing literature strengthens the dictum.

7. VALIDITY AND RELIABILITY

"Reliability and validity are tools of an essentially positivist epistemology" (Braun and Clarke, 2006). Riege (2003) explains reliability as the extent to which the research results are decisive over time and the selected sample should therefore represent the accurate percentage of total target population. Kirk and Miller (1986) discusses about three types of reliability in a quanitative study as follows;

- the degree to which a measurement, given repeatedly
- the stability of a measurement over time
- the similarity of measurements within a given time period

A high degree of stability indicates a high degree of reliability, which means the results are repeatable. The validity in a quantitative study as Golafshani (2003) explains is whether the study actually measures that which it is intended to measure or how truthful the results are.

Reliability in a qualitative paradigm is always based on Credibility, Neutrality or Confirm-ability, Consistency or Dependability and Applicability or Transferability (Kirk & Miller, 1986).

The maps used for the case study were the original maps derived from the archival department of Liverpool record office and Liverpool central library. The data related to the historical context were also derived from same places archival catalogues and books. Census and statistics were obtained from websites; Office for National Statistics, UK. Analysis was undertaken without any changes to their originality. The validity and reliability of interview data were stated in chapter five.

8. CONCLUSION AND RECOMMENDATION

8.1. OBJECTIVE ACHIEVEMENT

The first objective was to identify how the uses and functions of buildings have been changed over their lifecycles (pattern of building reuse and change of use). The case study research design employed in the study has conspicuously identified that the building change has occurred in past 100 years with a determination of the pattern of change in macro level. The second objective was to investigate the factors that influence for building reuse /change of use (reasons behind those changes). The same case study analysis has been capable of identifying the factors behind those changes linked with the historical context and background to the case study. Secondary data analysis helped to generalise the findings. Growth of population, education status, policy and legislative matters, interference of government, recession and growth of other sectors (industrial, commercial and educational) over the last century were the closest reasons behind these.

Exploring the adaptable potentials of the aforesaid buildings was the third objective and a comprehensive narration was given on adaptable buildings and their implications toward practical application while exploring the adaptable potential of the buildings within the selected cluster (case study) in order to achieve that. The supportive arguments were given by different participants in interviews. Different time periods during the last century proved the current need for designing new buildings towards potential adaptations. Whilst, improving the possibilities for extending the functional lifespans of buildings were deeply discussed with the incorporation of both secondary and interview data.

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8.2. IMPLICATIONS OF THE RESEARCH FINDINGS

This study emphasises the trend towards reuse of existing buildings and also reckon a need for designing new buildings to be future proof. The understanding of social, economic and environmental considerations (benefits and Disbenefits) of building reuse and adaptable buildings leads to encourage the DFA process and solely building reuse. Moreover, it helps clients/owners/ developers on their decision-making towards building adaption. The findings suggest more buildings would be reused while more adaptable buildings would be designed if there were a proper framework/ standardisation, easily reachable regulations/policies, improvement in adaptable/ reused buildings' value and rent, comfortable planning regulations, a positive change in the industry towards adaptability and, optimum use of lifecycle cost analysis.

There are both costs and benefits related to DFA and building reuse. But a properly clarified cost benefit analysis, with the help of WLC have the potential to assist the decision making process on the same. Thus, this research benefits for many stakeholders such as owners/ clients, developers/funders/investors, planning and policy makers, end users and the general public.

8.3. CONTRIBUTION TO THE CURRENT KNOWLEDGE BASE

The research findings strengthen and support the credibility of the existing knowledge base while embossing the fact that a trend for building change of use and building reuse is practically occurring. Additionally, the research also confirms the TBL sustainable considerations in building reuse and DFA while emphasising the most influential design parameters as spatial flexibility such as floor to ceiling height and structural stability.

8.4. RECOMMENDATION

Adaptable buildings are now identified as a leading requirement of the UK Government even though it is a shortfall of most parts in UK. A positive trend towards building functional change evidently proves that fact. Designing buildings for a long structural life and short functional life seems to be balanced need in terms of sustainability. It's economic unviability and social unacceptability and environmentally unsustainability is also on the contrary, as it is comprised with both benefits and Disbenefits. However, long term decisions on building.

Reuse and DFA can be achieved through in-depth investigations and WLA. Therefore modern construction industry led strategies require considering ways of ensuring adaptable features are included at the earliest possible phase of design. Literature reveals the initial capital cost of adaptable building as a critical challenge, although the cost in-use is comparatively low with time in adaptable buildings. To recapitulate this study is solely a mean of clarification towards long time decision on building reuse and design for adaptable buildings which is now achieved to help the aforementioned stakeholders to have a think on with insight shrewdness.

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