A MODEL FOR THE COMPLEX ASSESSMENT OF SUSTAINABLE HOUSING AFFORDABILITY

EMMA KATE MULLINER

A thesis submitted in partial fulfilment of the requirements of Liverpool John Moores University for the degree of Doctor of Philosophy

OCTOBER 2012

Any maps, pages, tables, figures graphs,or photographs, missing from this digital copy, have been excluded at the request of the university.

Do not scan

App 7-13

Fig 34. p178

Table 8 p96

Fig 8 p56

7 p45

6 p44

4 p35

Table of contents

List of figures

List of tables

List of acronyms and abbreviations

ACF and VCOSS	Australian Conservation Foundation and Victorian Council of Social Service
AHNRC	Affordable Housing National Research Consortium
AHP	Analytical Hierarchy Process
AHURI	Australian Housing and Urban Research Institute
ANOVA	Analysis of variance
BOS	Bristol Online Surveys
CABE	Commission for Architecture and the Built Environment
CLG	Department of Communities and Local Government
CMHC	Canada Mortgage and Housing Corporation
COPRAS	COmplex PRoportional Assessment
CTOD and CNT	Center for Transit-Oriented Development and Center for Neighborhood Technology
DEFRA	Department for Environment Food and Rural Affairs
DELG	Department of the Environment and Local Government
DETR	Department of the Environment, Transport and the Regions
DFT	Department for Transport
ELECTRE	Elimination and Choice Translating reality
GIS	Geographic Information Systems
HCA	Homes and Communities Agency
HCCPA	House of Commons Committee of Public Accounts
HMRI	Housing Market Renewal Initiative
HNZC	Housing New Zealand Corporation
IMD	Index of Multiple Deprivation
LCC	Liverpool City Council
LTV	Loan-to-value
MADM	Multi/Multiple Attribute Decision Making
MAUT	Multi/Multiple Attribute Utility Theory

MCA	Multi/Multiple Criteria Analysis
MCDA	Multi/Multiple Criteria Decision Aid
MCDM	Multi/Multiple Criteria Decision Making
MEW	Multiplicative Exponential Weighting
MODM	Multi/Multiple Objective Decision Making
NHPAU	National Housing and Planning Advice Unit
NPPF	National Planning Policy Framework
NWRA	North West Regional Assembly
ODPM	Office of the Deputy Prime Minister
OECD	Organisation for Economic Co-operation and Development
OR	Operations Research
PMSU	Prime Minister's Strategy Unit
PPS3	Planning Policy Statement 3
PROMETHEE	Preference Ranking Organisation Method for Enrichment Evaluation
RAHP	Revised Analytical Hierarchy Process
SAP	Standard Assessment Procedure
SAW	Simple Additive Weighting
SPSS	Statistical Package for the Social Sciences
TOPSIS	Technique for Order Preference by Similarity to an Ideal Solution
WCED	World Commission on Economic Development
WHO	World Health Organisation
WPM	Weighted Product Model
WSM	Weighted Sum Model

Acknowledgements

Firstly my profound appreciation must be expressed to my Director of Studies, Dr. Vida Maliene, for the endless guidance, expertise, motivation and reassurance I have received during my studies, and not forgetting the initial suggestion of conducting a PhD which has led me to this point. She is an inspiring and driven woman who has become a lifetime friend. Besides my principal supervisor, I would like to show gratitude to my second supervisor, Prof. Chris Couch, for his valuable comments, time and assurance.

Many other people also contributed to the completion of this thesis and I am enormously grateful to them all: Kieran Smallbone for his invaluable assistance with mathematical issues; Ryan James at Liverpool City Council for being extremely helpful and generously providing GIS mapping services; local authority employees who took time to partake in the interviews; and all those who kindly participated in the questionnaires. I would also like to acknowledge Liverpool John Moores University for providing the financial support for this research.

Special thanks and appreciation must of course go to my wonderful parents for helping me get through this journey. They have provided me with their unfaltering support and belief in my ability to accomplish this thesis, tolerated me living and working at home, as well as selflessly allowing me *(with a minimal amount of grumbling)* to take over much of their upstairs living space for my office. Living with the often quoted mantra of "*what's the worst that could happen*" always helped keep things in perspective. I also wish to express my heartfelt thanks to Kris who has given me great encouragement, motivation and confidence at a stage where I needed it most, along with a kind willingness to endeavor to help when possible and patience in times of stress. I would have struggled to achieve this thesis without the daily support from those close to me who, often without any knowledge of my progress, never failed to have faith in me. This thesis is dedicated to them.

Abstract

This study investigates the concept and assessment of housing affordability. Housing affordability is a multi-dimensional issue, yet it is typically assessed quite simply in terms of the financial burden of housing costs. The study frames the housing affordability problem as encompassing more than financial costs of housing and household ability to meet these costs, and extends to larger issues of social wellbeing and community sustainability.

This thesis provides an original contribution to new knowledge by developing and applying a complex model for the assessment of sustainable housing affordability. The model is holistic and is capable of considering a broad spectrum of criteria determining housing affordability and the wellbeing of households, including economic, environmental and social aspects. Multiple criteria decision making (MCDM) techniques are innovatively applied for the analysis of sustainable housing affordability. The chosen methodology of MCDM allows a multidimensional analysis of both quantitative and qualitative criteria influencing the affordability of housing and household wellbeing. The thesis presents the results of a case study assessment of 10 areas in Liverpool, UK as a practical example of the sustainable housing affordability assessment model. This allows the given areas to be ranked in respect of their sustainable housing affordability.

The model can assist stakeholders, such as central governments, local authorities, developers and consumers, on both a national and international scale, in making comprehensive and informed decisions concerning affordability. The model provides a complex analysis of the criteria that influence the affordability of housing, beyond the financial implications experienced by households and better reflecting household wellbeing and sustainability concerns. The tool could be utilised as a potential planning indicator for shaping local housing markets. The rankings derived from the model may be used as a locational decision aid and to support new housing development that will meet the needs of low and moderate income residents in ways that go beyond traditional notions of financial burden.

Keywords: Affordable Housing, Housing Affordability, Multiple Criteria Analysis, Multiple Criteria Decision Making, Sustainable Communities

Chapter 1

Introduction

This chapter provides an introduction to the subject area of the research, highlighting the importance of the topic and research problem, the research question, the aim and objectives that were established in order to carry out the study, the beneficiaries of the research, and how the research makes a significant contribution to new knowledge in this area. Finally, an overview of the chapters included within the thesis is provided.

1.1 The research problem

Decreasing housing affordability is currently a prominent issue within many developed countries (Harriot and Matthews, 2009; Jones *et al.*, 2011). For over a century housing affordability has been a continuing concern for consumers and governments, but in recent decades it has taken on even greater visibility in the face of rising housing costs (Stone *et al.*, 2011). The shortage of affordable homes has become a national crisis across the UK. For decades the supply of housing failed to keep pace with demand, contributing greatly to the sharp increase in house prices that occurred between the mid-1990s and 2007 in the UK (Barker, 2004; CLG, 2006a; NHPAU, 2009a). In addition to the well documented mismatch between the supply and demand for housing, the housing market is facing increasing strains arising from the recent economic crisis. Although the recession caused house prices to decrease, it has also resulted in tighter mortgage markets and increased deposit requirements, making it increasingly difficult for first time buyers to get a foot on the housing ladder (NHPAU, 2009a). The ability to access both market and affordable housing has been severely constrained by the tightening of credit and decreased public expenditure and resources. Today, it is not only those on low incomes experiencing housing affordability problems. Degree-level educated young professionals, some with well above average earnings, are experiencing great difficulties in accessing and affording housing (Bone and O'Reilly, 2010). Demand for housing may have been dampened by the credit crisis, but the need for housing has not abated. Nationally there are over 4.5 million people on social housing waiting lists (CLG and HCA, 2011).

However, housing affordability goes much deeper than simply the ability to access housing at an acceptable cost. Stone (1993, p.1) notes that "Housing is not only a necessity of life; it has a pervasive impact on all aspects of our existence". Housing affects our health, quality of life, well being and contributes to people's sense of security and stability (CLG, 2007a). It also determines access to jobs and to services (Stone, 1993). Consequently, housing can assist in achieving positive outcomes in education, health, employment and creating stronger communities. Housing affordability is thus a pressing problem that has significant implications which go beyond the immediate effect experienced by households, such as economic performance and labour market efficiency, social cohesion and polarisation of cities, along with environmental considerations (Shostak and Houghton, 2008; Yates and Milligan, 2007). Housing is said to be a principal factor in tacking social exclusion and achieving sustainable development (Carter and Fortune, 2007; Edwards and Turrent, 2000). Crucially, affordable housing has a fundamental role to play in contributing to the improved economic, environmental, social and physical health - the sustainability - of communities (HM Government, 2005; Maliene *et al.*, 2008). A key aim of government policy in the UK is to create sustainable communities, which are defined as places where people want to live and work, now and in the future (HM Government, 2005; ODPM, 2004). Housing affordability is a key issue that must be explored at local, regional and national levels in order for the government to address wider issues and goals, including the sustainability agenda. If affordability problems are not adequately addressed there will be profound social and economic consequences for our communities and future generations (NHPAU, 2008).

It is evident that housing affordability is a multi-dimensional issue, having implications for not only households but for the wider economy and the environment. The topic has therefore been subject to a great deal of research and policy making. A significant amount of research exists concerning the measurement of housing affordability (Bramley, 1990; Fisher *et al.*, 2009; Gan and Hill, 2009; Hancock, 1993; Hulchanski, 1995; Jones *et al.*, 2011; Kutty, 2005; Nepal *et al.*, 2010; Stone, 2006b; Whitehead, 1991; Whitehead *et al.*, 2009). Although research suggests that the theoretical foundations of the concept have received less attention (Gan and Hill, 2009). While the affordability topic has received increasing interest and growing relevance, there is still no common consensus on how best to conceive housing affordability. International literature highlights that a specific definition of housing affordability is unclear (Abelson 2009; Gan and Hill 2009; Ndubueze 2007; Stone 2005). Subsequently a specific and accepted measure of affordability is also uncertain. Nevertheless it is common to define and assess housing affordability in financial terms, primarily by looking at the cost of housing in relation to income (Lux, 2007; Whitehead *et al.*, 2009). However, OECD countries are increasingly recognising the need for a broad and more encompassing understanding of housing affordability (Gabriel *et al.*, 2005).

Shortcomings with the traditional approach to conceiving and assessing affordability are increasingly being documented (Belsky *et al.*, 2005; Bogdon and Can, 1997; Fisher *et al.*, 2009; Gabriel *et al.*, 2005; Rowley and Ong, 2012). Such a situation has brought about the need for innovations in the conceptualisation and assessment of housing affordability. The affordability of housing can be determined by a range of factors including, but not limited to, economic, social, political, housing market, and planning, the assessment of which depends on the capacity of measurement tools to analyse the aforementioned criteria. However, affordability assessment methods often only account for economic factors. An international desire to create more affordable and more sustainable communities means that closer links must be drawn between economic, social and environmental concerns. This means that a broader range of criteria ought to be considered in relation to housing affordability in order to create successful housing and communities for society to reside in.

In order to overcome the shortcomings in the assessment of housing affordability more complex assessments are required. Limitations in the assessment of housing affordability can be eliminated by the use of methods which are able to take into account a wider range of criteria than traditional methods do. Methods including cost benefit analysis (CBA) and hedonic modelling were considered for this purpose. CBA seeks to quantify the advantages (benefits) and disadvantages (costs) associated with a particular alternative. Although critics claim that CBA is of limited use in complex situations because all criteria must be measured in monetary terms (Hall and Tewdwr-Jones, 2010). However, a monetary value cannot be assigned to all factors related to housing affordability, such as social and environmental considerations, including individuals' welfare. Doing so can be potentially harmful for the likes of planning decisions (ibid). Hedonic modelling was also considered. Such methods are based on the fact that prices of goods in a market, such as housing, are affected by their characteristics. This helps to estimate the value of a commodity based on people's willingness to pay for the commodity as and when its characteristics change. However, if consumers are unaware of the relationship between certain characteristics and the benefits they may have on them or their housing, then the value will not be reflected in the property price. Once more, this method focuses on obtaining economic values for characteristics and this may be difficult to ascertain for some environmental and social factors. Moreover, the amount of data that needs to be collected for hedonic modelling is extremely large. Multiple criteria decision making (MCDM) methods, also known as multiple criteria analysis (MCA) are particularly suitable for this study. Such methods only came into existence in the second half of the 20th century. These methods are able to take into account a large number of criteria, including economic, environmental and social factors, so they can be used on both quantitative and qualitative data and permit multi-dimensional analysis.

1.2 Research question

Based on the apparent research problem, the following research question was proposed:

What is housing affordability and how can the concept be assessed in a comprehensive way, addressing a broad spectrum of criteria that influence the wellbeing of households in communities?

1.3 Research aim and objectives

To answer the research question, the following overall aim was devised:

To develop a complex model for the assessment of sustainable housing affordability, that is capable of considering a broad spectrum of criteria determining housing affordability and the wellbeing of households in communities.

The research ultimately strives to encourage a new paradigm of thinking in relation to housing affordability, by drawing closer links with household wellbeing and sustainability concerns.

The following objectives were set to investigate the aim:

1. ***Background research to investigate the concept of 'housing affordability', critically analysing definitions of the concept and traditional and recent measures used to assess affordability.***

2. ***Highlight the importance of providing affordable housing in the context of sustainable communities.***

3. ***Establish a comprehensive set of criteria by which sustainable housing affordability can be assessed in a holistic and sustainable manner.***

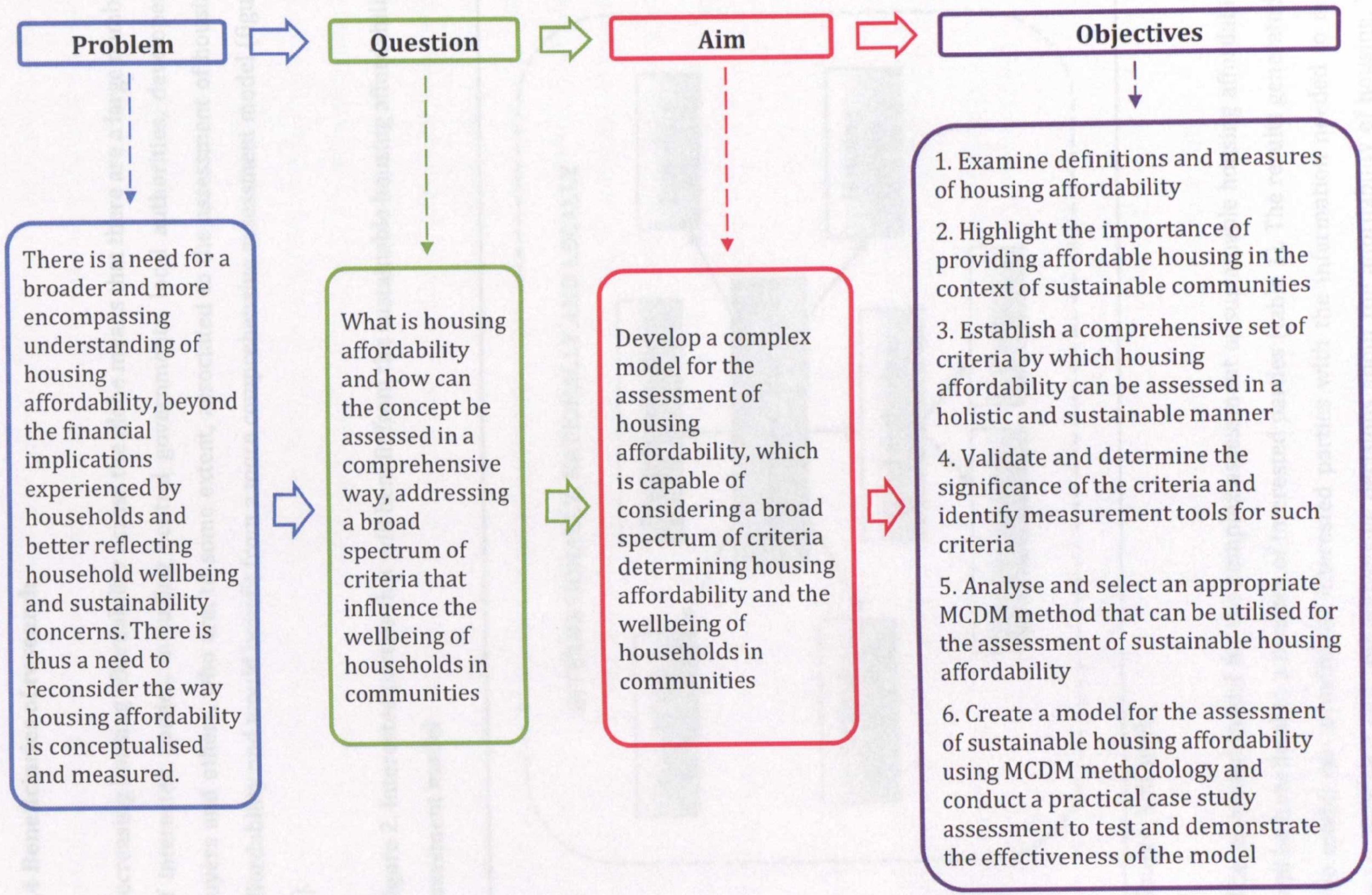
4. ***Validate and determine the significance of the assessment criteria and identify measurement tools for such criteria.***

5. ***Analyse and select an appropriate multiple criteria decision making methodology that can be utilised for the assessment of sustainable housing affordability.***

6. ***Create a model for the assessment of sustainable housing affordability using multiple criteria decision making methodology and conduct a practical case study assessment to test and demonstrate the effectiveness of the model.***

Figure 1 summarises the purpose of this research, from the identified research problem and how this ultimately links to the research objectives.

Figure 1. Purpose of the research



1.4 Beneficiaries of research

Decreasing housing affordability across the globe means that there are a large number of interested parties, including central governments, local authorities, developers, buyers and others, who are, to some extent, associated to the assessment of housing affordability and would benefit from a more comprehensive assessment model (figure 2).

Figure 2. Interested parties that will benefit from the sustainable housing affordability assesment model

Source: Self study

The proposed model for the complex assessment of sustainable housing affordability will be beneficial to a number of interested parties (table 1). The results generated by the model can provide all interested parties with the information needed to make more informed and comprehensive decisions about the affordability of housing. The assessment model would be useful for policy makers at all levels – global, national, local, community associations – who are attempting to respond to the issue of housing affordability and community sustainability. Central/federal governments can use the model to inform decision making on housing policy and investment priorities. The tool could be utilised by local authorities as a potential planning indicator for shaping local housing markets. Local authorities, along with developers and investors, can use the tool to select sites for affordable housing development between competing locations. It would assist in identifying areas that are suitable for affordable housing development, along with areas which may require alternative forms of investment to enhance affordability and create attractive and sustainable communities for wider society to reside in. Thus, it could provide and monitor affordable housing development, while at the same time promoting sustainable communities and high quality of life for households. Accordingly the research can also be beneficial for wider society. Furthermore, the results generated by the model can support housing consumers in making decisions on house purchase. The method is useful because it ranks areas according to a broader concept of affordability and is able to account for the opportunity costs and benefits of residing in a given location.

Table 1. Beneficiaries of research

Beneficiaries	Benefits of assessment model to stakeholders
Governments, local authorities and housing associations (local, national or international)	• Comprehensive assessment of sustainable housing affordability that is useful for more informed decision making around affordability issues. • Facilitate housing policy decision making. • Provide and monitor affordable housing development. • Promote and maintain high quality of life for sustainable communities.
Developers and investors in affordable housing (internationally)	• Aid in identifying areas which would be suitable for development of affordable housing and areas which may not be suitable. • Assist in identifying areas which may require alternative forms of investment to enhance affordability and create sustainable communities. • Use to compare and rank the sustainable housing

	affordability of different areas.
Housing consumers/buyers and wider society (internationally)	• Use the results to aid more informed decision making around affordability issues, assist in making better decisions on house purchase and to aid in choosing among alternative housing locations, helping to identify the one that best balances consumers' different needs and preferences. • The application of the model in practice will assist in creating affordable, sustainable and high quality communities for society to reside in.

Source: Self study

1.5 Original contribution to knowledge

This thesis provides a significant contribution to knowledge of the subject area owing to the following reasons:

- The research shows evidence of originality as it goes beyond the traditional notion of housing affordability. While affordability is habitually defined and assessed in economic terms, the research applies the concepts of community sustainability and thus extends the scope of affordability to reflect social well-being and environmental attributes. The study therefore also contributes to the sustainability agenda and sustainable housing/communities research.

- Moreover, the research provides originality by developing a comprehensive set of sustainable housing affordability assessment criteria, validated by UK professionals, by which the affordability of different housing locations can be analysed and compared in a meaningful way. The significance (importance) of the assessment criteria is also presented. This provides for a more complex understanding and analysis of the broad range of factors - economic, environmental and social - that are important to housing affordability and community wellbeing. The developed criteria system represents a broader concept of housing affordability and subsequently the study also contributes to the definition of housing affordability.

- In addition, the study presents a novel sustainable housing affordability assessment method that is more holistic than traditional affordability measures and is capable of considering the established assessment criteria, including economic, environmental and social attributes. The research innovatively applies multiple criteria decision models to the assessment of sustainable housing affordability and as a locational decision aid.

- The method of the multiple criteria decision analysis is applied for the first time in this study for the assessment of sustainable housing affordability.

- The chosen methodology of multiple criteria decision making allows the analysis of both quantitative and qualitative criteria affecting the affordability of housing and reflecting community sustainability.

- The study presents an overall model for the complex assessment of sustainable housing affordability using multiple criteria analysis methods that any interested parties, nationally or internationally, can adopt. Such a model and concept of sustainable housing affordability was not developed until now.

- The proposed multiple criteria analysis methods are flexible and available to all interested parties (for example, local authorities, planners, housing associations, developers, buyers and others) striving to attain their goals and needs. The number and significance of criteria can be easily amended in the application depending on the needs and preferences of the interested party.

In summary, the originality of the research lies in the novel notion of affordability and complex model for the assessment of sustainable housing affordability which could be adopted on a local, national or international scale.

1.6 Overview of chapters

Chapter 1 serves as an introduction and overview of the subject area and includes the research problem, research question, overall aim and objectives of this study, as well as the beneficiaries of the research and the original contribution to knowledge.

Chapter 2 and 3 include literature review to address objective 1 and 2 of the study. Firstly definitions of housing affordability are discussed, with reference to opinions from both academic and policy environments. Subsequently, the measurement of housing affordability is analysed, reviewing traditional and modern methods available and outlining their strengths and weaknesses. Finally, links between housing affordability and sustainable communities are highlighted. The chapters conclude by emphasising the importance of gaining a more comprehensive understanding of the housing affordability concept and developing a more holistic housing affordability assessment tool that is better aligned with sustainability concerns and household wellbeing, alongside economic factors.

Chapter 4 presents a literature review to aid in addressing objective 5 of the study. The chapter discusses multiple criteria decision making (MCDM) methodology, including an overview on popular methodologies and the necessary data collection process for the use of such methods in this study. Additionally, justification of using MCDM methods as the basis of the proposed sustainable housing affordability assessment model is provided.

Chapter 5 details the key research methods utilised during the empirical research. A mixed methods approach was adopted, using both quantitative and qualitative research methods sequentially. Initially, the qualitative methodology adopted within the study during stage 1 of the research process is discussed. The quantitative methodology adopted within the study during stage 2 of the research process is then explained. Finally, details of the data collection required for the use of multiple criteria analysis methods in stage 3 of the research is clarified.

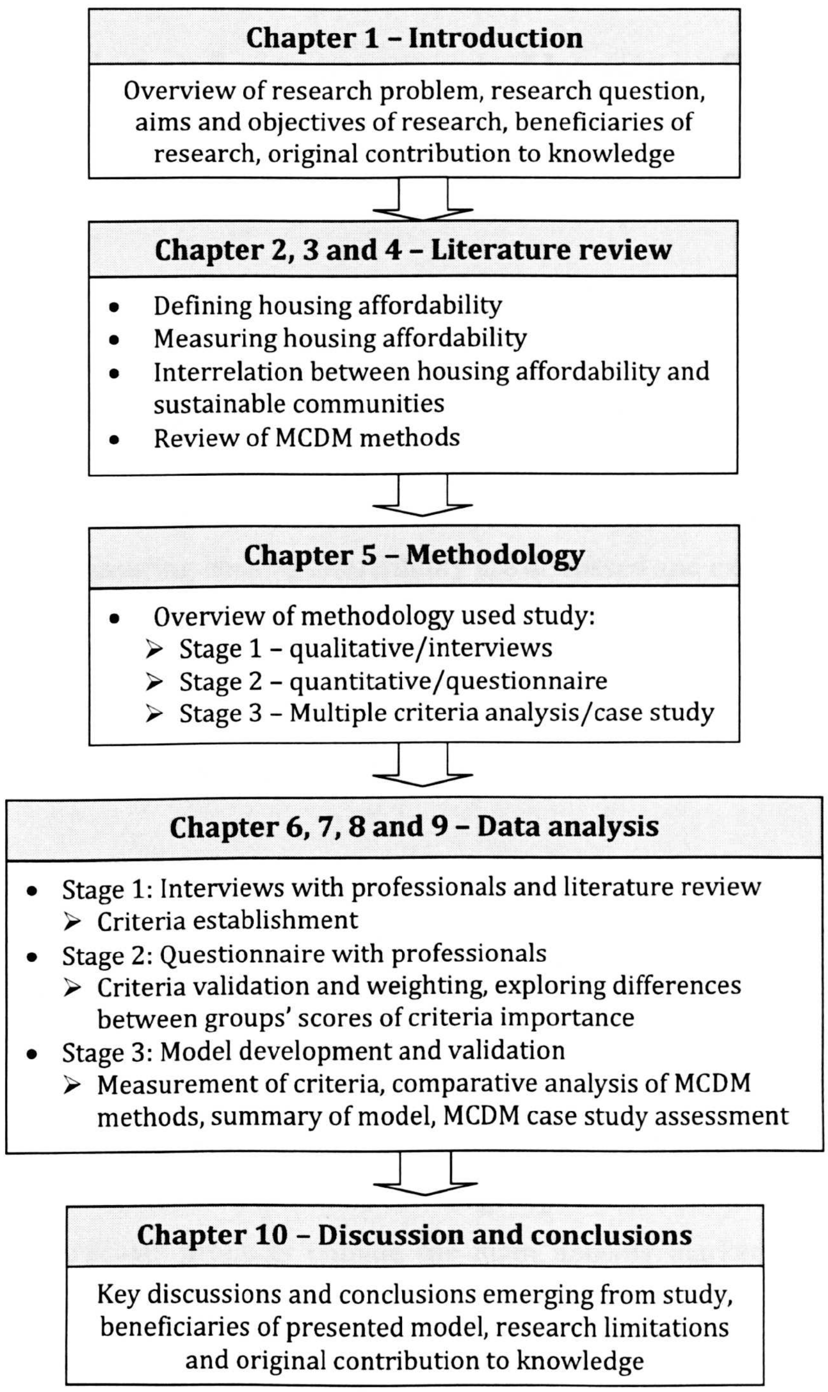
Chapter 6 and 7 subsequently provide the data analysis and key findings from stage 1 and stage 2 of the research methodology. Initially the key findings from stage 1, six semi-structured interviews with local authorities to identify assessment criteria, are discussed. Subsequently the key quantitative findings from stage 2, a survey with conducted with housing and planning professionals to verify criteria and establish criteria weights, are analysed using SPSS. This data also allowed comparisons between groups' rating of criteria importance to be made.

Chapter 8 and 9 include the data analysis from stage 3 of the research process, including the presentation of the model for the complex assessment of sustainable housing affordability. A practical comparative analysis of different MCDM methods is first offered to aid in the selection of an appropriate method for the model. Subsequently, a case study is presented using areas in Liverpool, UK to provide an example of the sustainable housing affordability assessment model.

Chapter 10 finally provides some overall conclusions from undertaking the study, including research limitations and highlighting the significant contribution to knowledge made by this research.

Figure 3 displays a visual representation of the thesis structure.

Figure 3. Thesis structure



Source: Self study

Chapter 2

The meaning and measurement of housing affordability

2.1 Introduction

The contested nature of the concept of housing affordability and its measurement are the principal subjects of this chapter. The first aim is to review existing literature on the notion of housing affordability, examining definitions of the concept used by both academic and policy environments. Subsequently, the aim is to discuss and analyse the main methods used to measure housing affordability. Traditional and alternative methods of measuring housing affordability are discussed and examined, outlining the strengths and weaknesses of the methods and identifying gaps within the research area.

2.2 The meaning of housing affordability

The first objective of the literature review is to provide a critical review of the literature relating to housing affordability in order to clarify how the concept has been defined and conceptualised by academics and policymakers. Several definitions of housing affordability are considered and examined. However, The Department for Communities and Local Government (CLG, 2011a) note that defining 'housing affordability' is different to defining 'affordable housing'. "Affordability is a measure of whether housing may be afforded by certain groups of households. Affordable housing refers to particular products outside the main housing market" (ibid, p.26). It is therefore important that the two terms are distinguished from one another at the outset of the study. Accordingly, the term 'affordable housing' is also briefly defined and discussed.

2.2.1 Defining affordable housing

'Affordability' is often expressed in terms of 'affordable housing' (Stone *et al.*, 2011). Although sometimes used interchangeably with 'housing affordability', the term 'affordable housing' is used by policy makers to refer to a diversity of housing tenures provided for low or moderate income households at sub-market rents or prices (Whitehead, 2007). Affordable homes are generally properties which are available through government-led schemes, run by housing associations or private developers, which are priced below market value housing. Specific definitions and eligibility for such housing will differ internationally depending on government and local authority policies.

The UK government has an admirable vision for housing policy stating that, "everyone should have the opportunity of a decent home, which they can afford, in a community where they want to live" (CLG, 2011a, p.6). The government's affordable housing policy is based around making sure that those who cannot afford market housing are provided with homes of a high quality in sustainable communities and making home ownership more accessible and affordable (ibid). This type of liberal policy goal has been embraced by successive UK governments since 1945 (Monk and Whitehead, 2010). Planning Policy Statement 3 (PPS3) previously set out the national planning policy framework for the delivery of the government's housing objectives in England and defined affordable housing as social rented and intermediate housing (CLG, 2006b). Intermediate housing has been targeted specifically at households who can afford to pay more than the price of social rented housing, but are unable to afford full-price open market housing (CLG, 2011a; Monk and Whitehead, 2010). However, the coalition government's recent National Planning Policy Framework (NPPF) (CLG, 2012) removes almost all existing national policy, including PPS3. The NPPF is now the main source of national policy on how the planning system should deal with housing, including affordable housing. This new framework had amended the definition of affordable housing, for planning purposes, to also include 'affordable rent', a new form of social housing (ibid). Providers of the new affordable rent product can charge social housing tenants rents of up to 80 per cent of local market rates. Accordingly, affordable housing is now defined as "Social rented, affordable rented and intermediate housing, provided to eligible households whose needs are not met by the market" (ibid, p.50). Housing policy documents habitually include promising and liberal statements such as 'the provision of decent affordable housing for all in need'. However, governments are often reluctant to explicitly define what they mean by affordable housing or housing affordability. The new NPPF simply states that "Eligibility [for affordable housing] is determined with regard to local incomes and local house prices" (ibid, p.50). However, the previous guidance in PPS3 stated that affordable housing should "Meet the needs of eligible households including availability at a cost low enough for them to afford, determined with regard to local incomes and local house prices" (CLG, 2011a, p25). There are concerns that the new NPPF has weakened the previous definition of affordable housing. Shelter (2011, p. 9) advise that the change of definition is very significant:

> It could result in a scenario where housing is considered affordable because households' eligibility for such homes is determined with regard to local incomes and house prices, regardless of whether the homes offered are at a cost low enough for people with average incomes to afford without financial assistance.

The definitions of affordable housing used by UK policymakers are rather vague and subjective, seemingly more so since the pressures of the recent economic crisis. Although Stone (1994, p.443) argues that:

> There is no such thing as "affordable housing." Housing, in and of itself, is neither affordable nor unaffordable. Affordability is not an inherent characteristic of housing, but a relationship among housing cost, household income, and a standard of affordability. The term "affordable housing" is at best meaningless and at worst misleading, for it ignores or obscures the central question of who can and cannot afford housing.

The term affordable housing seems to have fallen into use because no one wishes to use the terms 'social housing' or 'low income housing'. Rather than misrepresenting the term affordable housing, Stone (2006b) suggests that 'below-market housing' would be a more accurate term since it makes no claims of affordability which cannot be justified.

2.2.2 Defining and conceptualising housing affordability

The concept of housing affordability is by no means a new one. During the late 1980s affordability replaced other traditional housing issues such as inadequate housing supply and quality concerns in most developed countries (Linneman and Megbolugbe, 1992). In the UK the shift towards concerns about affordability was mainly due to a move towards a more privatised form of housing provision, with the widespread sale of public housing (Paris, 2007; Whitehead, 1991). By 1990 'affordability' had become a common term in UK housing policy (Whitehead, 1991) and it has continued to become an increasingly important policy issue. Nevertheless, although there is abundant talk of housing affordability, both in the UK and elsewhere across the globe, a specific definition of the concept is unclear. An analysis of literature reveals there is a lack of consensus among academics and experts on how affordability should be defined and measured. This is a key issue that is often raised in international literature. The ambiguity surrounding the concept of affordability was initially raised as a concern by researchers in the 1990's, both in the UK and the US, who suggested that the meaning of the term needed to be clarified or its use should be discontinued (Hulchanski, 1995; Maclennan and Williams, 1990). Linneman and Megbolugbe (1992) advise that an accurate definition of housing affordability is at best ambiguous. Furthermore, Bramley (1994, p. 10) indicates that "the lack of official clarity on definitions reflects inherent ambiguities to the housing affordability concept as well as political caution or expediency". Over 10 year after these concerns were brought to the fore, Stone (2005) concludes that both academic and policy environments are inconsistent with the notion of affordability. Nonetheless the term is still continually used internationally, often without much consideration for its meaning. Accordingly there are many differing definitions of housing affordability, those at local, regional, national and international levels and those proposed by academic and policy environments.

So what does 'housing affordability' mean? What follows is a variety of housing affordability definitions gathered from both academic and policy literature, followed by a summary of the concept. Although it is first worth considering where the need to define affordability stems from. Whitehead (1991) suggests that the concept would not need defining if acceptable housing outcomes were delivered by private markets, but because they are deemed unacceptable to society, suitable definitions of what is regarded as affordable need to be developed. And, subsequently, to determine whether housing outcomes meet definitions of 'affordable' we also need to be capable of measuring affordability.

2.2.3 Policy perspectives on the concept of housing affordability

There has been no official definition of housing affordability in the UK (McCord *et al.*, 2012). However, UK governments often refer to the 'ratio of lower quartile house prices to lower quartile earnings' as an affordability indicator (ODPM, 2005c; Scottish Government, 2008; Welsh Assembly Government, 2006). According to the CLG's Strategic Housing Market Assessments Practice Guidance (CLG, 2007b) home ownership is considered 'affordable' if it costs 3.5 times the gross household income for dual-income households or 2.9 times the gross household income for single earner households. Furthermore, rent payable for market rented housing should not constitute more than 25 percent of gross income; however local circumstances may justify using different figures (ibid; Whitehead *et al.*, 2009). The coalition government's recent NPPF (CLG, 2012) fails to provide a set definition of housing affordability; instead, it recommends that locally determined targets should be determined.

International policymakers, principally in developed countries, commonly advocate that no more than a certain specified percentage of income (ranging between 25 to 35 percent) should be spent on housing for it to be considered as affordable. The US Department of Housing and Urban Development signify that housing is considered as affordable if no more than 30 percent of gross income is spent on housing expenses (Dacquisto and Rodda, 2006). Policymakers in the US rely on the 30 percent threshold to identify an appropriate level of housing subsidy for programs such as the Housing Choice Voucher program. Similar percentages are also widely referred to in policy environments within Australia (AHNRC, 2001; Stone *et al.*, 2011), Canada (CMHC, 2003), Ireland (Affordable Homes Partnership, 2007; DELG, 2000) and New Zealand (HNZC, 2005). However, in Australia and New Zealand - in a bid to avoid overstating the affordability problem - affordability typically becomes a concern when housing costs exceed 30 percent of gross income for households in the lower 40 percent of the income distribution (AHNRC, 2001; HNZC, 2005; Stone *et al.*, 2011). Furthermore, the Housing New Zealand Corporation (HNZC, 2005) advocate that affordability is not purely a calculation of housing costs and income, but also entails the ability to obtain housing, maintain homeownership and have sufficient residual income to purchase basic necessities. In Canada attempts have also been made to distinguish between households who choose to spend more that 30 percent of their income on housing and those who have no alternative, thus seeking to identify households who are in 'core housing need' (Gabriel *et al.*, 2005).

The ratio approach is adopted by the Demographia International Housing Affordability Survey (Performance Urban Planning, 2012), covering urban housing markets primarily in Australia, Canada, Ireland, New Zealand, the UK and the US. The survey reveals that 'affordable' markets (having a median multiple of 3.0 or below) were found only within the US and 'severely unaffordable' major markets (having a median multiple of 5.1 and over) were found principally within the UK, the US and Australia (ibid). The US was found to have the most affordable urban markets by this particular study. However, these figures tell us nothing about what such 'affordable' markets are like in terms of location and quality, for example.

2.2.4 Academic perspectives on the concept of housing affordability

In contrast to policy definitions, there has been a plethora of affordability definitions proposed by academics. Stone (1993, p.6) advocates that affordability establishes the relationship between people and housing in monetary terms, but "at a deeper level affordability expresses a link between the social and economic system and the quest for the satisfaction of basic human needs that is not merely monetary". However, the majority of affordability definitions applied and proposed commonly focus on monetary issues related to housing.

MacLennan and Williams (1990) provide a widely quoted definition of affordability as being "concerned with securing some given standard of housing (or different standard) at a price or a rent which does not impose, in the eye of some third party (usually the government) an unreasonable burden on household incomes" (p.9). Bramley (1990) advises more specifically that "households should be able to occupy housing that meets well established (social housing) norms of adequacy (given household type and size) at a net rent which leaves them enough income to live on without falling below some poverty standard" (p. 16). Hancock (1993) also argues that "any rent will be affordable, which leaves the consumer with socially-acceptable standard of both housing and non-housing consumption after rent is paid" (p.144). Chaplin *et al.* (1994, p.6) affirm that "definitions of affordability must clearly take account not only of the cost of housing, but of housing standards and the price of other necessities of life". More simply put, Freeman *et al.* (1997, p.2) assert that "Definitions of affordability concentrate on the relationship between housing expenditure and household income and define a standard in terms of that income above which housing is regarded as unaffordable". Field (1997) also explains that affordability involves making normative judgments about the proportion of income a household should pay for housing (rent or monthly ownership) costs. Comparing the relationship between housing expenditure (rent or mortgage) and household income is certainly the most common way to define and express housing affordability (Kutty, 2005; Whitehead, 1991). Conversely, Glaser and Gyourko (2003) believe that income should not be used as an affordability benchmark. They believe that the physical construction costs of housing are a more rational benchmark to compare with housing prices (ibid). It seems sensible to consider supply in defining housing affordability; however, surely income (demand) also has relevance in the ability to 'afford' any good or service?

Housing affordability is complex and encapsulates an array of issues; Quigley *et al.* (2004, pp. 191-192) declare that this creates difficulties in interpreting even basic facts about affordability:

> ...economists are wary, even uncomfortable, with the rhetoric of "affordability," which jumbles together in a single term a number of disparate issues: the distribution of housing prices, the distribution of housing quality, the distribution of income, the ability of households to borrow, public policies affecting housing markets, conditions affecting the supply of new or refurbished housing, and the choices that people make about how much housing to consume relative to other goods.

Additionally, Belsky *et al.* (2005, p. i) stress that defining the concept of housing affordability entails making subjective judgments, for example:

> ...should households that spend a small fraction of their income on housing but that live in a substandard home or in an unsafe neighbourhood or at great distances from their jobs be construed as having affordability problems?...Should households with moderate incomes who spend so much on housing that they have too little leftover to save and invest be viewed as having an affordability problem? Should a low- or moderate-income household that spends a large share of their income on housing to live in an affluent neighbourhood be viewed as having an affordability problem or as having just made a choice to spend more on housing?

These are an interesting set of questions posed. It is difficult to decide which of these situations ought to be considered 'affordable' and which should not, or at what point they become 'unaffordable'. Many definitions of affordability fail to deal with such situations and tend to focus exclusively on income and housing costs. If households live in substandard housing, an unsafe neighbourhood or far from jobs, they would generally not be seen as an affordability problem by many standard definitions of affordability, if the housing itself is considered 'low cost'. Yet surely living in such situations is not adequate for any household and thus should not be considered affordable? Stone *et al.* (2011, p.2) recognise that:

> ...affordability cannot be divorced from housing deprivation and housing standards. If a household is achieving 'affordability', but only by virtue of living in overcrowded conditions, with insecure tenure or in unsafe or inaccessible locations, is that real affordability?

Rowley and Ong (2012) pose similar concerns and question the extent to which the quality of a neighbourhood is taken into account when assessing the appropriateness of housing that is considered as 'affordable' in terms of cost. Such questions create an element of subjectivity which makes affordability a complex issue to deal with. Subjectivity appears to be one of the principal problems with defining the concept of housing affordability, yet it is unavoidable since there are many aspects of the concept which require subjective judgments to set standards. Owing to this fact the meaning of affordability will always be open to scrutiny and reinterpretation (Gabriel *et al.*, 2005).

Moreover, confusion over the definition of housing affordability is in part due to the different opinions and goals of interest groups. Chaplin *et al.* (1994, p.6) emphasise that housing affordability means different things to different groups of people:

> For households it is about having enough income to be able to purchase at least the minimum requirements for a reasonable standard of living. For local authorities, associations and private landlords it is about ensuring that the rent or mortgage can and will effectively be paid. For social landlords it is about meeting their objectives of housing those in need. For lenders it is mainly about protecting their income stream. For government it is about how much subsidy has to be provided to ensure that the cost of adequate standards of housing is not so high that households cannot afford to buy the full range of necessary goods.

Furthermore, Gabriel *et al.* (2005) compared how economists and sociologists view affordability indicating that in attempts to define the concept economists tend to emphasise objectivity, conceptual clarity and value, whereas sociologists tend to focus on concerns regarding social inequality and capturing the 'real' housing experience of those in housing stress. The uncertainty surrounding the concept is also associated with the different understandings of the cause of affordability problems, namely the extent to which the problem can be attributed to inadequate household income or inadequate housing supply (ibid). It is likely to be the result of a combination of these factors. Although some economists believe that the leading causes of affordability problems are government regulations and restrictions that prevent or slow increases in housing supply (Glaser and Gyourko, 2002). Different opinions on the root cause of affordability problems can lead to different goals and policy outcomes, namely those that focus on supply-side approaches and those that focus on demand-side approaches to improve affordability.

It appears that there are two primary schools of thought on the meaning of housing affordability; one focuses on housing costs in relation to income and the other focuses on standards of housing and non-housing consumption and the income remaining once housing costs have been paid for. These ideas have fashioned two well known and widely used affordability measures; the ratio and residual measures, both of which will be discussed in 2.3. However, some researchers do not firmly agree with either school of thought, but rather they believe that affordability is affected by additional important factors.

Bogdon and Can (1997) criticised the pre-existing affordability literature for its focus on the price of housing rather than the condition, location and neighbourhood characteristics of supposedly affordable housing. Nevertheless, affordability is still commonly defined and assed by focusing primarily on financial burdens, with little or no regard for what households get in return for what they spend on housing, in terms of housing quality, location and neighbourhood characteristics. There are a number of recent studies on housing affordability that seek to go beyond the traditional notions of financial impacts on households. Researchers in Australia attempt to link the concept of affordability with environmental sustainability, arguing that 'true' housing affordability must take into account, not simply rent or mortgage costs, but also a wider range of costs that households face, e.g. accessing employment, services and facilities and energy costs (ACF and VCOSS, 2008). Correspondingly, Pollard (2010) suggests that to build affordable communities then housing costs should not be considered in isolation, transportation must also be addressed. Another exception is Fisher *et al.* (2009) who recommend that a more thoughtful definition of affordability should consider the opportunity costs facing households due to housing location, given that the purpose of affordable housing policy should be not only to provide adequate housing but, in addition, to supply homes that are in safe areas and are accessible to jobs and decent schools. The research "calls for a broader discussion and refinement of the criteria by which society judges the suitability of affordable housing, especially with respect to schools and other local amenities" (ibid, p. 735). Rowley and Ong (2012) also advise that neighbourhood quality issues must not be ignored in relation to housing affordability. The approaches taken here seem to be far more considerate ways to view housing affordability, having regard for quality of life and wellbeing, as opposed to simply focusing on the financial issues that face households.

2.3 Measuring housing affordability

Contrasting views on how best to conceive and define housing affordability have consequently extended into how best to measure it. The second aim of the literature review in this chapter is to examine traditional methods used to measure housing affordability, outlining the strengths and weaknesses of the methods. In addition, alternative methods of measuring housing affordability will be discussed.

Measures of housing affordability can shape our views on the extent of the problem and determine where investment in housing may or may not be directed. It is therefore important that they represent an accurate picture of reality. Internationally an extensive range of affordability measures have been developed and applied in different contexts (McCord *et al.*, 2011). Although there are two methods which are most commonly referred to and recognised internationally; one determines the proportion of income spent on housing costs (the ratio method) and the other examines at the amount of income remaining once housing and other essential cost of living have been paid for (the residual method).

2.3.1 Ratio measure

Measures of housing affordability are often based on assumptions about what should be paid for housing (rent or mortgage). Typical measures frequently relate the proportion of household income spent on housing costs (Whitehead *et al.*, 2009). This type of measure (or indicator) of affordability is referred to as the house price to income ratio (for owner occupiers). Alternatively a rent to income ratio can be used to determine affordability for households who rent rather than purchase housing. Housing costs will vary according to the type of tenure considered; for owner occupiers housing costs may include the cost of mortgage payments, maintenance and rates, whereas for tenants costs are generally limited to rental payments but may also include service charges. Income may be measured on gross or net terms and either individual or household income can be considered.

A household is said to have a housing affordability problem when it pays more than a certain percentage of its income to obtain housing. Thus, the measure relies on a 'rule of thumb' which suggests that any household spending more than a certain percentage/ratio of its income on housing costs lives in unaffordable housing. This approach stems from initial studies on housing affordability, which date back to 19th century studies of the household budget, which commonly equated "one week's pay for one month's rent" (Hulchanski, 1995, p. 471). However, this rule of thumb approach is merely based on *assumptions* about what average households tend to spend or think they ought to spend on housing (ibid). This subjective assumption has created much debate among academics since there appears to be no clear explanation of why such a rule of thumb is used or why a ratio that is deemed as 'affordable' changes (namely increases) at certain points in time (Stone, 2006b).

Hulchanski (1995, p.475) identifies six ways in which the ratio method (rule of thumb) has been used in post war housing literature:

(1) description of household expenditures;
(2) analysis of trends and comparison of different household types;
(3) administration of public housing by defining eligibility criteria and subsidy levels in rent geared-to-income housing;
(4) definition of housing need for public policy purposes;
(5) prediction of the ability of a household to pay the rent or mortgage; and
(6) as part of the selection criteria in the decision to rent or provide a mortgage.

Baer (1976) indicates that in uses one and two the rule of thumb is used as an indicator; an indicator measures change or relative differences, but does not provide an explanation. Whereas uses three, four, five and six represent affordability standards; when the standard is reached then affordability becomes a problem. Hulchanski (1995) concludes that the ratio method can be valid when used as a quantitative indicator (uses one and two). However, he suggests that the ratio is an invalid indicator of housing need and of the ability to pay for housing (uses four, five and six) and that use three should make no claim other than being a subjective judgment made in allocating means-tested subsidies.

Attention has been drawn to the fact that the ratio approach is not based on scientific knowledge and there is no empirical or logical basis for it (Hulchanski, 1994; Stone *et al.*, 2011). Although despite the lack of justification the ratio measure has gained widespread recognition and acceptance, and has subsequently been the prevailing approach used to measure housing affordability internationally (Chaplin and Freeman 1999; Stone, 2006b). It seems that this is mainly due to the simplicity of the approach and its long international tradition. The use of the ratio method is recommended by the World Bank and the United Nations; it is available on the UN-HABITAT database and is also tracked for 325 metropolitan markets in seven countries by the Demographia International Housing Affordability Survey (Performance Urban

Planning, 2012). The ratio approach is extensively applied to measure affordability in the UK and other European countries, the US, Canada, Australia, China (Hui, 2001) and New Zealand (HNZC, 2005). Globally, it seems that policy environments unquestionably adopt such a definition and assessment of affordability. This is not surprising since the ratio measure has the advantage of being easy to compute as it only relies on a few variables which are usually readily available. However, it is apparent that this approach is by no means consistently accepted among academics (Belsky *et al.*, 2005; Hancock, 1993; Hulchanski, 1994; Stone, 1993). Despite its criticisms the ratio measure is said to be a useful indicator for making comparisons over time or between areas (Bogdon and Can, 1997; Whitehead *et al.*, 2009).

2.3.2 Residual measure

While the ratio approach focuses on what households actually pay for housing, the residual approach focuses on a household's ability to pay for housing (Ndubueze, 2007). The residual measure addresses the fact that many low income households cannot even afford to pay the commonly specified 30 percent threshold of their incomes for housing, yet some households can afford to pay more. Arguments in support of a residual income measure, in place of the ratio approach, emerged initially in the US during the late 1960s and active interest followed in the UK and Australia in the 1990s, with some more recent applications in continental Europe and Asia (Stone *et al.*, 2011). The residual method is based on the notion that housing affordability is the ability of households to meet the cost of housing whilst maintaining the ability to meet other basic costs of living, i.e. the income left after paying for housing (Brownill *et al.*, 1990; Burke, 2004; Chaplin *et al.*, 1994; Stone, 2006b; Whitehead, 1991). This opportunity cost measure of affordability is clearly defined by Whitehead (1991, p. 875):

> The standard may be defined in terms of the absolute amount of residual income remaining once the housing has been purchased, i.e. it is set at a level which allows the households to pay for the housing and still purchase a socially acceptable bundle of goods.

It is evident that there is some quantity of non-housing consumption which is regarded as a socially acceptable minimum (Hanckock, 1993), e.g. food, clothing, education, health care and transport. This requires some estimate of the cost of essential non-housing goods. Accordingly the residual measure is essentially rooted in the social security and housing benefit systems. The "...income support level of cash is considered as a minimum standard of non-housing consumption" (Chaplin *et al.*, 1994, p. 15). This minimum standard is commonly referred to as a poverty standard or poverty line (Bradshaw *et al.*, 2008) of which households should not fall below. If households do fall below this standard then the housing benefit system is in place, in the UK, to ensure that such households have all their housing costs met and their income is brought in line with the income support level (Bramley, 1994). In the UK, it is usual to measure affordability for social housing tenants in terms of the residual income remaining after housing costs have been met (ODPM, 2005c).

In contrast to the ratio approach, Stone (1993; 2006a) recognises that housing affordability is not separable from housing standards. On the basis of the residual method Stone (1993) developed the 'shelter poverty' standard which refers to households as 'shelter poor' if, after paying for housing costs, they cannot meet their non-housing needs at a socially acceptable minimum level. Kutty (2005) promotes similar ideas to Stone but uses the term 'housing-induced poverty' to describe a housing situation where a household cannot afford a poverty basket of non-housing goods after paying for housing. Both approaches offer a sliding scale of affordability that takes into account the differences in household composition (size and type) and income (Kutty, 2005; Stone, 1993), rather than assuming a certain fixed percentage of income as 'affordable' for all housing situations. Each approach differs in its use of a normative standard for the residual income. Stone (2006a) utilises the non-housing components of the Family Budget Unit's Low Cost but Adequate Budgets in the UK (or the Bureau of Labour Statistics Lower Budget standards in the US), whereas Kutty (2005) utilises the official poverty thresholds in the US. Kutty (2005) advocates that her minimum adequate standard of non-housing goods is less generous than Stone's standard. Stone (1993) found that the residual measure does not necessarily reveal more extensive affordability problems, but rather it reveals that the distribution of affordability problems is more widespread amongst low-income households and larger households. Hancock (1993) affirms that the residual approach is more coherent than the ratio approach for measuring affordability.

The notion of the residual approach is generally favoured over the ratio approach, although there has only been a limited adoption of the former in the assessment of housing affordability in the UK (Stone, 2006a). Many academics have called for the use of the residual measure as an alternative to the ratio approach (Bramley, 1990; Kutty, 2005; Stone, 2006a). However, several flaws have been highlighted with both measures.

2.3.3 Limitations of traditional affordability measures

There is no single measure that is best for assessing housing affordability problems. Each measure emphasises different aspects of the problem. The ratio and residual approaches are most commonly referred to and applied to assess housing affordability internationally, with the former receiving considerably more applications than the latter. It is evident that the residual measure provides a more comprehensive analysis of affordability problems than the ratio approach, although the simplicity and familiarity of the ratio method appears to have made it more popular.

The ratio method is most frequently used to measure housing affordability due to its simplicity and ease of understanding (Stone, 2006a). Nonetheless, this simplicity is precisely what limits its effectiveness as it fails to incorporate a number of factors that affect housing affordability. The use of such normative standards to measure affordability has been subject to a wide range of criticisms (Bramley, 1994; Chaplin *et al.*, 1994; Hancock, 1993; Hulchanski, 1995; Stone, 2006b; Whitehead, 1991).

MacLennan *et al.* (1990) advocate that a single ratio of housing costs to incomes across all tenures, household types and locations is over simplistic. In addition, Malpass (1993) argues that affordability "is a virtually undefinable concept and certainly cannot be neatly or simply understood in terms of a fixed percentage of income" (p. 88). According to Stone (1993) the ratio measure understates the affordability problems of families with children and other larger households in comparison with one and two person households, whilst it overstates the affordability problems of higher income households.

Hanckock (1993, p.133) stresses that, "In a ratio definition, it is possible for individuals to be consuming very little of either housing or other goods and for the housing costs still to be considered affordable". The ratio approach does not give any reference to the standard of the housing; for example, housing may appear affordable but the housing may be of poor quality, the household may be consuming little non-housing goods or may be experiencing overcrowding. The approach is problematic as the same standards tend to be used irrespective of household type and their different levels of consumption (Stone *et al.*, 2011).

Hulchanski (1995) criticised the ratio measure as not logical for defining housing need or housing problems since it generalises households who spend more than a certain percentage of income on housing as having an affordability problem. A high ratio of housing costs to income might simply be due to a household's preference for high quality or large housing (Kutty, 2005).

Furthermore, Thalmann (2003) indicates that the commonly specified affordable ratio standards of 30 percent, and even 25 percent, are very high burdens for large low-income households, because it leaves them very little for other necessities. Gan and Hill (2009) also affirm that ratio measures can significantly understate affordability problems for households with low incomes. There is also no theoretical or logical basis for the ratios that are used (Hulchanski, 1994; Stone *et al*, 2011).

Stone *et al.* (2011, p.14) protest that:

> There can be no subjective and normative-based minimum housing shelter standard of affordability. There can be a minimum standard of occupancy...and there can be minimum conditions standards as defined though planning and building regulations, but there can be no affordability standard.

While the residual measure addresses the fact that not all households can afford to pay a fixed percentage of income for housing, most of the other flaws concerning the ratio measure also affect the residual measure.

The ratio measure fails to account for differences in housing costs that are the result of perceived higher neighbourhood quality (Bogdon and Can, 1997); the residual measure is also unable to account for such differences. Accordingly, households that have chosen to pay more for housing in order to live in a higer quality neighberhood are not identifed. On the other hand, Belsky *et al.* (2005) highlight the fact that ratio and residual approaches fail to take account of the trade-offs that households make in order to lower their housing costs, for example compromising on neighbourhood or housing quality. Correspondingly, Rowley and Ong (2012) stress that traditional indicators of housing affordability simply address the financial burden of housing costs; they neglect the fact that a household may have avoided a situation of housing stress by compromising in terms of location or housing quality. The fact that a household is able to 'afford' housing in a certain location may, in reality, be due to its lower quality or neighbourhood deprivation. Households, especially those on limited incomes, make trade-offs between what they desire and what they can afford to pay for housing (Ndubueze, 2007). Additional costs may be imposed on households as a result of such trade-offs, both monetary and socio-economic costs, which are disguised by traditional measures of affordability. Such costs could be detrimental to overall household wellbeing (Rowley and Ong, 2012). Disney (2007) signifies that some families only find affordable housing as a result of living lengthy distances from urban centres where the majority of job opportunities and community services are situated; social isolation, family stress, unemployment and welfare dependency are amongst the consequences that families may face from living in such areas.

Moreover, Bogdon and Can (1997) advocate that affordability should concern both supply and demand factors since it is a market outcome. However, the ratio and residual indicators only focus on the demand side of housing affordability.

Both measures require subjective third party benchmarking to set standards of affordability (Hui, 2001), e.g. the point when a house price to income ratio becomes 'unaffordable'. But how does one decide on the point when housing moves from being affordable to unaffordable by either measure? There is often no explicit basis for deciding on an affordable standard; such decisions are often made in a subjective way and may simply refer to past observations (Bramley, 1994).

Additionally, Gabriel *et al.* (2005) indicate that both residual and ratio measures are unable to distinguish between affordability problems arising from household choice and those arising from need. A housing situation may be interoperated as unaffordable by the ratio or residual measure, but not by the household. Therefore, it is possible that the number of households unable to afford housing may be overestimated in some situations.

A summary of the principal advantages and disadvantages of the traditional ratio and residual methods for assessing affordability are presented in table 2.

Chapin *et al.* (1994) suggest a combined approach to measuring affordability, using both the ratio and the residual methods, since each measure provides a different beneficial perspective on affordability. Bramley and Karley (2005, p. 688) also assert that "a household's situation is clearly 'unaffordable' if they both face a ratio of housing cost to income above certain norms and face a ratio of residual income to household requirements that is below certain other norms". Nonetheless, both measures still fail to deal with other crucial issues, such as housing quality and neighbourhood characteristics.

Table 2. Advantages and disadvantages of ratio and residual measures

	Advantages	Disadvantages
Ratio method	• Requires only a few variables that are easily available • Simple and easy to use • Has gained international acceptance	• No theoretical or logical foundation behind affordability benchmarks (entails subjective assumptions) • Ignores the cost of housing finance/interest rates/mortgage repayments and other non-housing costs • A single ratio is applied across all tenures, locations and household types • Focuses on financial factors. Does not consider issues of housing quality or neighbourhood quality/characteristics (no account of location trade-offs) • Generalises households who spend over (under) the benchmark as having (not having) an affordability problem (does not distinguish between choice and constraint)
Residual method	• Does not generalise that all households can afford to pay a fixed percentage of income for housing • Clear relationship between housing and non-housing costs • More accurate across household types than ratio measure	• More complex and time consuming in comparison to the ratio method (more data requirements on expenditure on goods and services) • Focuses on financial factors. Does not consider issues of housing quality or neighbourhood quality/characteristics (no account of location trade-offs) • Requires an element of generalisation and judgement about household type

Source: Self study

2.3.4 Alternative affordability measures

In 2008, as a result of the credit crisis, the UK saw the biggest fall in house prices since the 1990s (figure 4). Although by no means has housing become more affordable (NHPAU, 2008). While house prices decreased from boom period levels, the economic circumstances arising from the credit crisis have meant that affordability is still an issue for great concern. Traditional measures of affordability can reveal that housing is becoming more 'affordable' simply because of such falls in house prices, when in reality the subsequent tightening of lending criteria and requirements of larger deposits have created supplementary problems, especially for those wanting to get a foot on the housing ladder. In early 2007 the cost burden of entering the market severely increased with the extensive removal of 95 percent loan-to-value (LTV) mortgages, adversely affecting purchase affordability (McCord *et al.*, 2011). Hence, the nature of the affordability problem has simply changed. McCord *et al.* (2011, p.395) elucidate that "there has been a shift in the genre of affordability, with the house price-to-income retrenchment appearing to be a "false dawn"". Accordingly, this has given rise to a number of opposing approaches to measuring affordability that seek to better reflect the current financial climate.

Figure 4. Property booms and slumps in the UK during 1980-2010

These changes in the financial market have given rise to the notion of "access affordability" (the deposit gap), "purchase affordability" (the borrowing capacity of households) and "repayment affordability" (the burden imposed on a household from repaying a mortgage) (Abelson, 2009; Gan and Hill, 2009; McCord *et al.*, 2011). In the

UK, the 'Roof affordability index' has been developed to measure how difficult it is for a household to become a home-owner, unlike traditional measures the index uses average mortgage costs and thus takes account of variations in interest rates (Shelter, 2006). The National Housing and Planning Advice Unit (NHPAU) also recently developed three new affordability indicators in an attempt to provide a fuller picture of housing affordability. The measures include the deposit measure (deposit required as a proportion of household income after tax and national insurance contributions), the mortgage costs measure (mortgage costs as a proportion of household income after tax and national insurance contributions) and the rent measure (rent as a proportion of household income after tax and national insurance contributions) (NHPAU, 2010).

In the current economic climate these new measures are clearly more helpful than traditional ratio and residual measures at representing a household's financial situation. However they still fail to consider other important issues, such as what households get in return for what they spend on housing, in terms of neighbourhood and housing quality. As stressed by Seelig and Phibbs (2006), housing affordability - in the traditional financial sense - is only part of what households seek from their housing. Only few academics have begun to recognise and develop measures of affordability that consider the issue from a wider context, rather than focusing purely on the financial costs involved with owning or renting housing. Belsky *et al.* (2005) suggest that an ideal affordability appraisal would account for the tradeoffs that households make to lower housing costs, e.g. transportation and access to public services, health and safety. In addition, Stone *et al.* (2011) emphasise there is a growing concern that standard affordability measures do not recognise the trade-offs between cheap or affordable housing; just because a household has an 'affordable dwelling' does not necessarily mean it has 'affordable living', owing to tradeoffs such as travel costs. Rowley and Ong (2012) also recognise that, in reality, housing affordability encompasses quality and location trade-offs. Research carried out in the US posits that housing affordability should consider the welfare of residents, which is affected by a wide range of location-related attributes, such as transportation costs, proximity to employment opportunities and public safety (Fisher *et al.*, 2009). Accordingly, Fisher *et al.* (2009) developed an affordability assessment tool that looks at a bundle of attributes an area possesses, namely school quality, job accessibility and safety, and assesses whether taking implicit prices of such attributes into account makes a difference to whether an area can be regarded as affordable. Rather than viewing affordability as a ratio of income to housing cost, the research recognise that house prices are affected by location, since the price includes the value of the services provided by the local amenities. The investigation concludes that focusing on price alone may lead to inaccurate conclusions about the affordability of an area (ibid). Location is also highlighted as a significant factor related to housing affordability by other US researchers. The Housing and Transportation Affordability Index has been developed in the US which takes into account not just the cost of housing, but also its location efficiency by measuring the transportation costs associated with place (CTOD and CNT, 2006). Housing may be considered affordable on a ratio scale, but location costs are often underestimated or ignored; the interaction between housing and location is believed to provide a more meaningful measure of affordability (ibid). Stone *et al.* (2011) advocate that for areas such as Australia, where cities are becoming more polarised, this issue will become more problematic.

It is important to consider how the concept of affordability is perceived by low and moderate income families themselves; are these wider notions of affordability important outside of expert opinion? Seelig and Phibbs (2006) conducted qualitative analysis of housing affordability in order to appreciate how low-income renters understand residential affordability. They found that low-income families often did not choose to live in the lowest cost housing if it presented poor options in terms of amenity and location. Thus, while cost was an essential consideration, addressing needs or preferences for dwelling features, location or proximity to services and facilities was a priority for many low income renters, even though such choices resulted in tighter household budgets and paying more for housing (ibid). The research demonstrates that an array of attributes, in addition to purely economic factors, can influence a household's perception of affordability. Specifically, housing quality, location and access to services and facilities appear to be important considerations directly related to a household's opinion of housing affordability.

It is clearly difficult, perhaps impossible, to address all concerns related to affordability within one simple measure. Issues such as housing adequacy - e.g. physical quality, location and access to services - and appropriateness (occupancy standards) may need to be addressed by additional complementary indicators (Gabriel *et al.*, 2005). McCord *et al.* (2011) elucidate that a one measure fits all approach to assessing affordability is problematic and policy makers must consider more than one measure when reforming policy instruments.

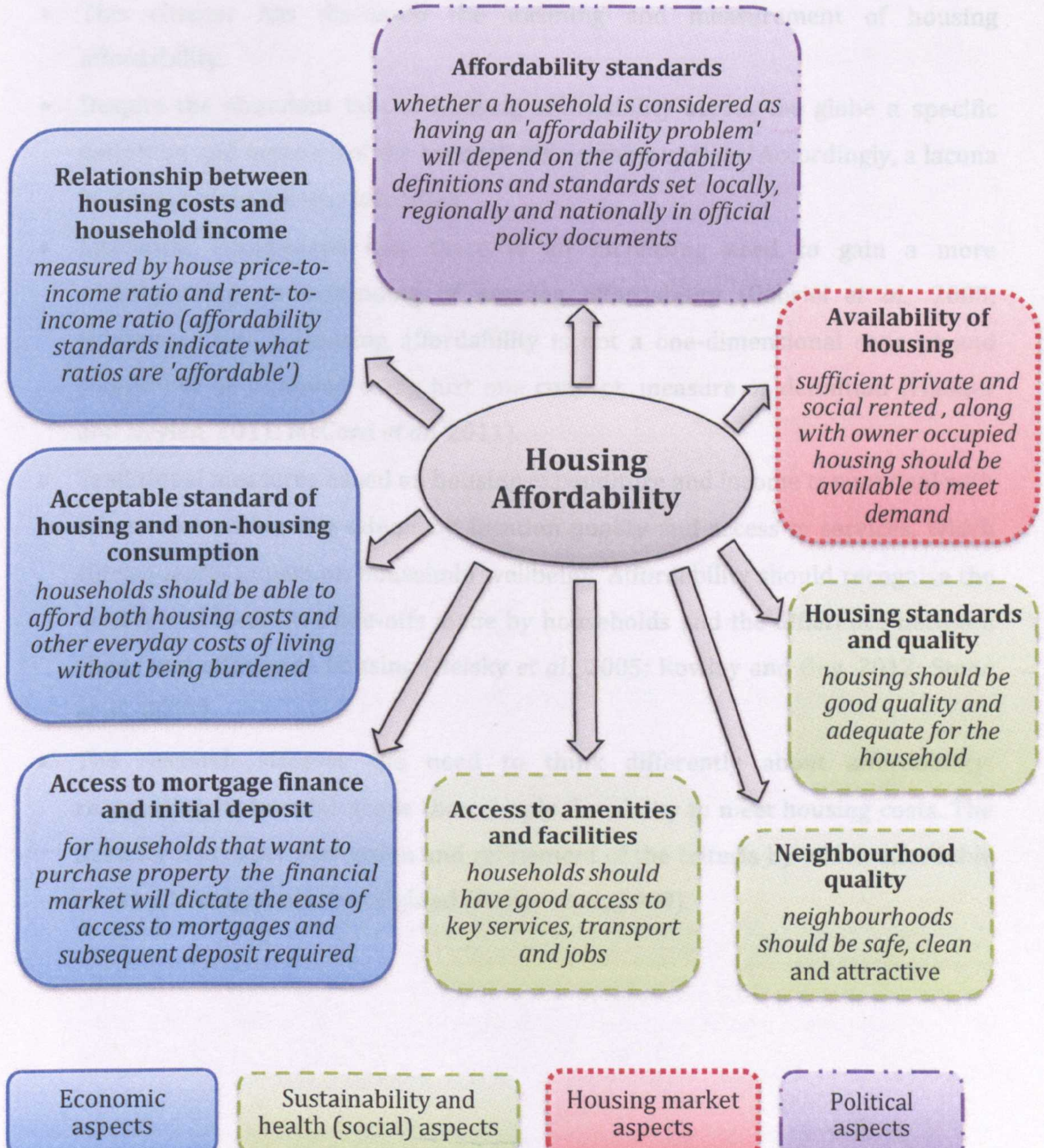
2.4 Housing affordability concept summary

The conceptualisation and measurement of housing affordability are ultimately subjective. There is no single correct answer or agreement to the questions of how affordability should be conceived, how affordability should be measured, or how much households can afford to spend on housing and other every day costs of living. However, housing affordability is typically assessed in terms of economic criteria; most commonly by the relationship between housing costs and household income (CLG; 2007b; Lux, 2007; Whitehead *et al.*, 2009). International housing policy documents in developed countries tend to follow the traditional 'rule of thumb', advocating that approximately no more than 30 percent of income should be spent on housing for it to be considered as affordable (Affordable Homes Partnership, 2007; AHNRC, 2001; CLG, 2007b; CMHC, 2003; Dacquisto and Rodda, 2006; HNZC, 2005). Such definitions are often without regard for household size, composition, housing quality or neighbourhood characteristics. In general, it seems that policy environments unquestionably adopt such a definition of affordability. However, it is apparent from the literature studied that such a rule of thumb approach is by no means consistently accepted among academics (Belsky *et al.*, 2005; Fisher *et al.*, 2009; Hancock, 1993; Hulchanski, 1994; Rowley and Ong, 2012; Stone, 1993; Thalmann, 2003).

It is clear from the examined literature that researchers are beginning to have wider consideration for the factors that influence housing affordability, rather than focusing exclusively on the price of housing and income as the principal determinants. If participants in the housing market were to begin thinking in a different way about affordability then considerable positive effects on households and communities could be derived (CTOD and CNT 2006). To assist in creating more affordable and also more sustainable communities it is important to move away from viewing housing affordability as a purely monetary issue and begin to have consideration for a broader range of factors that influence households and their quality of life.

Composed from the literature reviewed, figure 5 provides a comprehensive summary of the housing affordability concept. The concept incorporates a number of different aspects that determine affordability, including economic, sustainability and health, housing market, and political aspects. Housing affordability is often thought of in terms of just one or a few of these aspects. However, research asserts that housing affordability should not be analysed using one concept, measure or definition (Gan and Hill, 2009; McCord *et al.*, 2011). Affordability is not a one-dimensional concept, and a combination of more than one concept will offer better insight into housing affordability (Haffner and Heylen, 2011). The research emphasises the importance of conceptualising and examining affordability in a more meaningful way, having consideration for the broad range of aspects that influence households.

Figure 5. Housing affordability concept



Source: Self study

2.5 Chapter summary

- This chapter has discussed the meaning and measurement of housing affordability.
- Despite the abundant talk of housing affordability across the globe a specific definition and measure of the concept still remains unclear. Accordingly, a lacuna in current research was identified.
- Literature emphasised that there is an increasing need to gain a more encompassing understanding of housing affordability (Gabriel *et al.,* 2005; Ndubueze, 2007). Housing affordability is not a one-dimensional concept and should not be analysed using just one concept, measure or definition (Haffner and Heylen, 2011; McCord *et al.*, 2011).
- Traditional measures based on housing expenditure and income cannot deal with issues such as housing adequacy, location quality and access to services, which subsequently impact on household wellbeing. Affordability should recognise the quality and location trade-offs made by households and the difference between cheap and affordable housing (Belsky *et al.*, 2005; Rowley and Ong, 2012; Stone *et al.*, 2011).
- The research stresses the need to think differently about affordability; recognising its broader scope than simply the ability to meet housing costs. The need for a broader discussion and refinement of the criteria by which affordable housing is judged was highlighted (Fisher *et al.*, 2009).

Chapter 3

Linking the notion of housing affordability with sustainable communities

3.1 Introduction

The literature reviewed thus far has emphasised that housing affordability is a multi-dimensional issue that not only affects households, but has implications for the wider economy and the environment. Furthermore the research has highlighted the need to think differently about affordability; recognising its broader scope than simply the ability to meet housing costs, but also the need to address community wellbeing. This section of the literature review seeks to stress the importance of providing affordable housing in the context of sustainable communities.

3.2 Importance of linking affordable housing with sustainable communities

The environments that we reside in are recognised as important determinant of quality of life and well-being:

> Housing is a basic requirement for everyone. Our homes influence our well-being, our sense of worth, and our ties to our families, communities and work. If we live in decent housing we are more likely to benefit from good health, higher educational attainment and better-paid work (DETR, 2000, p.15).

It is clear that, for everyone, having a decent home is imperative in order to live a healthy and successful life. However, it is also acknowledged that housing alone may not be enough to provide a good quality of life. A fear of crime, a lack of jobs, or a degraded environment can significantly reduce a household's quality of life (ibid). The World Health Organisation (WHO, 2004) suggests that adequate shelter is more than simply a roof over one's head; it requires an adequate and accessible location in relation to employment and key facilities, in addition to suitable environmental quality and health related factors. The UK government affirms that "we are all healthier, happier and wealthier when we have decent homes close to schools, healthcare and transport links" (CLG, 2007a, p.6). It is evident that providing successful affordable housing is not purely about access to low-cost homes; there must also be consideration for the environments in which housing is situated.

Currently affordable housing and sustainable development are major challenges facing the UK and many other countries across the globe. Internationally, sustainable development is customarily defined as "development which meets the needs of the present without compromising with the ability of future generations to meet their own needs" (WCED, 1987, p.8). The issue of sustainability is growing in importance on a global scale. Initially, sustainability discourse emanated with global environmental concerns (ibid), reflecting anxieties about carbon emissions, global warming and resource depletion. However, Kearns and Turok (2004) emphasise that sustainability functions at different dimensions, relating to environmental, economic and social initiatives (figure 6). Depending on the particular issue being addressed, these three pillars of sustainability - social, economic and environmental - can occupy different positions in a hierarchy (Lehtonen, 2004); they are not always given equal weight. Today there is a growing interest and increasing amount of investment on the social dimension of sustainability, specifically creating sustainable communities. This is reflected in the government's Sustainable Communities Plan (ODPM, 2003).

Figure 6. Dimensions of Sustainability

3.2.1 What are sustainable communities?

Although used fairly loosely, the term 'communities' means the interacting localities and neighbourhoods that make up towns and cities (Kearns and Turok, 2004). A sustainable community is defined in the Egan Review: Skills for Sustainable Communities (ODPM, 2004, p.18):

> Sustainable communities meet the diverse needs of existing and future residents, their children and other users, contribute to a high quality of life and provide opportunity and choice. They achieve this in ways that make effective use of natural resources, enhance the environment, promote social cohesion and inclusion and strengthen economic prosperity.

Similarly, Kearns and Turok (2004, p.9) provide the following working definition:

> Sustainable communities are settlements which meet diverse needs of all existing and future residents; contribute to a high quality of life; and offer appropriate ladders of opportunity for household advancement, either locally or through external connections. They also limit the adverse external effects on the environment, society and economy.

The UK the government more succinctly defines sustainable communities as "Places where people want to live and work, now and in the future" (ODPM, 2005a, p.56). Seven key components of a sustainable community have been identified (figure 7), including governance, transport and connectivity, services, environment, economy, housing and built environment, social and cultural (ODPM, 2004). Additionally, sustainable communities should be active, inclusive and safe, well run, environmentally sensitive, well designed and built, well connected, thriving, well served and fair for everyone (ODPM, 2005a).

Figure 7. Various components of sustainable communities

For housing in particular, Newman (2002, p. 1) defines what sustainability means:

- Ensuring there is a 'roof overhead' for the housing disadvantaged,
- Ensuring housing is more eco-efficient, and

- Ensuring housing is well located or is part of a project to improve locational amenity.

Edwards and Turrent (2000, p. 21) suggest that sustainable housing is "housing that meets the perceived and real needs of the present in a resource efficient fashion whilst providing attractive, safe and ecologically rich neighbourhoods". Two of the most significant aspects of sustainable housing are said to be design and location (ibid). Furthermore, Brown and Bhatti (2003) pointed out that a sustainable housing system must incorporate social, economic and environmental sustainability in a mutually reinforcing way. Choguill (2007) also specifies that housing must be economically viable, technically feasible, environmentally friendly and socially acceptable in order to be sustainable. Again, the three pillars of sustainability are emphasised.

Pollard (2010, p.14) highlights the multiple economic, health, social, and environmental benefits that sustainable and inclusive development can provide:

- More affordable housing
- Lower costs to taxpayers to provide services to development
- Better access to jobs
- Less congestion, saving businesses and people money
- Shorter commutes, saving people time and money
- Less driving and more efficient buildings reduce vulnerability to volatile energy prices
- Cleaner air and water
- Improved health
- Enhanced economic competitiveness and job growth
- Better employee recruitment and retention
- A higher quality of life

3.2.2 Where does affordable housing fit in?

The government's Sustainable Communities Plan elucidates that decent and affordable housing must feature in a sustainable community (ODPM, 2003). Research conducted by Maliene *et al.* (2008) affirms that affordable housing is perceived to be one of the key factors in creating sustainable communities. This is not surprising since housing is considered central to the successful delivery of overall sustainable development (Carter and Fortune, 2007; Winston and Eastway, 2008). In pursuit of creating sustainable mixed communities government policy seeks to ensure that housing is developed in suitable locations which have good access to jobs, key services, infrastructure and a range of community facilities (CLG, 2011a). Sustainable communities should provide decent and affordable homes that have access to jobs, schools, health services, shops, banks, public space and public transport, all of which should be located in a clean and safe environment (CLG, 2007a; ODPM, 2005a). In addition, the government's affordable housing policy recognises that affordable housing must be located within communities that are sustainable and mixed (CLG, 2011a). Similar views are shared in other developed countries, such as Australia and the US. In Australia, the Queensland Department of Housing (2000) stress that the concept of affordable housing should surpass the financial cost to the household and be linked with the development of sustainable communities in order to achieve successful housing outcomes. Housing policy in the US has also become increasingly oriented toward ensuring that people live in sustainable neighbourhoods that are low in poverty, low in crime, walkable, transit-served, and accessible to a wide variety of services and facilities (Talen and Koschinsky, 2011).

Increasingly, sustainability and housing affordability issues are being discussed mutually and are recognised as being interlinked. Affordable housing clearly has a fundamental role to play in contributing to the improved economic, environmental, social and physical health - the sustainability - of communities (CLG, 2007a; HM Government, 2005; Maliene *et al.*, 2008; Malienė and Malys; 2009, ODPM, 2005a). While at the same time, a sustainable living environment has an essential role to play in contributing to the success of affordable housing (CLG, 2011a; Pollard, 2010; Queensland Department of Housing, 2000; Talen and Koschinsky, 2011). It is therefore important that such issues are tackled simultaneously. However the ODPM (2005b) admit that, previously, in a rush to build more homes to meet demand the government too often did not build communities. Many housing estates have simply been dumped into spaces with no amenities and no consideration for their governance in the future (ODPM, 2004). The government acknowledge that "too many new developments have suffered from a lack of attention to quality, safety, energy efficiency, environmental impact or infrastructure. Subsequently, people's quality of life suffered and the cost of repair and renewal was considerable" (CLG, 2007a, p.57). It is therefore imperative that housing is not considered in isolation from other important factors. Pollard (2010) recommends that building affordable and strong communities requires a focus on addressing the links between jobs, transportation, and affordable housing. Jobs, shops, services, transport and green spaces are important factors for creating thriving communities (ODPM, 2005b). It is not enough to simply provide more homes, there must also be a strong focus on creating sustainable communities (Maliene *et al.*, 2008). The Senate Select Committee on Housing Affordability in Australia (2008, p.3) share parallel views, recommending that:

> The way to improve housing affordability is not to build cheap houses on the outskirts of cities away from employment, services and public transport links...Rather, the aim must be to build affordable housing in areas where infrastructure can provide for and attract new residents. In considering longer-term changes in the housing stock, thought must also be given to it being environmentally sustainable for it to be truly 'affordable' in a broader sense.

The links between affordability and sustainability are multifaceted, but the two issues are closely related. In some regards there is a contention in achieving both affordability and sustainability for housing. On the one hand, improving the sustainability of housing by design can be seen as a costly. Although on another hand, more energy efficient housing by design - with subsequent lower running costs - can improve affordability in the long term. Furthermore, socially sustainable housing with good accessibility to jobs, key services and public transport should result in reduced car dependency and less expenditure on everyday travel. Accordingly, sustainable communities and housing can create reductions in infrastructure costs, while at the same time reducing ecological impacts and increasing social sustainability.

3.3 Socio-economic consequences of declining affordability and poor quality environments

Households that cannot afford to live in good quality housing may be forced to reside in inadequate housing, or in housing that is located within poor quality environments. There are a number of significant social and economic consequences associated with deteriorating affordability, poor quality housing and unsustainable neighbourhoods.

Social and economic

Not adequately addressing sustainability concerns alongside affordable housing can result in 'unsustainable costs' for individuals, families and communities, for example increasing rates of stress, significant growth in crime rates, along with indirect costs such as community breakdown and negative impacts on educational attainment (Queensland Department of Housing, 2000).

Research suggests that a number of physical and mental health problems relate to the built environment, particularly owing to poor urban planning and inadequate housing (Raffestin and Lawrence, 1990). Housing affordability problems may influence the health of households in a number of ways, for example it can affect the quality (Evans *et al.*, 2000), tenure (Kearns *et al.*, 2000) and location (Wright and Kloos, 2007) of housing that can (or cannot) be accessed. Deprived neighbourhoods can have reduced levels of social capital and social cohesion which are positive determinants of health. Children's lives can be considerably affected by poor housing environments. As well as causing a number of health problems, poor housing conditions can harm young children's ability to achieve at school, develop emotionally, form healthy relationships, and may possibly exacerbate behavioural problems; all of which would have a lasting impact on a child's chances of succeeding in life (Harker, 2006).

The failure to locate affordable housing within mixed communities can also create social problems. Social cohesion and community bonds can be undermined by high concentrations, or segregation, of low-income households in low cost housing, as well as increased levels of crime and anti-social behaviour (Gabriel *et al.*, 2005).

A lack of decent affordable housing can cause economic problems for communities. The inability to access affordable housing can discourage key workers from seeking employment in a particular area (Gabriel *et al.*, 2005; NHPAU, 2009b). This can result in reduced labour market flexibility (NHPAU, 2008) and low cost labour becoming limited in areas which fail to provide affordable housing. Subsequently this may have a negative effect on a community's ability to retain and recruit employees. Additionally, households who are forced to reside in areas that are at great distance from employment may suffer in the long term. It has been suggested that those who live in locations with poor accessibility to jobs are less likely to be employed in the future (Aslund *et al.*, 2006). Accordingly, declining affordability can affect economic performance and labour market efficiency and may therefore contribute to social exclusion and spatial polarisation (Yates and Milligan, 2007).

Furthermore, housing that is located in neighbourhoods that are far from employment opportunities can cause environmental consequences. If households cannot afford to locate in their area of employment they are likely to be forced to live in lower cost areas further from work, thus increasing commuting times and subsequently impacting negatively on the environment (NHPAU, 2008; 2009b). This also places increased pressures on transportation systems. Increased commuting time resulting from poor accessibility to employment is also seen to reduce worker productivity and result in less time available to spend at home with family (Belsky *et al.*, 2005). Living lengthy distances from jobs and community services can cause social isolation, family stress, unemployment and welfare dependency (Disney, 2007).

Furthermore, poorly located housing, in relation to key services, facilities and jobs, increases reliance on cars and imposes additional transportation costs on households.

Housing market failure

Building housing that is not well connected to jobs, services and infrastructure can and has contributed to areas experiencing low housing demand and abandonment. As well as areas of rising house prices and affordability problems, there are areas within the UK experiencing low housing demand and consequently housing market failure. Such locations may have an abundance of low value properties. Therefore, lack of housing supply and high housing costs are not the only concerns for the housing sector; problems as a result of low quality housing and undesirable neighbourhoods also exist. Imbalances between the demand and supply of housing can create high and low demand areas; both of which can occur at the same time in different parts of a city or area (Maliene *et al.*, 2008). In particular this has occurred in many parts of the North and the Midlands of England. This can, and usually does, result in polarised housing markets where areas of high demand see steeply rising house prices and areas of low demand see falling house prices and abandonment. The Housing Market Renewal Initiative (HMRI) was prompted by the government in 2002 to tackle problems of low demand and the emergence of housing abandonment in several parts of the North and the Midlands of England (HCCPA, 2008). HMRI is a programme of refurbishment, redevelopment and improved area management that seeks to address housing market failure and the associated problems of poor quality housing and a lack of choice and tenure (Audit Commission, 2011). In such neighbourhoods, high levels of low demand properties, population loss and high vacancy rates created decline and deprivation (Cole and Nevin, 2004; HCCPA, 2008). These areas suffered from a lack of jobs, poor public services, crime and anti-social behaviour, with streets and parks in disrepair (ODPM, 2005b). While the HMRI programme concerns the renewal of local housing markets, it has been acknowledge that the cause of market failure is not necessarily housing-derived, but potentially covers a range of non-housing factors such as fear of crime, lack of access to transport, failing schools, labour market change and so on (Cole and Nevin, 2004). It seems that the overall success of renewal initiatives will not only depend on improving housing stock and problems of affordability, but also on local economic performance, access to high quality public amenities, transport, employment opportunities and community safety. Burke (2004) affirms that as well as creating more affordable housing, improvements need to be made to amenities and facilities in low cost areas so that a wider socio-economic range of households will choose to locate there.

As failing housing market demonstrate, while some areas may have an abundance of lower than average value properties, they are often in neighbourhoods where people have no desire to live, where much of the housing may be outdated, in poor environments, of poor quality and even non-decent. The traditional notion of affordability, i.e. low housing costs in relation to income, may suggest that such areas or properties are 'affordable' simply because they are low value. However, this approach fails to indicate anything about the quality of the housing or the environment in which the housing is situated. Accordingly, this may be a rather simplistic and unsustainable way to view affordability (Mulliner *et al.,* 2013). It has been suggested that a distinction needs to be drawn between low value and affordable housing (NWRA, 2007). For an area to be regarded as affordable it ought to have more than relatively low house prices. The government needs to build better homes, at high standards, both in terms of design and environmental impact, and homes that are part of sustainable mixed communities (CLG, 2007a). "There is both an efficiency and equity imperative to ensure that housing affordability is environmentally sustainable and socially equitable" (ACF and VCOSS, 2008, p. 7). To overcome this problem it is essential that affordable homes are made decent and decent homes are made more affordable in high quality communities where people aspire to live. Accordingly, in certain areas it may be the case that it is not only the price of housing that needs to be addressed in order to improve housing affordability; access to amenities, facilities and local infrastructure and the energy efficiency of housing may need to be improved to create attractive and sustainable living environments (Mulliner and Maliene, 2012).

It is not only individual households that take on the weight of the economic and social costs of decreasing affordability and unsustainable neighbourhoods. They can create great expenditure implications for the government in terms of, for example, homelessness, increased health care, policing, renewal and regeneration activities, as well as costs to the environment.

3.4 Chapter summary

- This chapter has highlighted the importance of linking the notion of housing affordability with sustainable communities.
- It is manifest that both sustainability and affordability issues are simultaneously tackled in order to create successful housing and communities. The literature stressed that decent affordable housing alone is not enough to achieve community and family wellbeing; households need decent affordable housing that is well located within good quality environments that are clean, safe and have good access to jobs, key services and public transport.
- The research posits that housing affordability must be defined and assessed in a more thoughtful way, requiring a new paradigm of thinking that goes beyond the financial implications experienced by households and is better aligned with sustainability concerns and household wellbeing. Applying the concept of community sustainability would broaden the scope of affordability to reflect community well-being and environmental factors.

Chapter 4

Review of multiple criteria decision making methods

4.1 Introduction

The literature studied has highlighted the complex nature of housing affordability and the broad range of criteria that influence the wellbeing of households. Given the complexity of the issue under consideration in this study and the presence of numerous conflicting factors, multiple criteria decision making (MCDM) was determined as appropriate for the basis of the complex assessment tool for sustainable housing affordability.

This chapter discusses MCDM theory and methodologies, in order to aid in the selection of an appropriate method to use for the study. Additionally, the data collection process required for MCDM is established. Further justification for selecting decision making methods for the assessment of housing affordability is also presented.

4.2 Overview of multiple criteria decision making methods

MCDM, often called multi criteria decision aid (MCDA) and multi criteria analysis (MCA), is a set of methods which deal with the evaluation of a set of alternatives in terms of numerous, often conflicting, decision criteria (Triantaphyllou, 2000). MCDM therefore concerns making choices in the presence of multiple conflicting criteria (Köksalan *et al.*, 2011). Thus, given a set of alternatives (options) and a number of decision criteria (also known as attributes), the goal of MCDM is to provide an ordering of alternatives, from the most preferred to the least preferred option. MCDM is a branch of a general class of Operations Research (OR) models. MCDM was introduced as a promising and important field of study in the early 1970's (Carlsson and Fuller, 1996). MCDM has evolved rapidly since then and contributions to the field have an international nature. Such methods play a critical role in many real life problems (Triantaphyllou and Mann, 1995).

Generally, the process of MCDM defines objectives, chooses criteria to measure the objectives, specifies alternatives, transforms the criterion scales into commensurable units, assigns weights to the criteria that reflect their relative importance, selects and applies a mathematical algorithm for ranking alternatives, and finally chooses an optimal alternative (Howard, 1991; Massam, 1988). MCDM does not claim to give the 'right' answers, but as suggested by Stewart (1992), it aims to provide guidance to decision makers in discovering the most desired solution to the problem in question. MCDM methods generally aim to achieve one of the following goals (Jacquet-Lagreze and Siskos, 2001):

1. Find the best/optimal alternative;
2. Group the alternatives into well-defined classes;
3. Rank the alternatives in preference order;
4. Describe how well each alternative meets all the criteria simultaneously.

The literature presents an array of MCDM methodologies, each with their own characteristics and varying levels of sophistication. De Montis *et al.* (2000, p.2) explain how MCDM methods may vary:

> MCDA methods differ in the way the idea of multiple criteria is operationalised. In particular each method shows its own properties with respect to the way of assessing criteria, the application and computation of weights, the mathematical algorithm utilised, the model to describe the system of preferences of the individual facing decision-making, the level of uncertainty embedded in the data set and the ability for stakeholders to participate in the process.

However, there are three stages that all MCDM techniques follow (Triantaphyllou, 2000, pp. 5-6):

1. Determine relevant criteria and alternatives;
2. Attach numerical measures to the relative importance of the criteria and to the impacts of the alternative on these criteria;
3. Process the numerical values to determine a ranking of each alternative.

A typical decision problem can be represented by a decision matrix consisting of a number of alternatives and a number of decision criteria (figure 8). Each alternative (A_i) can be evaluated in terms of the decision criteria (C_j) and the relative importance (weight) (W_j) of each criterion can be estimated. Let a_{ij} (i=1,2,3,...,M, and N=1,2,3,...,N) denote the performance value of the i-th alternative (i.e., A_i) in terms of the j-th criterion (i.e., C_j) and W_j denotes the weight of the criterion C_j (ibid).

Figure 8. Typical structuring of a decision problem

Another factor to take into consideration is that decision criteria can be grouped into two categories, usually termed the 'positive' (maximizing/benefit) and the 'negative' (minimizing/loss) criteria. A positive criterion means that a higher criterion value is better for the decision maker, whereas for negative criteria a lower criterion value is better for the decision maker.

Identifying the most suitable MCDM method to process the numerical values will depend on the problem in question. There is no single method that will be appropriate for all decision making situations. This aspect alone proposes a problem which requires a decision; which method is the most suitable for the situation in hand? Triantaphyllou (2000) indicates that this paradox has become one of the most crucial yet difficult questions to answer.

MCDM methods can be categorised in a number of ways. MCDM problems are frequently categorised according to the nature of the alternative(s); either discrete or continuous (Hwang and Yoon, 1981; Belton, 1986; Zanakis, 1998; Hajkowicz *et al.*, 2000). A discrete problem can be described as a multi attribute discrete option, which often consists of a modest collection of alternatives (Multi Attribute Decision Making (MADM)), whereas a continuous problem usually consists of a vast or infinite amount of decision alternatives (Multi Objective Decision Making (MODM)) (De Montis *et al.*, 2000). MCDM methods may also be classified depending on their compensatory or non-compensatory nature. Compensatory methods allow explicit tradeoffs among attributes, whereas non-compensatory methods are principally based on the comparison of alternatives with respect to individual criteria (Shaniana and Savadogob, 2009). Alternatively, Wong (1999) and Zopounidis (1999) divide MCDM problems into the following categories: (1) a choice problem (where a decision maker wishes to determine a best alternative or a subset of best alternatives), (2) a ranking problem (where alternatives need to be ranked from best to worst), or (3) a sorting problem (where a decision maker seeks to divide the set of alternatives into subsets according to some norms).

The objective of this study is to assess the affordability of different housing locations based on an established set of sustainable housing affordability assessment criteria. The decision making situation is thus a ranking problem where alternatives need to be ranked from best to worst, i.e. from most affordable to least affordable housing location. The problem has a discrete nature, that is to say the alternatives (housing locations) will be pre-specified, and therefore a MADM method will be suitable in this instance. Consequently, the literature review focuses on MADM methods. For MADM problems there are generally two families of methods; those based on Multi-attribute Utility Theory (MAUT) and those based on outranking methods. The methods based on MAUT (Keeney and Raiffa, 1976) commonly have a compensatory nature, whereas the outranking methods allow for incomparability between alternatives (non-compensatory nature).

4.3 Common Compensatory MCDM methods

Utility based approaches emerged mainly from Keeney and Raiffa (1976), but this stream of thought has been implemented in a number of methods. Some of the most commonly applied and most acceptable methodologies include the weighted sum model (WSM) (Fishburn, 1967), the weighted product model (WPM) (Bridgman, 1992; Miller and Starr, 1969), the analytic hierarchy process (AHP) and its revised version (Belton and Gear, 1983; Saaty, 1994), TOPSIS (Hwang and Yoon, 1981) and COPRAS (Zavadskas *et al.,* 1994). As the name of this group suggests, these methods permit complete compensation between criteria, that is to say the gain on one criterion can compensate for the loss on another criterion (Keeney and Raiffa, 1976).

4.3.1 Weighted sum model (WSM)

The WSM (also known as simple additive weighting (SAW) method) (Fishburn, 1967) is one of the simplest and most commonly used MCDM methods. The method involves adding together criteria values for each alternative and applying the individual criteria weights. Minimizing (negative) criteria should be transformed into maximizing (positive) ones prior to normalization if using the WSM. Once values for all alternatives have been aggregated, the alternative with the highest value (if all criteria are maximizing) is then selected as the best solution (Fishburn, 1967):

(1)

Here the $M \times N$ matrix A has data entries a_{ij} corresponding to the value of the jth (of N) alternatives in terms of the ith (of M) decision criterion. A^* is the WSM score of the optimal alternative and w_i is the weight (importance) of the ith criterion. Difficulty can arise when the WSM method is applied to multi-dimensional decision making problems; where data are expressed in different units of measure they should not be added as this is equivalent to "adding apples and oranges" (Triantaphyllou, 2000). This problem may be overcome by normalising each data point with respect to the total of each row (i.e. the total across all alternatives), known as the AHP (Belton and Stewart, 2002; Triantaphyllou, 2000).

4.3.2 Weighted product model (WPM)

The WPM (Bridgman, 1992; Miller and Starr, 1969) is akin to the simple WSM method. The principal difference is that in the main mathematical process there is multiplication instead of addition (Triantaphyllou and Mann, 1989).

Starting from a normalised matrix, we calculate (Bridgman, 1992; Miller and Starr, 1969):

(2)

Again, A^* is the WPM score of the optimal alternative.

4.3.3 Analytic hierarchy process (AHP)

The AHP is based on the use of pair-wise comparisons, both to estimate criteria weights and to compare the alternatives with regard to the decision criteria (Belton and Stewart, 2002). A decision problem is represented in a hierarchy in which each level consists of a matrix of pair-wise comparisons with reference to the semantic scale and a 1-9 numeric scale for qualitative data (Saaty, 1980). A value of 1 indicates equal importance between criteria, whilst at the highest end of the scale a value of 9 indicates extremely more importance of one criterion over another (Pohekar and Ramachandran, 2004). The output of the AHP process therefore reflects the relative importance of each of the criteria when compared against all other criteria. AHP uses relative values rather than actual values, i.e. units of measure are eliminated, so that the method can be used in multi-dimensional MCDM (Triantaphyllou, 2000). On the basis of pair-wise comparisons the relative weights (priorities) of the criteria are determined, concentrating on just two aspects at a time. However, Stewart (1992) implies that this method encourages decision makers to express criteria weights in isolation from the specific range of available options. Furthermore, the process can be very time consuming if there are numerous criteria to consider (Schniederjans *et al.*, 1995). If data (criteria values and weights) cannot be obtained directly then a method based on the pair-wise comparisons must be employed.

If criteria weights and values are predetermined the AHP method can still be used to process the numerical values. Full implementation of the AHP uses pairwise comparison to establish relative performance scores for each of the options on each criterion. The final step in the AHP deals with the construction of an $M \times N$ matrix (where M is the number of alternatives and N is the number of criteria) that is made using the relative importances of the alternatives in terms of each criterion (Triantaphyllou, 2000). The entry a_{ij}, in the $M \times N$ matrix, represents the relative value of the alternative A_i when it is considered in terms of criterion C_j. In the original AHP the sum of the formula below is equal to one:

(3)

The best alternative (when all the criteria are maximizing) is indicated by the following relationship:

$$A^{*}_{AHP} = \max_{i} \sum_{j=1}^{N} a_{ij} w_j, \quad for \ \ i = 1, 2, 3, ..., M. \tag{4}$$

Although this formula is similar to the one used by the WSM, a central difference with the AHP method is that the a_{ij} values of the decision matrix are normalized to sum to 1.

4.3.4 The revised AHP

Belton and Gear (1983) observed a problem with the original AHP method; they noted that AHP can reverse the ranking of the alternatives when an alternative identical to one already existing is introduced. Accordingly, Belton and Gear (1983) proposed a revised version of the AHP method in order to overcome this inconsistency. Instead of having the relative values of the alternatives sum up to one (as in AHP), in the revised AHP each relative value is divided by the maximum value of the relative values (ibid; Triantaphyllou and Mann, 1995; Triantaphyllou, 2000). This revision was subsequently accepted as a variation of the original AHP and is also referred to as 'ideal mode AHP' (Saaty, 1994). Triantaphyllou and Mann (1989) advocate that the revised version appears to be more powerful than the original AHP approach. As in the original AHP, the best alternative is given again by the additive formula (4), but the normalization procedure is different.

4.3.5 COPRAS (COmplex PRoportional Assessment)

The COPRAS method was first announced in 1994 (Zavadskas *et al.*, 1994). COPRAS acts in a similar way to the WSM. However, COPRAS allows for both positive and negative criteria to be considered within the matrix and the data are normalized so that different measurement units can be used and compared. The significance of the comparative alternatives is determined on the basis of describing positive and negative characteristics of the alternatives. The method estimates the priority order and utility degree of the alternatives, showing, as a percentage, the extent to which one alternative is better or worse than the others being compared (Banaitiene *et al.* (2008). The procedure of the COPRAS method is generally carried out in the following stages (Zavadskas *et al.*, 2004):

Stage 1: The first step is the normalisation of the decision-making matrix:

$$d_{ij} = \frac{q_i}{\sum_{j=1}^{n} x_{ij}} \cdot x_{ij} \qquad (5)$$

Where x_{ij} is the value of the i-th criterion of the j-th alternative, and q_i is the weight of the i-th criterion. With this transformation, the sum of the dimensionless weighted values d_{ij} of each criterion x_i always equals the weight q_i of this criterion:

$$q_i = \square_{j=1}^{n} d_{ij} \qquad (6)$$

Stage 2: The sums of weighted normalised criteria describing the j-th alternative are calculated. The alternatives are described by positive (maximising) criteria S_{+j} and negative (minimising) criteria S_{-j}. Sums are calculated according to the formulae:

$$S_j^{+} = \square_{z_i=+} d_{ij}$$
$$S_j^{\square} = \square_{z_i=\square} d_{ij} \qquad (7)$$

Stage 3: The significance of the comparative alternatives is determined on the basis of describing positive (+) and negative (-) qualities that characterise the alternatives. The relative significance Q_j of each alternative A_j is determined according to:

$$Q_j = S_{+j} + \frac{S_{-\min} \cdot \sum_{j=1}^{n} S_{-j}}{S_{-j} \cdot \sum_{j=1}^{n} \frac{S_{-\min}}{S_{-j}}}, \quad j = \overline{1,n}. \tag{8}$$

The first term of Q_j increases for higher positive criteria S^{+}_{j}, whilst the second term of Q_j increases with lower negative criteria S^{-}_{j}. Alternative formulations of Q_j are possible (see 4.3.6).

Stage 4: The prioritisation Q_j of the alternatives is determined in this stage. The greater the value Q_j, the higher the priority (significance) of the alternative. In this case, the significance $Q_{\max}$ of the most rational alternative will always be the highest.

Stage 5: The final stage determines the degree of utility of the alternatives. With the increase/decrease of the priority of the analysed alternative, its degree of utility also increases/decreases. The degree of utility is determined by comparing each analysed alternative with the most efficient one. The optimal alternative is expressed by the highest degree of utility N_j equalling 100%. All utility values related to the considered alternatives will range from 0% to 100%, between the worst and best alternative out of those under consideration. The degree of utility N_j of the alternative A_j is determined according to the following formula:

$$N_j = \frac{Q_j}{Q_{\max}} \times 100\% \tag{9}$$

Where Q_j and Q_{max} are significances of the alternatives calculated at stage 4.

4.3.6 Modified COPRAS

Modified COPRAS follows the same process as the COPRAS method, except that stage 3 is different. A simple subtraction of the negative criteria from the positive criteria creates a simpler version of COPRAS:

$$\bar{Q}_j = S_j^{+} \square S_j^{\square} \tag{10}$$

4.3.7 TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution)

The TOPSIS method (Hwang and Yoon, 1981) approaches a MCDM problem by identifying a best case scenario (i.e. $\sum$ the best data points achieved in the matrix) and a worst case scenario (i.e. $\sum$ the worst data points achieved in the matrix) from a set of given alternatives. The best alternative will be the one that is closest to the ideal solution (best case scenario) and the maximum distance away from the anti-ideal solution (worst case scenario) (Chen and Hwang, 1992; Hwang and Yoon, 1981). Thus, the optimal alternative should be the one that best maximises the beneficial criteria and minimises the unbeneficial criteria. However, while these two reference points (ideal and anti-ideal) are identified, TOPSIS does not consider the relative importance of the distances from such points (Opricovic and Tzeng, 2004).

TOPSIS can be applied both to maximizing and minimizing criteria (Antuchevičiene *et al.*, 2010; Jakimavičius and Burinskienė, 2009; Zavadskas *et al.*, 1994). The TOPSIS procedure generally consists of the following stages (Triantaphyllou, 2000):

Stage 1: The TOPSIS method first converts criteria dimensions to non-dimensional criteria in a normalized decision matrix, using vector normalisation. The normalized value r_{ij} is calculated as:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{M} x_{ij}^2}}. \quad (11)$$

Wher x_{ij} represents the value of j-attribute for i-alternative, r_{ij} represents the value of the new normalized decision-making matrix.

Stage 2: Calculate the weighted normalized decision matrix. A set of weights $W = (w_1, w_2, \ldots, w_n)$ with $\sum w_i = 1$ is used in combination with the previous normalised decision matrix to determine the weighted normalized matrix V, defined as:

$$v_{ij} = w_{ij} r_{ij}, \quad (12)$$

Stage 3: Determine the ideal (A*) and negative-ideal (A⁻) solutions:

$$\begin{aligned} A^* &= \{ (\max_i v_{ij} \mid j \in J), (\min_i v_{ij} \mid j \in J') \mid i = 1,2,3, \ldots, M\} = \\ &= \{ v_{1*}, v_{2*}, \ldots, v_{N*} \}. \end{aligned} \quad (13)$$

$$\begin{aligned} A^- &= \{ (\min_i v_{ij} \mid j \in J), (\max_i v_{ij} \mid j \in J') \mid i = 1,2,3, \ldots, M\} = \\ &= \{ v_{1^-}, v_{2^-}, \ldots, v_{N^-} \}. \end{aligned} \quad (14)$$

where $J = \{j = 1, 2, \ldots, N$ and j is associated with benefit criteria$\}$; and $J' = \{j = 1, 2, \ldots, N$ and j is associated with cost/loss criteria$\}$.

The ideal solution represents a hypothetical option that consists of the most desirable level of each criterion across the options under consideration. Whereas the negative-ideal solution represents a hypothetical option that consists of the least desirable level of each criterion across the options under consideration.

Stage 4: Calculate the separation measure (distance) of each alternative from the ideal-solution and negative-ideal solution using the n-dimensional Euclidean distance method:

$$S_i^* = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^*)^2}, i = 1, \ldots, M. \tag{15}$$

where S_{i^*} is the separation (in the Euclidean sense) of each alternative from the ideal solution.

$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}, i = 1, \ldots, M. \tag{16}$$

where S_{i^-} is the separation (in the Euclidean sense) of each alternative from the negative-ideal solution.

Stage 5: Calculate the relative closeness of each alternative A_j to the ideal solution A^*:

$$C_{i^*} = S_{i^-} / (S_{i^*} + S_{i^-}), 0 \leq C_{i^*} \leq 1, i = 1, 2, 3, \ldots, M \tag{17}$$

If $C_i = 1$ then $a_i = A^*$ (ideal solution) and if $C_i = 0$, then $a_i = A-$ (anti-ideal solution). Therefore, the conclusion is that the alternative a_i is closer to A^* if C_i is closer to the value of 1.

Stage 6: Finally, the preference order is ranked according to C_i. The best alternative is the one that has the shortest distance to the ideal solution, meaning that the bigger the C_i value, the better the alternative is. The relationship of alternatives reveals that any alternative which has the shortest distance to the ideal solution is guaranteed to have the longest distance to the negative-ideal solution.

The fact that the TOPSIS method uses squared terms in the evaluation of criteria should be highlighted. The consequence of this is that very good and very bad data points (criteria values) can be exaggerated, having more of an impact on the final outcome, whereas average data points will not have as much of an impact (in comparison with methods that do not utilise squared terms). See the simple example provided in table 3.

Table 3. Example of use of squared terms in TOPSIS

Criteria	Weight	Alternative 1	Alternative 2
A	1	0	10
B	1	20	10
Weight x Value		20	20
Weight x Value ^{2}		400	200

Source: Self study

Methods that utilise squared terms may be suitable particularly where criteria values for different alternatives are similar, thus requiring further distinguishing.

4.4 Outranking methods

The compensatory methods discussed are widely used, however Natividade-Jesus *et al.* (2007) indicate that in many decision making situations a good performance in one criterion may not necessarily compensate for a poor performance in another criterion. Thus, the outranking methods allow for incomparability between alternatives. ELECTRE (Elimination and Choice Translating reality) (Roy, 1991) and PROMETHEE (Preference ranking organisation method for enrichment evaluation) (Brans *et al.*, 1986) are the most widely used outranking methods.

4.4.1 ELECTRE

ELECTRE compares criteria for each alternative on a pair-wise basis to establish the overall degree of dominance for each criterion over all others. The methods analyse the outranking relations between alternatives by using concordance and discordance principles and threshold values (Wang *et al.*, 2009). Thus, an alternative *a* is 'at least as good as' an alternative *b* if a sufficient majority of criteria support this suggestion (concordance principle) and if no criterion is too strongly opposed to it (non-discordance principle) (Bouyssou, 1996). The chosen alternative(s) should be the one(s) that is preferred over most of the criteria and that does not cause an unacceptable level of dissatisfaction for any of the criteria. Once the concordance and discordance indices are determined for each pair of alternatives, two complete preorders can be obtained which show ascending and descending distillation procedures (Wang *et al.*, 2009). ELECTRE has evolved through a number of versions (I through IV and TRI) with the most widely used versions known as ELECTRE II and ELECTRE III (Wang and Triantaphyllou, 2008). Each version is based on the same fundamental concepts but they are operationally different to some extent. Buchanan *et al.* (1999) suggest that ELECTRE I should be used for selection problems, ELECTRE II, III and IV for ranking problems and ELECTRE TRI for assignment problems. ELECTRE III uses pseudo-criteria which allow for the imprecision and uncertainties inherent in the complex human decision processes, unlike traditional criteria the pseudo-criteria have thresholds (Giannoulis and Ishizaka, 2009). ELECTRE IV is the only ELECTRE method that does not introduce weights to the criteria (Shaniana and Savadogob, 2009). Thus ELECTRE IV could be used when it is not possible or not required to quantify the relative importance of criteria.

Many authors have indicated that ELECTRE is not always able to identify the best alternative, although it does produces leading alternatives by eliminating less favourable ones (Pohekar and Ramachandran, 2004; Triantaphyllou, 2000, Wang *et al.*, 2009). As a result it seems that a shortlist of alternatives may be produced by

ELECTRE methods rather that an identifiable 'best' alternative. If a best alternative is needed then it is possible that an additional method will be necessary. Stewart (1992) advocates that ELECTRE is more valuable for problems that have a small amount of alternatives.

4.4.2 PROMETHEE

The PROMETHEE methods (Brans and Vincke, 1985) perform pair-wise comparisons of alternatives according to a set of criteria to establish if an alternative *a* outranks another alternative *b* or whether there is indifference between *a* and *b*. PROMETHEE measures the difference between two alternatives by using preference functions, six basic types of preference function have been proposed, namely the usual criterion, quasi criterion, criterion with linear preference, level criterion, criterion with linear preference and indifference area, and Gaussian criterion (Brans *et al.*, 1986). The PROMETHEE methods rank alternatives according to their entering flows and leaving flows. The leaving flow represents the outranking character of each alternative, i.e. how much the alternative is outranking all the others, the higher the flow the better the alternative. While the entering flow represents the outranked character of each alternative (ibid), i.e. how much the alternative is outranked by all the others, the lower the flow the better the alternative. PROMETHEE I provides a partial ranking of alternatives and PROMETHEE II provides a complete ranking of alternatives (Ananda and Herath, 2009). In PROMETHEE II the net outranking flow is considered for each alternative, it is equal to the difference of incoming flow and outgoing flow; the best alternative is the one with the highest net flow (Wang *et al.*, 2009).

4.5 MCDM applications within the built environment

MCDM methods are useful in supporting decision making problems where conflicting objectives are involved, e.g. economic, environmental, social, technical, and aesthetic (De Montis *et al.*, 2000). MCDM can therefore incorporate such conflicting criteria, which are often present within built environment related problems, into one evaluation process to aid in determining a solution to a decision making problem. Numerous MCDM methods have been successfully applied in various areas of property, planning and built environment related research.

Ball and Srinivasan (1994) proposed the AHP method to aid house selection for buyers. The AHP was also used to analyse the environmental preferences of homeowners in Swiss cities (Bender *et al.*, 2000). Zavadskas *et al.* (2001) utilised COPRAS to assess building life cycles in order to select an optimal alternative. Viteikienė and Zavadskas (2003) applied the WSM, WPM, AHP, revised AHP, TOPSIS and COPRAS to analyse the process of building maintenance, helping to ensure a more effective facilities management process. Zavadskas *et al.* (2004) presented a model of housing credit access for a Lithuanian case study, which sought to determine the most rational housing investment instruments and lenders, using the COPRAS method. Kaklauskas *et al.* (2005) used COPRAS in order to design and realise efficient building refurbishment options. Johnson (2005) utilised PROMETHEE to enable clients under the Housing Choice Voucher Program in the USA to make better decisions about neighbourhoods in which to search for housing. Marinoni (2006) used an iterative approach in order to assess land-use suitability for residential housing construction based on Geographic Information Systems (GIS) and the PROMETHEE method. Natividade-Jesus *et al.* (2007) proposed a decision support system, including the use of SAW, TOPSIS and ELECTRE, in order to assist several stakeholders in making better decisions on housing evaluation; the research concluded that ELECTRE was the preferred method. Viteikienė and Zavadskas (2007) evaluated the sustainability of residential areas in Vilnius City using COPRAS. COPRAS has also been used in order to define the utility and market value of real estate (Kaklauskas *et al.*, 2007). Banaitiene *et al.* (2008) adopted the COPRAS method, along with SAW and TOPSIS to test the effectiveness of COPRAS, to support decision-making on a building's life cycle selection by designing alternatives of the building life cycle and evaluating their qualitative and quantitative aspects. The final rankings produced by the three different methods were equivalent (ibid). Ginevičius and Podvezko (2009) employed SAW, TOPSIS and COPRAS to evaluate the social and economic development of

Lithuanian regions. Lotfi and Solaimani (2009) made an assessment of urban quality of life in Iran using the AHP. Uilaityte and Martinaitis (2010) sought to identify a building's optimal renovation solution, from a number of possible alternatives, using COPRAS. Furthermore, COPRAS, SAW and multiplicative exponential weighting (MEW) were applied for the purpose of selecting an appropriate one flat dwelling house, taking into account the environmental impact of its construction, financial and qualitative criteria; all three MCDM methods produced the same final ranking of alternatives (Medineckienė, 2010).

4.6 Selecting the appropriate MCDM method

Despite the large quantity of MCDM methods available, no single method is considered the most suitable for all types of decision-making situation (Guitouni and Martel, 1998). This generates the paradox that the selection of an appropriate method for a given problem leads to an MCDM problem itself (Triantaphyllou 2000). A major criticism of MCDM is the reality that different methods can yield different results when applied to the same problem (Gershon and Duckstein, 1983).

The literature presents a number of practical comparative analyses of different MCDM methods. For example, Zanakis *et al.* (1998) used simulated data to evaluate eight MCDM methods, including SAW, MEW, TOPSIS, ELECTRE, and four variants of the AHP. The authors concluded that, of the eight methods tested, SAW and MEW were the most favorable methods, followed by TOPSIS and the variants of AHP methods, while ELECTRE performed the worst (ibid). Mahmoud and Garcia (2000) compared five MCDM methods – SAW, PROMETHEE II, compromise programming, ELECTRE and AHP – and confirmed that SAW was the most useful method for the task in question (ibid). Chang and Yeh (2001) performed an empirical study of the three methods – SAW, WPM and TOPSIS – and found that SAW was the optimal method. Banaitiene *et al.* (2008) used three methods – COPRAS, SAW and TOPSIS – for the analysis of a building's life cycle and found they produced equal rankings of alternatives for that particular study; although the authors found that the COPRAS method had a supplementary advantage owing to its ability to calculate the 'utility degree' of each alternative. Simanaviciene and Ustinovicius (2012) evaluated the reliability and biases of three methods, SAW, TOPSIS and COPRAS. The comparative study concluded that the decision yielded by COPRAS was the most efficient and least bias (ibid). It appears that simple methods can often be optimal. Although Caterino *et al.* (2009) compared eight MCDM methods (TOPSIS, WSM, WPM, ELECTRE, MAUT, VIKOR, PROMETHEE I and PROMETHEE II) for seismic retrofit of structures and found TOPSIS and VIKOR to be more appropriate for solving such problems.

The identification and selection of an appropriate MCDM method is not a simple task and considerable consideration must be given to the choice of method. Consequently, Guitouni and Martel (1998) proposed a conceptual framework for articulating tentative guidelines to choose an appropriate MCDA method. However, it has also been acknowledged that several methods can be potentially valid for a particular decision making situation; there is not always an overwhelming reason to adopt one technique over another (Hajkowicz and Higgins, 2008). It seems that one of the most important criteria in selecting a MCDM method is its compatibility with the problem's objective (Roy, 1991). The problem proposed in this study is to assess the sustainable housing affordability of a number of alternative areas. To achieve this, a ranking of alternatives needs to be identified. Therefore, the objective of this problem is to rank alternatives. Consequently, a MCDM method that has the ability to provide a complete ranking of alternatives (indicating the position of each alternative) is required. Additionally, the method must have the ability to handle criteria of both positive and negative influence and those of a quantitative and qualitative nature. Furthermore, ease of use and understanding of the MCDM technique is important so that any interested parties can easily adopt the proposed method.

4.7 Data collection required for MCDM

The data collection process for MCDM methods generally includes the following stages:

1. establish assessment criteria;
2. determine criteria weights (significance);
3. select decision alternatives for comparison;
4. calculate criteria values for each alternative;
5. create a decision making matrix with the aforementioned data;
6. problem solving using chosen MCDM method.

4.7.1 Selecting and weighting decision criteria

Keeney and Raffia (1976) suggest that a literature review and/or panel of experts should be used to identify decision criteria in the problem area to facilitate the use of MCDM methods. Once decision criteria have been identified, weightings generally need to be established. The criteria considered in a decision making situation may be of equal importance to the decision problem or some criteria may be more important than others. The relative importance of each criterion can therefore be indicated by its weight. Accurately estimating criteria weights is a crucial step in the MCDM process (Triantaphyllou, 2000). Criteria weights can be obtained objectively or subjectively. The weights of the criteria are usually determined on subjective basis whereby they represent the opinion of either a single decision maker or a synthesis of the opinions of a group of professionals. Contrastingly, weights obtained objectively have no consideration for decision makers' preferences; rather they are obtained by mathematical methods based on the analysis of initial data. Alternatively criteria may be assigned equal weights, although this method ignores the relative importance among the criteria (Wang *et al.*, 2009). Criteria weights are usually normalized to add up to one (Triantaphyllou, 2000).

4.7.2 Decision making matrix

To carry out multiple criteria analysis a decision making matrix must be prepared (table 4). A matrix format easily expresses the MCDM problem (Triantaphyllou, 2000).

The decision matrix combines all information for the analysis including the assessment criteria, the individual criteria weights and the criteria values for each comparable alternative under assessment. Once all data has been gathered within the decision making matrix a suitable MCDM method can be used to process the numerical values in order to prioritise the alternatives.

Table 4. Decision making matrix for multiple criteria analysis

Criteria under consideration	+/-	Weight	Measuring unit	Alternatives to be assessed					
				1	2	...	j	...	n
Assessment criteria	z_1	q_1	m_1	x_{11}	x_{12}	...	x_{1j}	...	x_{1n}
	z_2	q_2	m_2	x_{21}	x_{22}	...	x_{2j}	...	x_{2n}
	...	...	...	...	...	...	...	...	...
	z_i	q_i	m_i	x_{i1}	x_{i2}	...	x_{ij}	...	x_{in}
	...	...	...	...	...	...	...	...	...
	z_t	q_t	m_t	x_{t1}	x_{t2}	...	x_{tj}	...	x_{tn}

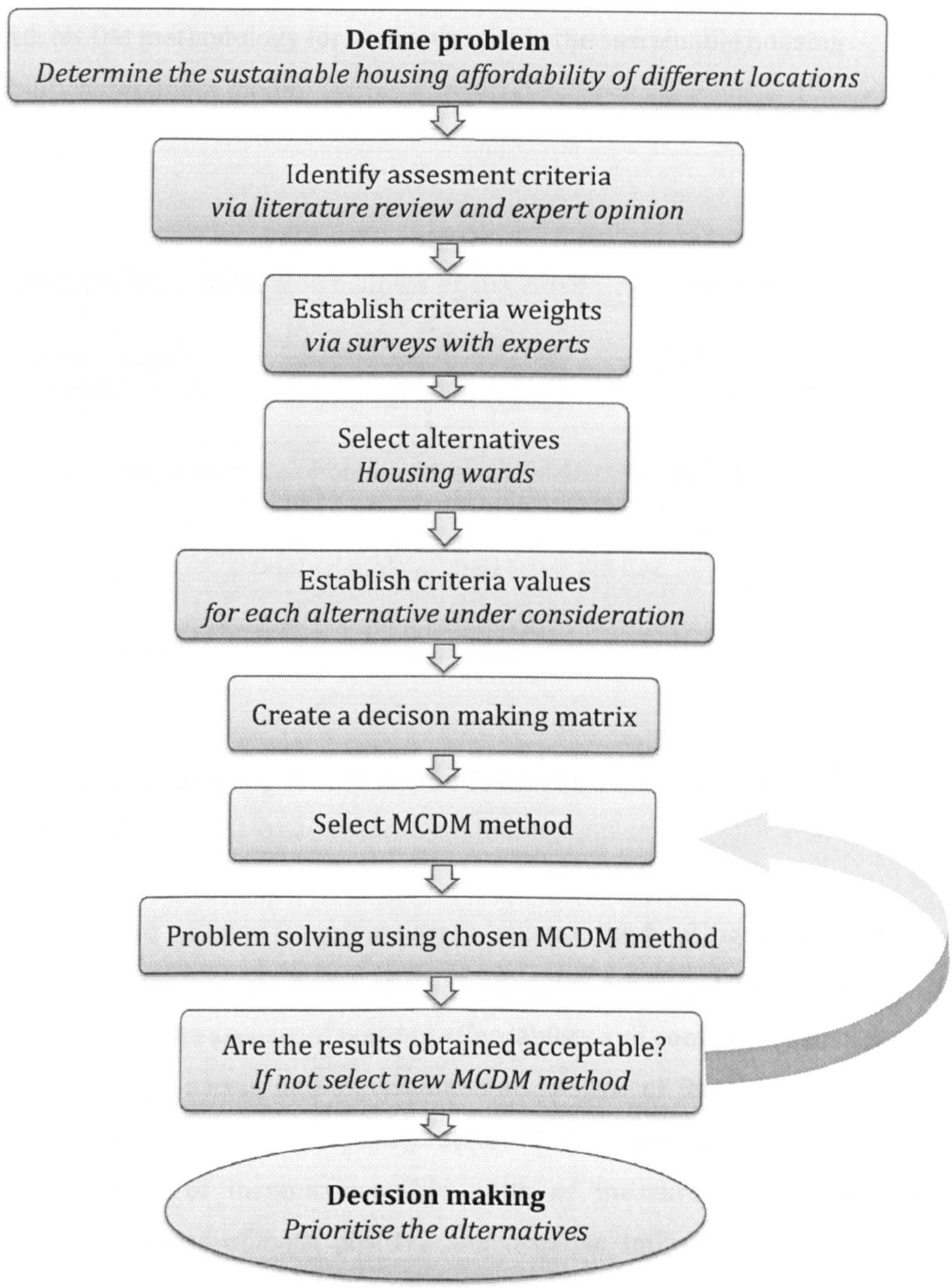
*The sign z_i (+/-) indicates that a higher/lower criterion value satisfies the interest party/decision maker

Source: Self study

4.8 MCDM process for the assessment of sustainable housing affordability

The MCDM process required for the comprehensive assessment of sustainable housing affordability is illustrated in figure 9. These stages form the basis of the methodology used within this study.

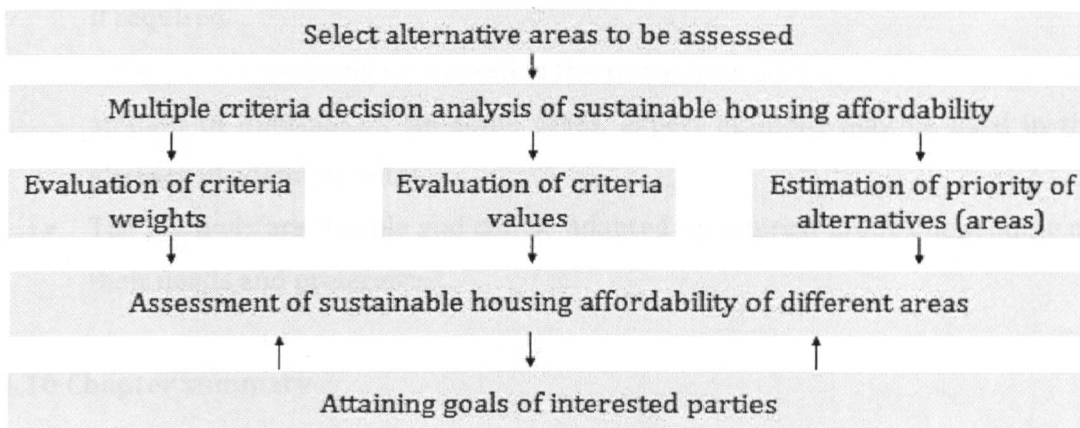
Figure 9. Process for the assessment of sustainable housing affordability using multiple criteria decision making methods



Source: Self study

The process detailed in figure 9 contributes to the development of the sustainable housing affordability assessment model. Figure 10 illustrates the methodology that will be included within the final model.

Figure 10. MCDM methodology for inclusion within the sustainable housing affordability assessment model



Source: Self study

4.9 Justification of choosing MCDM methods for the assessment of sustainable housing affordability

MCDM methods are suitable for this research because the housing affordability issue is complex and involves multiple, often conflicting, criteria. MCDM methods can incorporate the various aspects of housing affordability and community sustainability, including economic, social and environmental factors of both quantitative and qualitative nature, into one evaluation process. MCDM methods are also capable of considering criteria of incommensurable units of measure (e.g. ratios, points, percentages) and those of both positive and negative influence. In summary, the benefits of MCDM methods include:

- MCDM methods allow the multidimensional character of the sustainable housing affordability evaluation criteria to be taken into account, as well as their varying levels of significance (weight).
- MCDM can work with mixed data, allowing for the incorporation of both quantitative and qualitative information of incommensurable units of measure.
- The analysis is transparent to participants/interest groups.
- MCDM is participative allowing direct involvement of multiple interest groups if required.
- If data is not available or accessible the procedure can be used with a minimal amount of information (in some cases, expert opinions may be used in the absence of adequate data).
- The methods are flexible and can be adapted by interest groups depending on their needs and preferences.

4.10 Chapter summary

- This chapter has provided an overview of MCDM and discussed several different available methodologies, including the WSM, WPM, AHP, TOPSIS, COPRAS, ELECTRE and PROMETHEE.
- The use of such methods for a range of problems within the built environment was documented.
- Further justification for selecting MCDM methods for the assessment of sustainable housing affordability was also provided. The ability of such methods to deal with numerous conflicting criteria - such as economic, social and environmental factors, of both quantitative and qualitative nature - in one evaluation process are principal reasons why such methods are applicable for this study.

Chapter 5

Methodology

5.1 Overview of literature review findings

An initial literature review of relevant publications, such as existing academic literature, government publication, reports and strategies was conducted. The principal aim of the literature review was to clarify and expand the author's knowledge of the housing affordability concept and to examine the way in which affordability has traditionally and is currently defined and assessed. This assisted in identifying any gaps within the research area.

Through reviewing the body of literature in chapter 2, it became apparent that the traditional way of defining and measuring housing affordability - the relationship between household's income and expenditure - may be too limited (ACF and VCOSS, 2008; CTOD and CNT, 2006; Fisher *et al.*, 2009; Gabriel *et al.*, 2005; Rowley and Ong, 2012). Furthermore, the literature highlighted the need for broader discussion and refinement of the criteria by which affordable housing is judged (Fisher *et al.*, 2009). However, recent research often continues to focus on economic criteria as the basis of housing affordability assessments (Gan and Hill, 2009; Jones *et al.*, 2011; Nepal *et al.*, 2010; Whitehead *et al.*, 2009). Accordingly, a lacuna in current research was identified. There is an increasing need to gain a more encompassing understanding of housing affordability and develop a more comprehensive housing affordability assessment method.

However, the literature review process could not provide all the data required to achieve the research aim and objectives, and therefore primary data also needed to be collected and analysed. In the following sections, the choice of methodologies for this research are justified and explained.

5.2 Research design

In general, research may be classified according to weather it is of a quantitative or qualitative nature. Within these two categories there are a number of different methods that can be employed to collect and analyse data. There has been widespread debate regarding the relative merits of quantitative and qualitative research approaches. Quantitative research consists of studies in which the data concerned are in numerical form and can be analysed using statistics (Punch, 1998). Thus, data are quantitative when any single observation is a number that represents an amount or count (Witte and Witte, 2009). Whereas qualitative research can describe and understand experiences and meanings (Denzin and Lincoln, 1998), without the use of numerical data. Therefore, data are qualitative when any single observation is, for example, a word, or a sentence, or a code representing a category (Witte and Witte, 2009). Qualitative data are generally more about attempting to understand something, in comparison to quantitative data which are commonly concerned with proving something.

Each approach has advantages and disadvantages. For example, a major advantage of quantitative research is that it is greatly numerical so results can be communicated and represented in the form of tables, graphs and charts. This subsequently reduces the possibility of biased data as the results produced are independent of the researcher. However, obtaining responses can be a problem with quantitative research. The sample needs to be large enough to allow for statistical analysis of the data. A further disadvantage of quantitative data collection is that it can be considered quite superficial as respondents only answer the specific question asked; they are generally not able to elaborate or go into depth on their opinions. Care must be taken with the design of quantitative data collection tools as there is only one chance to ask the questions and there is no opportunity to ask additional questions on a particular subject. Piloting the tool can help reduce this problem. In contrast, a principal advantage of qualitative research is that it allows the researcher to explore critical issues in considerable depth. Furthermore, the researcher may diverge into questions that were not previously anticipated prior to the data collection. However, a potential difficulty with qualitative approaches is that the researcher can become distracted from the main purpose of the discussion and large parts of the data collected may therefore be irrelevant. Furthermore, qualitative data analysis can have a higher opportunity to be biased as the researchers' own perceptions of the subject can influence the way the data is interpreted. In addition, qualitative data collection and analysis can be more time consuming than quantitative approaches if a large sample needs to be collected.

Quantitative and qualitative approaches are not mutually exclusive; both methods may be adopted within the same study. Bryman (1988) argued for a 'best of both worlds' approach and suggested that qualitative and quantitative approaches should be combined. Furthermore, Raftery *et al.* (1997) advocate that both qualitative and quantitative approaches are valid methodologies, neither approach is superior to the other. The most appropriate methodology will depend on the particular research problem.

This study adopted a sequential mixed methods approach using both quantitative and qualitative methods. Such an approach helps to expand findings of one method with another (Creswell, 2003). This study began with a qualitative method (semi-structured interviews) for exploratory purposes and followed up with a quantitative one (questionnaires) on a larger sample in order to expand and verify the findings (ibid). This was followed by the development and validation of a model for the assessment of sustainable housing affordability, using multiple criteria analysis methods. These methods are primarily numeric and quantitative in nature. However, some of the methods have the ability to consider both quantitative and qualitative criteria within the analysis, but expressed in numerical form.

5.2.1 Research paradigm

A research paradigm is a "cluster of beliefs and dictates which for scientists in a particular discipline influence what should be studied, how research should be done, [and] how results should be interpreted" (Bryman, 1988, p.4). It is simply the philosophical ideas that help guide research practice. This study was influenced by a pragmatist paradigm. Creswell (2003, p.12) indicates that "Pragmatism is not committed to any one system of philosophy and reality". The pragmatic paradigm considers the research problem as most important, rather than the method (ibid). With the research problem central there is no philosophical loyalty to any paradigm. Instead, data collection and analysis methods are matched to the specific purpose of the research. Accordingly, this applies to mixed methods research in that both quantitative and qualitative methods may be employed (ibid).

A main difference between quantitative and qualitative methods is the use of theory. Creswell (2003, p.140) states that "Mixed methods researchers use theory either deductively (as in quantitative research) or inductively (as in qualitative research)". An inductive approach formulates theory based on the collected information, thus it can be done without any existing theories. Whereas a deductive approach starts with existing theories and then formulates hypothesis that will be examined (Bryman, 1988). Qualitative research (in the form of semi-structured interviews) was used at the outset of this study in order to facilitate quantitative research (in the form of questionnaires). One could assert therefore that the initial qualitative element of this research took an inductive approach, through constructivism, to explore and build theory. The qualitative element of the methodology assisted in providing background information on the how the concept of housing affordability is perceived by professionals and aided in the initial construction of a criteria system representing housing affordability. The nature of the semi-structured interviews means that the participants' views were interpreted to develop subjective opinions, based on their experiences. Accordingly, this aspect of the research fits within a constructivist philosophical framework. The subsequent quantitative element of the research adopted a positivist theoretical perspective, deductive in approach, to test and verify theory. This allowed the validation and weighting of the criteria system with a larger sample and further statistical analysis of criteria importance.

5.2.2 Research stages

Figure 11 illustrates the overall research structure for this study, documenting the key methodological stages.

Stage 1: Determine sustainable housing affordability criteria through qualitative analysis and literature review

- Semi-structured interviews

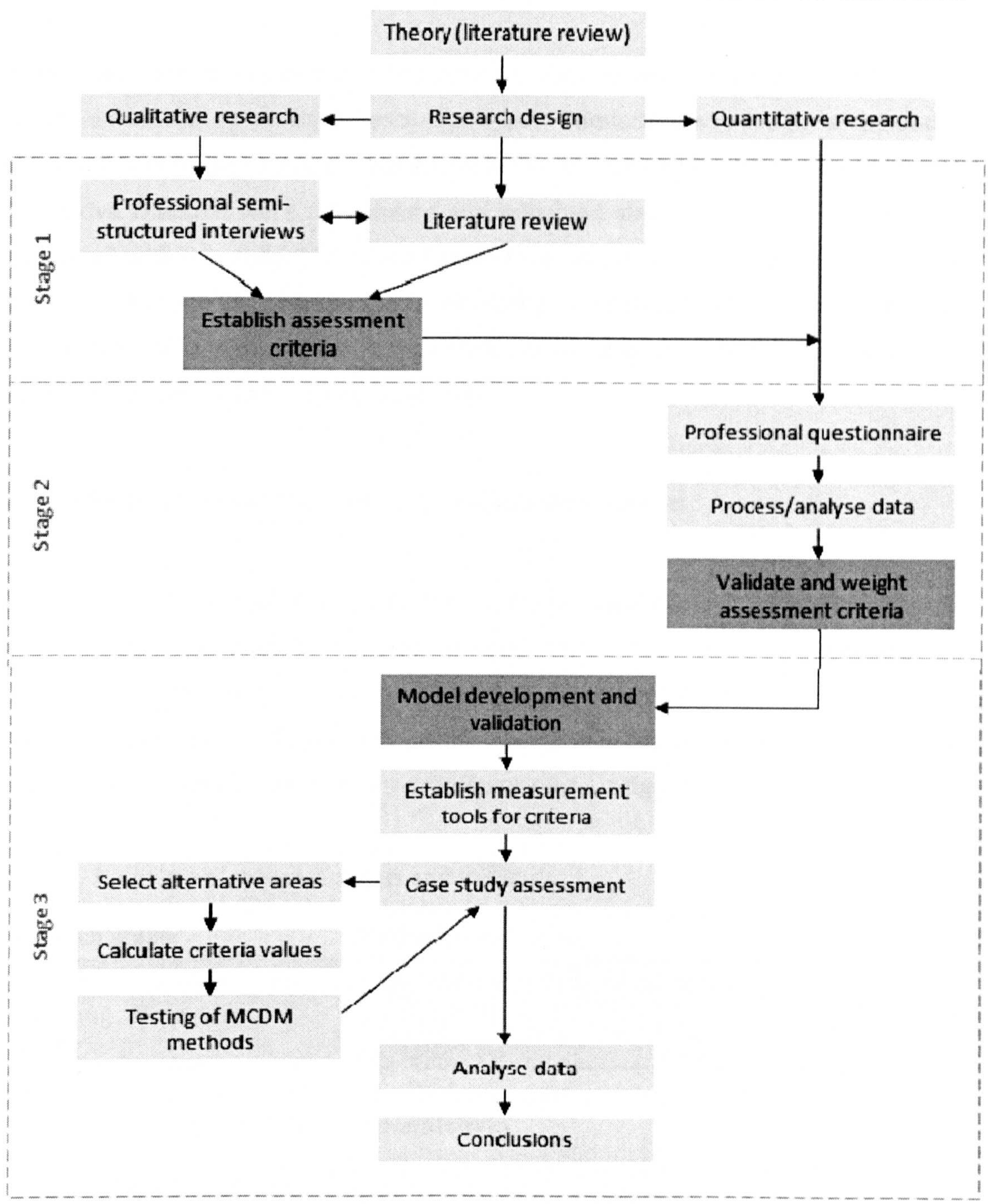
Stage 2: Validate criteria and establish criteria weights (significance) via quantitative analysis

- Pilot questionnaire survey with professionals
- Final questionnaire survey with professionals

Stage 3: Model development and validation

- Define measurement tools for the established assessment criteria
- Comparative analysis and selection of suitable MCDM method
- Case study assessment:
    - Select decision alternatives for comparison
    - Calculate criteria values for each alternative
    - Decision making using chosen multiple criteria analysis method

Figure 11. Research structure



Source: Self study

5.3 Ethical Considerations

It has been essential to consider the ethics of the research undertaken. Full ethical approval from the University's Research Support Committee was sought at the outset of the study in order to ensure that all participants involved in either quantitative or qualitative research were fully aware and informed about the processes and risks associated with the study. This was achieved by briefing each interview participant on the research scope and process and by obtaining a completed consent form from each participant. All questionnaire respondents were also provided with participant information before commencing the survey.

5.4 Methodology stage 1: qualitative analysis undertaken

This section provides more detail on the qualitative methodology adopted within the study during stage 1 of the research process which was aimed at, along with an extensive literature review, determining a set of criteria by which sustainable housing affordability can be assed (part of the third objective of the study). Table 5 provides a summarised version of the overall research structure in figure 10.

Table 5. Summary of research stages and methods

Research stage	Methods employed
1. Determine sustainable housing affordability criteria	Semi-structured interviews with professionals (qualitative) Literature review
2. Validate criteria and determine criteria weights	Questionnaire survey with professionals (quantitative)
3. Model development and validation	Define measurement tools for assessment criteria Test and select MCDM method Case study assessment

Source: Self study

It is essential to define a list of assessment criteria so as to facilitate the use of MCDM methods, not only in the case study assessment but also for potential commercial use. Keeney and Raffia (1976) suggest that a literature review and/or panel of experts should be used to identify decision criteria in the problem area to facilitate MCDM. Both of these approaches were adopted within the study to identify a set of housing affordability assessment criteria.

Interviews with housing and planning professionals were undertaken in order to gain an understanding of how housing affordability is currently conceived and assessed in practice, identifying what factors professionals think are important to housing affordability. This data provided a basis for the development of the sustainable housing affordability criteria system, which was further developed via literature review.

5.4.1 Interviews

Conducting interviews is a common means of gathering qualitative data. Qualitative interview data is typically collected via discussion in either a structured, semi structured or unstructured way (Carruthers, 1990; Rowley, 2012). Structured interviews can be similar to questionnaires in that the expected answers are generally fairly short and the questions are presented in the same order for every interview (Rowley, 2012). Conversely, unstructured interviews are far more flexible and open. The emphasis of unstructured interviews is largely on encouraging the respondent to talk around a theme and allowing the interviewer to modify their questions according to what the respondent says (Bryman, 2001). Semi-structured interviews are the most common form of interview (Rowley, 2012). Robson (2002) defines a semi-structured interview as having predetermined questions, of which the order can be modified, wording changed, questions omitted, or additional ones included based upon the interviewer's perception of what seems most appropriate during each interview. Thus, whilst the researcher can have a set of somewhat specific questions, they are only used as a guide to provide a basic structure to the interview. This allows for flexibility and means the interviewer can deviate into other questions that the researcher may not have had knowledge of prior to the interview. This study adopted a semi-structured interview approach owing to these reasons.

Face-to-face interviews were used in this study. However, one planned face-to-face interview could not be conducted and therefore a telephone interview was performed in its place. Rowley (2012) signifies that if there is difficulty in agreeing to a face-to-face interview then telephone, Skype, or e-mail interviews can be considered. An example of the questions asked during the interviews is provided in Appendix 1. However, as the process was semi-structured the ordering of the questions was not fixed and supplementary questions/topics were discussed in some of the interviews. A Dictaphone was used for recording purposes in order to maximise the accuracy and eligibility of the data collected in the face-to-face interviews. Using a Dictaphone also allowed the recordings to be transferred and saved directly onto a computer.

Silverman (2010) suggests that when transcribing interviews, the first few interviews should be transcribed in detail and analysed and then the researcher can decide which of the remaining interviews need detailed transcription. The process suggested by Silverman (2010) was followed and the first two interviews were transcribed in detail. This process was adopted because some of the interviews did run off topic. However, the interview process was still useful for obtaining an understanding of the way in which affordable housing is tackled within local authorities. Accordingly, the researcher did not stop the interviewees in their train of conversation as the information provided was interesting and aided the researcher in gaining detailed background knowledge to the subject. However, some of the material collected during a number of the interviews was not actually necessary in order to meet the objectives of the data collection. Accordingly, the remaining interviews were transcribed, but a small number of answers where the interviews went off topic where not included within the transcription. However, all Dictaphone recordings were saved.

5.4.2 Determining the sampling group

The interviews were conducted with housing and planning professionals working within local authorities. It was considered that the opinions of a sample of such public sector professionals would be most beneficial to the study at the initial exploratory stage of data collection owing to the experience that such professionals would have with implementing housing policies and their involvement with defining and assessing housing affordability in practice. Although stage 1 was limited to public sector professionals, stage 2 of the research further verifies the results using quantitative data gathered from both public and private sector professionals. The interviews were restricted to the North West area owing to time and budget constraints. Attempts were made to interview senior housing and planning professionals within each local authority. It was not possible to interview the most senior members of the housing and/or planning team in each authority, but all participants have a breadth of experience dealing with housing issues. Table 6 details the position/job role held by each interview participant and their relevant experience within the housing industry.

Six interviews with professionals were conducted in total. Five face-to-face semi-structured interviews were undertaken, taped using a Dictaphone and then transcribed. Examples of interview transcripts can be found in Appendix 4 and 5. One semi-structured telephone interview was also conducted. This interview was not taped using a Dictaphone, although it was fully transcribed during the conversation (the interview transcript can be found in Appendix 6).

Table 6. Details of interview participants

Local authority	Position of interviewee	Experience
Sefton Council (two interviewees)	Strategic Planning and Information Manager	20 years working in this capacity (under differing job titles). Lead responsibility for all policy matters relating to housing and affordable housing
	Principal Housing Strategy Manager	Over 30 years experience in various housing policy and management roles across the North West region
Warrington Borough Council	Housing Policy and Performance Manager	Position held for six years. 24 years prior experience as a planning policy officer with direct involvement in affordable housing provision
Cheshire West and Chester Council	Housing Strategy and Enabling Team Manager	Senior manager advising on housing strategy and enabling affordable housing delivery, with 20 years experience
Halton Council (two interviewees)	Senior Planner	Position held for eight years covering housing and planning matters. 13 years prior experience in local government
	Housing Strategy Officer	Position held for eight years. 25 years experience working in housing strategy
St. Helens Council	Housing Strategy Officer	Position held for nine years. 20 years experience working in housing
Knowsley Council	Strategy and Commissioning Group Manager	Lead role in developing strategy and policies, including affordable housing. Over 20 years experience

5.5 Methodology stage 2: quantitative analysis undertaken

This section elaborates on the quantitative methodology adopted within the study during stage 2 of the research process (table 7) which was aimed at validating the sustainable housing affordability criteria system and determining criteria weights (part of the fourth objective of the study). The criteria identified in stage 1 of the methodology differ according to their relative importance to sustainable housing affordability; weighting was thus required in order to reflect the significance/importance of the criteria, a prerequisite for MCDM assessments.

Table 7. Summary of research stages and methods

Research stage	Methods employed
1. Determine sustainable housing affordability criteria	Semi-structured interviews with professionals (qualitative) Literature review
2. Validate criteria and determine criteria weights	Questionnaire survey with professionals (quantitative)
3. Model development and validation	Define measurement tools for assessment criteria Test and select MCDM method Case study assessment

Source: Self study

5.6 Survey research

Surveys are the most common method for obtaining quantitative data. The fundamental steps required to design and administer a questionnaire survey generally include:

1. Defining the objectives
2. Determining the sampling group
3. Designing a data collection strategy
4. Developing a questionnaire survey
5. Administering the questionnaire and collecting the data
6. Analysing and interpreting the results

5.6.1 Defining the objectives

Stage 2 of the primary research intended to address part of the fourth objective of the study which was to validate the housing affordability criteria system and determine criteria significance (weights) for use within the multiple criteria analysis. Thus a questionnaire survey was devised in order to gather this quantitative data.

5.6.2 Determining the sampling group

Surveys generally function by surveying a sample of the desired population. The survey for this study was targeted towards housing and planning professionals within the UK. It was not possible to predict a total general population of such professionals. However, to ensure the sample was representative of the desired population it was deemed important to distribute the survey to professionals within all regions of the UK. It was concluded that the best way to distribute the survey to professionals in each region was to approach housing and planning departments in all local authorities located within the UK. In addition to local authorities, the survey was distributed primarily to professionals working within housing associations, housing developers, urban regeneration and housing consultancy across the UK. The response rate for the survey is provided in the research findings in 7.2.

5.6.3 Data collection strategy

There are a variety of means by which surveys can be undertaken, e.g. by telephone, mail, in person or online/via email. Whilst considering the most appropriate survey approach for the data collection a number of constraints were identified:

- Time - consideration had to be given to the time it would take to administer the survey.
- Geographical spread - the survey required national exposure across all regions of the UK.
- Budget - conducting surveys over a broad geographical area can have high costs associated to it.

It was determined that the most cost-effective and time-effective survey method to use was an online approach. Bristol Online Surveys (BOS) was utilised to administer the final questionnaire. BOS allows the user to develop, administer, and collect survey responses via a web-based software package. A hyperlink is created directing the survey to a central database, which is subsequently disseminated by email to the potential survey participants. Once the survey is completed online by the participant the data is sent automatically to a central database. Survey responses can be exported into a statistical analysis package which makes BOS an efficient method for gathering data. SPSS (Statistical Package for the Social Sciences) was utilised for this research study as it is the most widely used and comprehensive package available for survey research.

5.6.4 Developing the survey

Quantitative research involves the collection of numeric data that are used to assess or measure subjects in relation to particular variables. There are a number of different levels of measurement that may be used for this purpose. Data may be, for example, nominal, ordinal, interval or ratio (Sheskin, 2007).

Nominal data are organised according to categories or characteristics and differences between such classes are not measureable. An example of nominal data could be categorising participants according to gender. Ordinal data is the next level higher of data classification than nominal data. It is numerical data where a number is assigned to represent a qualitative description, similar to nominal data. However, these numbers can be arranged to represent best to worst or vice versa. Ordinal data are data that can be placed on a scale that has an order to it but the distance between consecutive responses is not necessarily the same. We know about order but we have no information about the size of the interval between points (ibid), thus lacking magnitude. Scales that go from "most important" to "least important" or a Likert-type scale are examples of ordinal data. Interval data are essentially ordinal, but they have an extra property - the intervals between each value are equally split over the scale so the distances between the numbers are comparable, unlike with ordinal data. With interval scales there is no absolute/true zero point, although there may be an arbitrary zero point with further numbers placed at equal intervals (ibid). Contrastingly, ratio variables do have a true zero point, e.g. height.

- **Pilot study**

A pilot questionnaire was conducted acting as a preliminary to the actual study. This was a smaller version, in terms of sample size, of the final questionnaire and provided a trial run before the actual study was embarked upon. Most importantly, this allowed the sustainable housing affordability criteria (identified in stage 1 of the methodology) to gain initial validation and determine whether any criteria should be added or removed from the criteria system. Furthermore, the pilot study assisted in:

- testing the adequacy and logistics of the survey design, helping to identify and problems which could be rectified before conducting the actual study with a larger sample;
- providing experience of administering the survey and collecting the data;
- determining if the survey was collecting the right type of data and whether it was usable;
- providing opportunity for data analysis.

The pilot survey proposed an ordinal scale of measurement to determine the level of importance/significance of the sustainable housing affordability criteria. Each criterion was rated using a 10-point scale which ranged from 1 = "not important at all" to 10 = "most important" to sustainable housing affordability. Respondents also had the opportunity to suggest if any additional criteria should be included within the system. A copy of the pilot questionnaire is available in Appendix 2.

The results of the pilot study were sufficiently informative to provide initial validation of the criteria system, i.e. determining if any criteria ought to be added or rejected. Furthermore, descriptive statistics (measures of central tendency) were used to determine the average rating of criteria importance. This subsequently allowed initial criteria weights to be calculated which could be compared to the data collected from the actual study. The pilot study also allowed any problems with the questions to be identified so that changes could be made before the actual study was embarked upon with a larger sample.

Following the pilot study some minor revisions were made to the survey. Principally, background questions were added to the survey to create filters in order to allow for comparisons between different groups opinions on criteria importance. It was not necessary to remove any criteria from the criteria system following the pilot study. However, three criteria - established in the course of further literature review and finding from the pilot study - were added to the criteria system before the actual survey was distributed (see 7.2.1 and 7.4 for further details).

- **Actual study**

Succeeding the pilot study and some minor revisions to the survey, the actual study was embarked upon. The survey proposed a mixture of nominal and ordinal questions (see Appendix 3 for a copy of the final questionnaire survey). Initially the survey asked some fundamental/background questions on:

- *Gender*
- *Age*
- *Area/type of employment* - this filter question was used to be able to determine the employment sector each respondent worked in.
- *Region of employment* - because of the broad scope of the target population, this filter question was used to be able to determine the region of the UK each respondent was based in.

This type of information is known as nominal data and is useful for establishing facts and filters within the data. Subsequently, the survey used an ordinal scale of measurement to determine the level of importance/significance of each of the housing affordability assessment criteria. Each criterion was rated using a 10-point scale which ranged from 1 = "not important at all" to 10 = "most important" to housing affordability.

5.6.5 Administering the questionnaire and collecting data

As BOS software was used to create and administer the survey, it meant that all responses were sent to a central BOS database. Once all data was collected, it was therefore necessary to export the data into SPSS, a package with more advanced capabilities for statistical analysis. Survey responses had to be coded accordingly in order for the data to be inputted to SPSS, for example, 1 = "female" and 2 = "male". One of the benefits of using BOS software is the data coding process is done automatically. Additionally, to ensure that the data was managed robustly it was fully backed up. A copy of the data was stored on both the researchers' personal hard drive computer and a pen drive.

5.6.6 Analysing the data

SPSS was used to analyse the quantitative data. In order to choose the appropriate statistical test, the first question to answer is: *What are you looking for?* Primarily, the survey sought to determine the level of significance (the weight) of the sustainable housing affordability criteria. Descriptive statistics were appropriate for this purpose, for example, looking at measures of central tendency and measures of spread.

5.6.6.1 Central tendency tests

Measures of central tendency - mean, median and mode - are used to identify a value that best represents an entire group. The mean is calculated by adding all values in a given variable together and then dividing that sum by the amount of people who responded to that variable. The median is established by identifying the midpoint in a set of scores. Finally, the mode is calculated by determining the most frequent score in data set. Mode values are usually more beneficial when data are not numerical in nature. And in general, median values are used when extreme scores are present in the data and the mean could thus be significantly affected and distorted by such extreme sores. For the purposes of this study a mean calculation is best suited as the values are primarily numerical and are rated on a scale between 1-10.

Measures of spread/variability also need to be referred to in order to test the strength of central tendency tests. The standard deviation can be calculated for this purpose. The standard deviation shows the level of variability in a set of scores. The mean becomes more representative the lower the standard deviation is. A high standard deviation indicates that there is a lot of difference between scores and accordingly a different measure of central tendency may be more suitable.

5.6.6.2 Exploring differences between groups

Furthermore, the subsequent aim of the data analysis was to establish if differences exist between groups' opinion regarding the importance of the sustainable housing affordability criteria. The following research questions were established:

- Does opinion on criteria importance differ depending on the region of the UK in which the expert is based in?
- Does opinion on criteria importance differ depending on the expert's type of employment (e.g. planner/developer)?
- Does opinion on criteria importance differ depending on the expert's age?
- Does opinion on criteria importance differ depending on the expert's gender?

In order to facilitate the choice of a statistical test to analyse the data it is necessary to consider a number of factors. In order to test if there are statistically significant differences between groups, it is essential to first establish if the data follows a normal (Gaussian) distribution. Normal distribution is represented by a symmetrical, bell-shaped curve, which has the greatest frequency of scores in the middle and smaller frequencies towards the extremes (Pallant, 2005). If the data follows a normal distribution pattern then parametric tests are appropriate for statistical analysis. However, if the data is not normally distributed then less powerful non-parametric tests, or distribution-free methods, ought to be adopted in order to maintain the validity and accuracy of the data. Furthermore, it is important to classify variables according to their level or scale of measurement. There are certain statistical analyses which are only meaningful for data which are measured at certain measurement scales (i.e. nominal, ordinal, interval or ratio). As well as these factors, the appropriate method for statistical analysis depends on another criterion - the number of groups (two versus more than two) involved in the comparison. Table 8 provides a summary of the appropriate statistical methods to employ depending on data type, distribution and number of groups under consideration.

Table 8. Appropriate methods for statistical analysis of differences between groups

It is important to note that in the context of statistical analysis, significance is referred to when testing whether a difference or relationship between values that exists is due to some systematic influence or has merely occurred by chance. 'Statistical significance' means that a finding has not occurred by chance. After finding a statistically significant relationship, it is important to evaluate its strength. Popular levels of significance (or alpha level) are 5% ($p<0.05$), 1% ($p<0.01$), 0.5% ($p<0.005$), and 0.1% ($p<0.001$), where p means probability. For example, a significance level of $p<0.05$ means that there is only 5 chances out of 100 that the relationship has occurred by chance, i.e. 95% confidence that the finding it is not due to chance. Thus, when conducting tests for statistical significance we must generally have a significance level between 0.00-0.05 to assume that the data being tested is statistically significant.

Test of normality

The Kolmogorov-Smirnov test was used to check the normality of the distribution of scores. The test compares the scores in a given sample to a theoretically normally distributed set of scores with the same mean and standard deviation (Field, 2009). If the test result is non-significant (Sig value >0.05) this indicates normal distribution. If the test result is significant (Sig value <0.05) then the distribution of the sample is significantly different from a normal distribution (violation of the assumption of normality) (Pallant, 2005); in such cases non-parametric tests must be used for analysis.

The Kolmogorov-Smirnov test was conducted on the survey data and each variable produced a significance value of $p<0.05$, meaning that further statistical analysis to understand differences between variables must be non-parametric. Figure 12 gives an example of this test using SPSS.

Figure 12. Example of Kolmogorov-Smirnov test in SPSS

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
C1	.216	337	.000	.778	337	.000
C2	.204	337	.000	.826	337	.000
C3	.170	337	.000	.905	337	.000
C4	.148	337	.000	.905	337	.000
C5	.144	337	.000	.944	337	.000
C6	.123	337	.000	.960	337	.000
C7	.106	337	.000	.967	337	.000
C8	.139	337	.000	.935	337	.000
C9	.147	337	.000	.957	337	.000
C10	.137	337	.000	.948	337	.000
C11	.132	337	.000	.963	337	.000
C12	.143	337	.000	.956	337	.000
C13	.117	337	.000	.964	337	.000
C14	.128	337	.000	.971	337	.000
C15	.127	337	.000	.965	337	.000
C16	.125	337	.000	.961	337	.000
C17	.172	337	.000	.907	337	.000
C18	.191	337	.000	.914	337	.000
C19	.110	337	.000	.963	337	.000
C20	.126	337	.000	.957	337	.000

a. Lilliefors Significance Correction

This figure shows that the significance level for the variables is $p<0.05$, meaning that they are significantly different from a normal distribution

Source: Self study

In summary, the data in this study are not interval, nor does the data satisfy the test of normal distribution. Accordingly, the data fails to meet the requirements for parametric tests and therefore non-parametric tests were deemed appropriate for the statistical analysis. Table 9 highlights the type of data used in this study and the statistical tests which were deemed suitable to analyse the data.

Table 9. Summary of data analysis required for research

Data type	Parametric vs non-parametric	No of groups	Appropriate test
• Ordinal scale of measurement • Data is not normally distributed • Independent groups	Non–parametric test required	Comparing differences between 2 groups	Mann Whitney U test
		Comparing differences between 3+ groups	Kruskal-Wallis H test

Source: Self study

5.6.6.3 Mann-Whitney U Test

The Mann-Whitney U test is used to compare differences between two independent groups when the dependent variable is either ordinal or interval, but not normally distributed. Instead of comparing the means of two groups, the score on the continuous variable are converted to ranks, across the two groups (Pallant, 2005). Accordingly, the Mann-Whitney U test is the most appropriate non-parametric test for identifying differences between two independent groups for this study.

While it is commonly recognised that non-parametric tests are not as powerful as their parametric equivalents, the Mann-Whitney test it is still the most valid method to use in order to accurately test the data in this study.

5.6.6.4 Kruskal-Wallis Test

The Kruskal-Wallis test is the non-parametric equivalent to the one-way ANOVA (analysis of variance) and an extension of the Mann-Whitney U Test to allow the comparison of more than two independent groups, so for three or more groups (Pallant, 2005). The test makes no assumptions that data are normally distributed. The Kruskal–Wallis test is thus the most appropriate non-parametric test for identifying differences between three or more groups for this study. However, a significant Kruskal-Wallis test result merely tells you that the groups differ in some way; the results do not identify which of the groups differ significantly from each other. If the Kruskal-Wallis test is significant then one wants to know which of the groups differ. Follow-up (post hoc) tests are therefore required on significant results. The Mann-Whitney U test can be used to evaluate pairwise differences among the significant groups. However, 'Type I error' must be controlled for if conducting multiple comparisons. A Type I error means that you find more significant differences than there actually are; differences that could have actually occurred by chance (Pallant, 2005). The Bonferroni approach can be used to overcome Type 1 error when making multiple comparisons. The Bonferroni adjustment sets a more rigorous alpha level, used to judge statistical significance, for each comparison by dividing the alpha level (usually 0.05) by the number of comparisons that need to be made, the result of which is the new alpha level (Pallant, 2005). The formula $k(k-1)/2$ tells you the number of comparisons that need to be made, where k is the number of groups involved.

5.6.6.5 Reliability/internal consistency

Cronbach's alpha coefficient was used to determine the internal consistency of the scale that was used in the survey to rate the importance of the sustainable housing affordability criteria (from 1 = "not important at all" to 10 = "most important"). Cronbach's alpha coefficient values range from 0 to 1, with a higher score indicating greater reliability of the scale. A reliable score should preferably be above 0.7 (Pallant, 2005). Cronbach's alpha coefficient was calculated as 0.93 for the 10-point scale that was used within the study (figure 13). This value is well above 0.7 and shows good internal consistency, therefore, the scale used to rate criteria importance can be considered reliable with the sample in this study.

Figure 13. Reliability statistic in SPSS

Reliability Statistics

Cronbach's Alpha	N of Items
.933	20

A figure above 0.7 indicates good internal consistency

Source: self study

5.7 Methodology stage 3

This section provides more detail on the steps undertaken during stage 3 of the research process which aimed to address the fifth and sixth objective of the study. Table 10 provides a summarised version of the overall research structure shown in figure 11, highlighting stage 3 of the research process.

Table 10. Summary of research stages and methods

Research stage	Methods employed
1. Determine sustainable housing affordability criteria	Semi-structured interviews with professionals (qualitative) Literature review
2. Validate criteria and determine criteria weights	Questionnaire survey with professionals (quantitative)
3. Model development and validation	Define measurement tools for assessment criteria Test and select MCDM method Case study assessment

Source: Self study

5.8 Defining measurement tools for the assessment criteria

The criteria identified in stage 1 of the research methodology must be capable of being measured, either quantitatively or qualitatively. It is essential to define measurement tools for each assessment criterion so as to facilitate the use MCDM methods, not only in the case study assessment but also for potential commercial use. Suitable measurement tools were already in place for certain criteria, but where this was not the case measurement scales had to be developed.

5.9 Comparative analysis of MCDM methods

The goal of decision making is the selection of the best alternative, from a number of given alternatives, and/or the prioritisation of alternatives in respect of one another. To achieve this goal there are a number of available methods. The characteristics of several different MCDM methods have been discussed in chapter 3. However, there is no single method that is considered the most suitable for all types of decision making situation (Guitouni and Martel, 1998). Accordingly, in order to test the performance of potentially suitable methods, a comparative analysis of six MCDM approaches - WSM, WPM, revised AHP, TOPSIS, COPRAS and modified COPRAS - was undertaken. The comparative analysis of these different methods aided in selecting the most appropriate methodology for the complex sustainable housing affordability assessment model.

5.10 Case study assessment

A case study is used in this research as it provides a practical example of how the MCDM model works to assess sustainable housing affordability. Furthermore, the case study can confirm the effectiveness of the assessment model for potential commercial use. This section highlights the data that was required in order to carry out a case study assessment of sustainable housing affordability.

5.10.1 Select alternative areas for comparison

In this study the 'alternatives' represent the different areas that are being compared and assessed to determine their sustainable housing affordability. To provide a practical example of the assessment model, a number of different areas (wards) within Liverpool, UK were selected for a case study comparison. A ward is simply a subdivision of a municipality; they are often the electoral districts for local authorities. 10 areas (wards) were randomly selected, from the 30 wards that comprise Liverpool, to be used within the case study assessment (see 8.3.3 for further details).

- **Justification of the case study area**

Liverpool was chosen as the case study area for the empirical case study. The presented MCDM methodology could have potentially been applied in any region within the UK. However, Liverpool in particular was chosen for the case study assessment in this study as the researcher is based within the city. This enabled a simplified and less time consuming research process, allowing the researcher to gain access to a wider range of data. Colleagues at the university where the research is based were also able to provide useful contacts for the Liverpool area. Furthermore, Liverpool has a diverse housing market with areas of both rapidly rising house prices and areas experiencing housing market failure, such as low demand and abandonment. It was thought that this would allow for an interesting analysis of the criteria system and the assessment model.

- **Background to Liverpool's housing market**

Merseyside was cited as the most decentralised city in England in relation to its population, with Liverpool in particular experiencing a total population loss of four percent between the 1930s and 2000 (ECOTEC, 2005). During the period 1981 to 1996, 83,000 jobs were lost in Merseyside (Nevin *et al.*, 2001). This subsequently deterred inward migration from new residents. The severe decline in population contributed to housing market failure and a general oversupply of housing. Low housing demand and abandonment has been a feature within Merseyside since the late 1970s (ECOTEC, 2005). Liverpool displays the familiar characteristics of multiple deprivation, such as poor environments, low educational achievement, high crime levels and anti-social behaviour (Cole and Nevin, 2004). Furthermore, Liverpool's housing stock is significantly unbalanced; over 80 percent of homes are in Council Tax bands A and B, resulting in substantial over supply at the bottom end of the market and real shortages of better quality homes in Council Tax bands C, D, E and above (LCC, 2005). However, Liverpool also has thriving housing markets. The City therefore has a polarised housing market with both rapidly rising house prices and some of the lowest property prices in the UK (LCC, 2005; LCC, 2009).

5.10.2 Calculate criteria values for each alternative

The identified measurement tools were used in order to calculate criteria values for each alternative area under consideration. These values formed the basis of the MCDM process, which were then processed using the selected decision making method (following the comparative analysis).

5.10.3 Carry out MCDM assessment using chosen method

Table 11 summarises the data collection process required for the use of MCDM methods and documents the stages of the research in which each step was achieved.

Table 11. Research stages in which data required for MCDM was collected

MCDM process	Research stage
Establish sustainable housing affordability assessment criteria	Stage 1
Determine criteria weights	Stage 2
Select decision alternatives for comparison	Stage 3
Calculate criteria values for each alternative	Stage 3
Create a decision making matrix with the aforementioned data	Stage 3
Problem solving using chosen MCDM method	Stage 3

Source: Self study

5.11 Model development

Overall, stage 1, 2 and 3 of the research methodology contribute to the creation of the complex model for the assessment of sustainable housing affordability.

5.12 Chapter summary

- This chapter has elaborated on the methodology used within this research, along with the philosophical paradigm underpinning the study.
- A mixed methods approach was taken, where qualitative and quantitative data were collected in sequential phases. Qualitative research was used at the outset of the study in order to facilitate quantitative research.
- The overall research structure of the mixed methods approach was illustrated, documenting and explaining the three key stages undertaken within the research process.

Chapter 6

Data analysis stage 1: Interview and literature review results

6.1 Introduction

The literature studied highlights the complex nature of the housing affordability concept and the wide range of factors that may influence households. The study is based on the notion that the housing affordability problem encompasses more than the financial costs of housing and must address larger issues such as social and environmental sustainability and the wellbeing of households. Therefore, the need arises for a broad and more encompassing set of criteria by which housing affordability can be assessed.

This chapter discusses the results of the data collection for stage 1 of the research methodology that sought to identify a comprehensive list of assessment criteria, for the sustainable housing affordability assessment model, via both interviews and literature review. The criteria identified by each process and an overall summary of the criteria are provided within this chapter.

6.2 Interview (qualitative data) analysis

The interviews carried out with housing and planning professionals assisted in providing an initial background to the study by allowing the researcher to get a feel for the way in which affordable housing and housing affordability are currently defined and assessed in practice. Further details of the interview process are provided in 5.4.1. The principal questions asked during the interviews were as follows:

- Do you have an affordable housing policy in place?

- How do you define affordable housing?
- How do you define housing affordability?
- Do you think that it is important for affordable housing to be of a high quality?
- Do you think that it is important for affordable housing to be sustainable?

The subsequent purpose of the interview process was to identify the main factors that were mentioned as important to housing affordability in order to create a foundation for the set of housing affordability assessment criteria. Table 12 provides an overall summary of the interview findings. It was clear from the local authority interviewees that, in practice, affordability is commonly conceived and assessed in line with government definitions and guidance on affordable housing (set out in PPS3). That is to say, "Affordable housing includes social rented and intermediate housing, provided to specified eligible households whose needs are not met by the market" (CLG, 2011a, p25). The price of which is "determined with regard to local incomes and local house prices" (ibid). Although, specific levels of 'affordability' for local areas were less apparent. One participant suggested that housing should not cost more than *"25% of gross household income"*. Other interviewees cited government guidance as their go to source, which provides an indication that home ownership is considered affordable if it costs 3.5 times gross household income, while market rented housing should not constitute more than 25 percent of gross income (CLG, 2007b). The local authority interviewees that did seek to measure affordability generally adopted the house price-to-income ratio method. Although, two of the local authorities did not actually seek to specifically define or assess affordability. Yet there was an explicit consensus among all participants interviewed that housing costs in relation to income were the principal factors determining housing affordability. When probed further on additional factors that are important to affordable housing, it was confirmed by a number of local authority interviewees that housing quality and the sustainability of housing and community were also essential. Significantly, one participant highlighted that *"It's not just about housing. Housing really cannot be seen separately from all of these other things"*. The next section goes into further detail on the specific criteria identified.

Table 12. Summary of interview findings

Local Authority	Is an affordable housing policy in place?	Definition of affordable housing adopted	Definition of housing affordability adopted	Main factors mentioned important to affordability
Sefton	Yes - affordable housing sought on development sites with a general requirement of 30% affordable housing (80/20 split between social rented and intermediate housing), but subject to economic viability.	Defined in terms of the type of social housing that is required (defined as 80% social rented and 20% intermediate housing).	On the basis of income and following government practice guidance.	• Housing costs in relation to incomes • High standard housing • Sustainable housing • Mixed communities • Access to mortgages
St. Helens	Yes - attempt to seek 30% affordable housing on development sites, but not a blanket approach. Usually require equal split between social rent and shared ownership.	Use government guidelines set out in PPS3.	No specific definition.	• Incomes • Open market value of housing • Access to mortgages • Sustainability of site • Good quality housing • Affordable to run the property (e.g. energy efficient) • Range of models of affordable housing
Cheshire West and Chester	Yes - require an element of affordable housing on the back of market development. Percentage requirement differs within borough, but roughly 25-30%.	Start with government guidelines in PPS3.	Benchmark rents for social rented or any other accepted method of affordable housing. Also look at average income levels and multipliers; mainly by price and income.	• Average incomes • House price/rents • Mortgage

Knowsley	Being developed - at time of interview only non-planning policies in place that acknowledge affordable housing.	Use government definition set out in PPS3.	Whether house prices (for rent or ownership) are affordable and sustainable in relation to incomes. Currently monitor affordability by house price to income ratio.	• Incomes • House price/rents • Decent homes quality and stock age • Sustainable design • Location to industry and employment • Good communication links • Ability to access good public transport
Halton	No - specific policy not in place at time of interview.	Housing provided with subsidy, which is available below market rates.	No adopted definition. Anything that is below market values is considered affordable.	• Income • Interest rates/mortgage finance • Access to key services • Sustainable communities
Warrington	Yes – through a Unitary Development Plan (affordable housing is negotiated with private developers on the basis of it).	Use government definition set out in PPS3.	Use government guidelines. Housing should not cost more than 25% of gross household income.	• Housing costs in relation to income

Source: Self study

6.2.1 Criteria derived from interviews

The interviews revealed that the overwhelming majority of local authority participants considered housing costs (rent or house price) in relation to income to be the principal determinant of housing affordability. These were also the principal criteria that the local authorities used to assess affordability, except where affordability was not actively defined or assessed (see table 12).

A summary of the responses to the question: *'How do you define housing affordability?'* - with emerging criteria important to affordability highlighted in bold - are as follows:

> **Housing costs in relation to incomes.** It's on the CLG practice guidance and it doesn't go beyond that really...We define it on the basis of **income.** I mean that is the critical thing and that is the basis of assessment (Sefton Council).
>
> We would start to look at **average income** levels and applying **income multipliers.** So it is mainly **price** and **income**...The difficulty we have as a local authority with applying anything more sophisticated mechanisms of defining affordability is that we have very limited access to income information...In the past there used to be slightly more sophisticated models that looked at the **total cost of housing**, so not only how much you are paying in terms of **rent or mortgage** but also the **running costs** of the house...Again, because of the lack of info around on meaningful income it is very difficult to apply those (Cheshire West and Chester Council).
>
> Whether **house prices**, be it for **ownership** or **rental**, are affordable and **sustainable** in relation to **incomes**...We currently monitor affordability by a **house price to earnings ratio** (Knowsley Council).
>
> We rely on the government on this. We have always had this problem, how do you decide what is affordable? Government guidelines say if something costs more than 25% of your **gross income** it is not affordable. So we take it the opposite way and say it should not cost any more that 25% of **gross household income**...Just basically keep it purely and simply a relationship between the **cost of the property** and the **income** of the people that you are targeting. We don't want to get too sophisticated (Warrington Council).

> In talking to the private sector they would be quite keen for us not to have blanket approaches to affordable housing and definitions of affordability (Cheshire West and Chester Council).

Surprisingly, two of the local authorities did not actively seek to define or assess housing affordability, but they still discussed housing costs and income:

> I am not sure we have got a specific definition really. I don't think we do as such. The housing needs study may well go into **incomes** and those sorts of things and probably gives an indication of disposable **income** and will probably then give an indication of how much people can raise on a **mortgage**...So I would say we don't have a defined definition of affordability (St Helens Council).

> I don't think we have a measure of housing affordability...We don't have an adopted definition. Anything that is **below market values** would be considered affordable (Halton Council).

The interview participants were rather stringent with their ideas on affordability. They did not initially diverge from economic criteria, specifically housing costs and incomes, when discussing what 'housing affordability' meant. Accordingly, housing costs (rent or house price) in relation to income were principal criteria to be considered for the housing affordability assessment criteria system. It was also apparent that obtaining and maintaining a mortgage is a principal barrier for many wishing to get a foot on the property ladder, especially in the current economic climate. Thus, mortgage availability and interest rates were also important criteria to take into consideration:

> At the moment we have got historically low **interest rates**, so if you can get a **mortgage** then you are paying very low **interest**. But how long that remains is possibly quite questionable...if **interest rates** go up by a couple of percent then your monthly bills to service that **mortgage** will go through the roof. So what's affordable in that regard today could be quite different in a couple of years time (Halton Council).

> ...intermediate housing has problems because people can't get **mortgages** really (Sefton Council).

Interviewees were asked for their opinion on other factors, such as housing quality and sustainability, to determine if they thought such factors were also important to consider with regard to housing affordability. A number of interviewees suggested that affordable housing must be high quality and meet certain sustainability standards. In addition, making sure that housing is located within sustainable communities with good access to key services, principally public transport, schools and employment, were highlighted as important to consider for affordable housing by a number of the interview participants. Some examples of answers to the question: *'Do you think that it is important for affordable housing to be of a high quality'* and *'Do you think that it is important for affordable housing to be sustainable?'* were as follows:

> We would expect the affordable housing to be built to at least as **high** a **standard** as the private sector housing (Sefton Council).

> Important factors to consider are **decent homes quality** and the **stock age**, **sustainable design**, **location** to **industry** and **employment**, **good communication links** with the ability to **access good public transport** (Knowsley Council).

> The affordable housing shouldn't sit at the back corner basically and look of a lesser quality or be of a lesser quality...It is quite important that what we are building is of a **good quality** and also affordable in terms of **running the property**. So obviously we are quite interested in if it's **carbon neutral** if it can keep the costs down for the client (St Helens Council).

> In terms of planning guidance we insist that affordable housing is **pepper potted** within schemes because that is part of being **sustainable**; **mixed** and **indistinguishable** from the private housing...A lot of the focus of the effort is to **make communities more sustainable** and make them areas where people want to live and want to stay and to have **jobs** and **transport**; the whole thing coming together. It's not just about housing. Housing really cannot be seen separately from all of these other things (Sefton Council).

> As planning applications or pre-applications come through to the authority the **sustainability of the site** is quite key. Obviously there is not a great deal of point in putting affordable housing on a site where there is no

> **employment** or no **bus routes**, no local **schools**; how would people get to the services they need? (St Helens Council).

> In this time of recession and decline, large swathes of the population are unable to **maintain** their properties up to the **decent homes standard** resulting in detrimental health conditions, possible repossession, child poverty and deprivation (Knowsley Council).

> There is no point developing if it is not **sustainable** because you are going to end up with a problem in 15 to 20 years time because you can't allocate the housing as nobody wants to live there because there is nothing nearby, no **services**...It is vital to have **access to key services** (Halton Council).

Table 13 indicates the principal factors (emerging as important to affordable housing) that were mentioned during the interviews and indicates in how many of the interviews, out of a total of six, such factors were discussed.

Table 13. Principal factors discussed within interviews

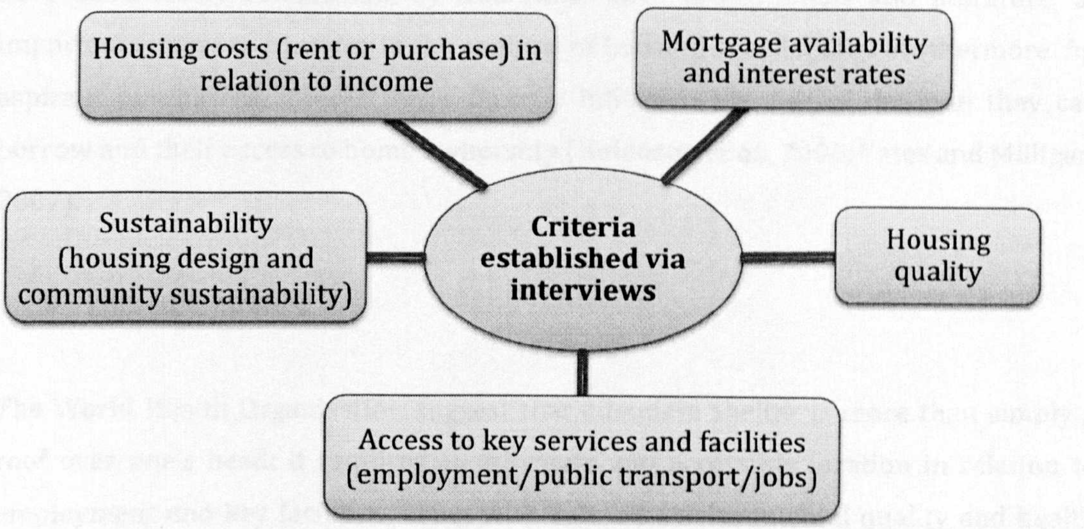
Principal factors emerging in interview	No of interviews mentioned
House prices/housing costs	6
Income	6
Mortgages	4
Interest rates	1
Range of housing tenures/mixed communities	2
Sustainable/sustainability	4
Quality/decent housing	3
Services/facilities	2
Transport	3
Employment/jobs	3
Schools	1

Source: Self study

6.2.2 Summary of criteria identified via interviews

The principal criteria considered important to housing affordability, derived from the six semi-structured interviews with local authority participants, are summarised in figure 14.

Figure 14. Housing affordability criteria emerging from interviews with professionals



Source: Self study

6.3 Criteria derived from literature review

To look more broadly at the affordability concept and draw closer links with sustainability concerns a literature review was conducted alongside the interviews. This assisted in identifying a wider range of criteria that are important to consider in the broader notion and assessment of housing affordability. This section provides an overview of the factors identified during the literature process which are considered important to sustainable housing affordability, a breakdown of which is provided in table 14.

- **Economic factors**

Income directly impacts on a household's ability to purchase and make housing payments, while the price of housing and rents represent the level of payment that is required to secure the housing (Robinson *et al.*, 2006). Housing affordability is most commonly expressed by the relationship between housing expenditure (rent or mortgage) and household income (CLG 2007b; Whitehead *et al.*, 2009). These factors have been firmly established, by interviews with professionals and literature, as important factors to consider in the analysis of housing affordability. Furthermore, for aspirant purchasers, interest rates directly influence the size of the loan they can borrow and their access to home ownership (Robinson *et al.*, 2006; Yates and Milligan, 2007).

- **Location factors**

The World Health Organisation suggest that adequate shelter is more than simply a roof over one's head; it requires an adequate and accessible location in relation to employment and key facilities, along with suitable environmental quality and health related factors (WHO, 2004). The location of housing, and its subsequent quality and access to key services and facilities, can have a significant impact on household wellbeing. The ODPM (2005a) suggest that the most important factors in making an area a good place to live are things such as crime, health, housing, employment, and transport. As well as housing, jobs, shops and services, transport and green spaces are important factors for creating thriving communities (ODPM, 2005b). Research undertaken on behalf of the Commission for Architecture and the Built Environment (CABE) questioned home buyers' attitudes to new housing and found that, "For potential buyers, the first concern in choosing a new home is the quality of an area, notably in terms of access to facilities and services, a sense of community, and safety and security" (Samuels, 2005, p.6). The research confirms that, for home buyers, the presence of shops, schools and local services all enhance the attractiveness of a housing location (ibid). In addition to housing and transportation costs, neighbourhood amenities, schools quality and crime rates also influence a household's decision to locate in a particular area (CTOD and CNT, 2006). Correspondingly, Fisher *et al.* (2009) found that school quality, job accessibility and safety are characteristics that individuals care about when deciding on an area to live. Pollard (2010) affirms that in order to create affordable and strong communities there must be a focus on addressing links between jobs, transportation, and affordable housing. Neighbourhood quality issues cannot be ignored in relation to housing affordability (Rowley and Ong, 2012).

Moreover, for communities to be sustainable they should have good transport services and communication, public and green spaces, opportunities for leisure and sport activities, low levels of crime, job and training opportunities, well-performing local schools and education, high quality local health care and social services, early years child care, and a good range of public, community, voluntary and private services (e.g. retail, fresh food, commercial) (CLG, 2007a; ODPM, 2005a; 2005b). Furthermore, Winston (2010) signifies that sustainability demands housing be built close to good quality public transport and employment. It is evident that an important aspect of housing affordability depends on the amenities based in a particular housing location since they will impact on the welfare of households (Fisher *et al.*, 2009). Hence, accessibility to a range of key services and facilities are very important criteria to consider from both a sustainability and affordability view point.

- **Housing supply and mix factors**

In addition, the supply of housing is an essential determinant of affordability (Robinson *et al.*, 2006; Yates and Milligan, 2007). It is imperative that communities provide a diverse and sufficient range of affordable and quality housing within a balanced housing market, helping to ensure the social mix of the community (CLG 2006a; Maliene and Malys, 2009; ODPM 2005a; 2005b; Winston, 2010). Thus, the availability of different housing tenures (both market value and affordable options) must be considered in order to allow households to move through the market depending on their needs and to ensure socially mixed communities.

- **Quality of environmental planning and design factors**

Furthermore, research suggests that housing affordability ought to take into account a wide range of costs facing households, such as energy costs (ACF and VCOSS 2008). Making improvements to the energy efficiency of housing could provide economic benefits for households. For housing to be sustainable it should be high quality, energy saving, using ecological building materials, sustainable waste management and aesthetical design (Maliene and Malys, 2009). In terms of construction, sustainable development demands a shift towards high quality housing, built with sustainable building and design techniques and locating housing in attractive, clean and safe residential environments that have access to green space (Winston, 2010).

6.4 Summary: conceptualising sustainable housing affordability

A comprehensive set of sustainable housing affordability assessment criteria was established via a combination of literature review and expert opinion (interviews). A summary of the criteria identified in stage 1 of the study's methodology, their derivation (literature and/or interview) and reason for inclusion are provided in table 14. It should be noted that the numbering of the criteria is purely for reference purposes and plays no role in an ordering of importance. The set of housing affordability assessment criteria are also illustrated in figure 15. These criteria ultimately represent a broader concept of housing affordability that is more aligned with sustainability concerns and household wellbeing.

Table 14. Summary of sustainable housing affordability criteria

Criteria	Derivation	Reasoning
C_1. House prices in relation to incomes C_2. Rental costs in relation to incomes	CLG (2007b); Robinson *et al.* (2006); Whitehead *et al.* (2009); Yates and Milligan (2007); Interviews.	Housing costs (prices/rents) and household income are key determinants of housing affordability (Robinson *et al.*, 2006; Yates and Milligan, 2007). Housing affordability is often expressed by the relationship between housing expenditure (rent or mortgage) and household income (CLG, 2007b; Whitehead, 2009). The cost of purchasing or renting housing in relation to income will directly influence the accessibility of an area, with higher house price (rent) to income ratios being less accessible (affordable) for some households. Interviews revealed that housing costs in relation to income was the principal determinant of housing affordability.
C_3. Interest rates and mortgage availability	NHPAU (2010); Robinson *et al.* (2006); Yates and Milligan (2007); Interviews.	Interest rates are a key determinant of housing affordability (Robinson *et al.*, 2006; Yates and Milligan, 2007). Interest rates and mortgage payments directly impact a household's ability to save and increase their housing consumption in the future. For housing to be affordable it is important the households can afford the ongoing costs of owning housing (NHPAU, 2010). Interviews highlighted that one of the principal barriers to the housing market, including affordable homeownership products, was access to mortgage finance.
C_4. Availability of private and social rented accommodation C_5. Availability of low cost home ownership products C_6. Availability of market value home ownership products	ODPM (2005a; 2005b); Robinson *et al.* (2006); Winston (2010); Yates and Milligan (2007).	The supply of housing is a determinant of affordability (Robinson *et al.*, 2006; Yates and Milligan, 2007). Supply constraints may limit the ability of an area to provide housing for those who need it. Communities ought to provide a diverse and sufficient range of affordable housing products within a balanced housing market (ODPM, 2005a; 2005b). A good supply of affordable housing tenures ensures the social mix and sustainability of a community (Winston, 2009). Together, C4, C5 and C6 represent a balanced housing marking, providing a range of private and social tenure options for both renting and owner occupation.
C_7. Safety (low crime levels)	Fisher *et al.* (2009); ODPM (2005a;	Safety has been identified as an important factor in making an area a good place to live (Fisher *et al.*, 2009; ODPM, 2005a; 2005b). High crime levels may cause

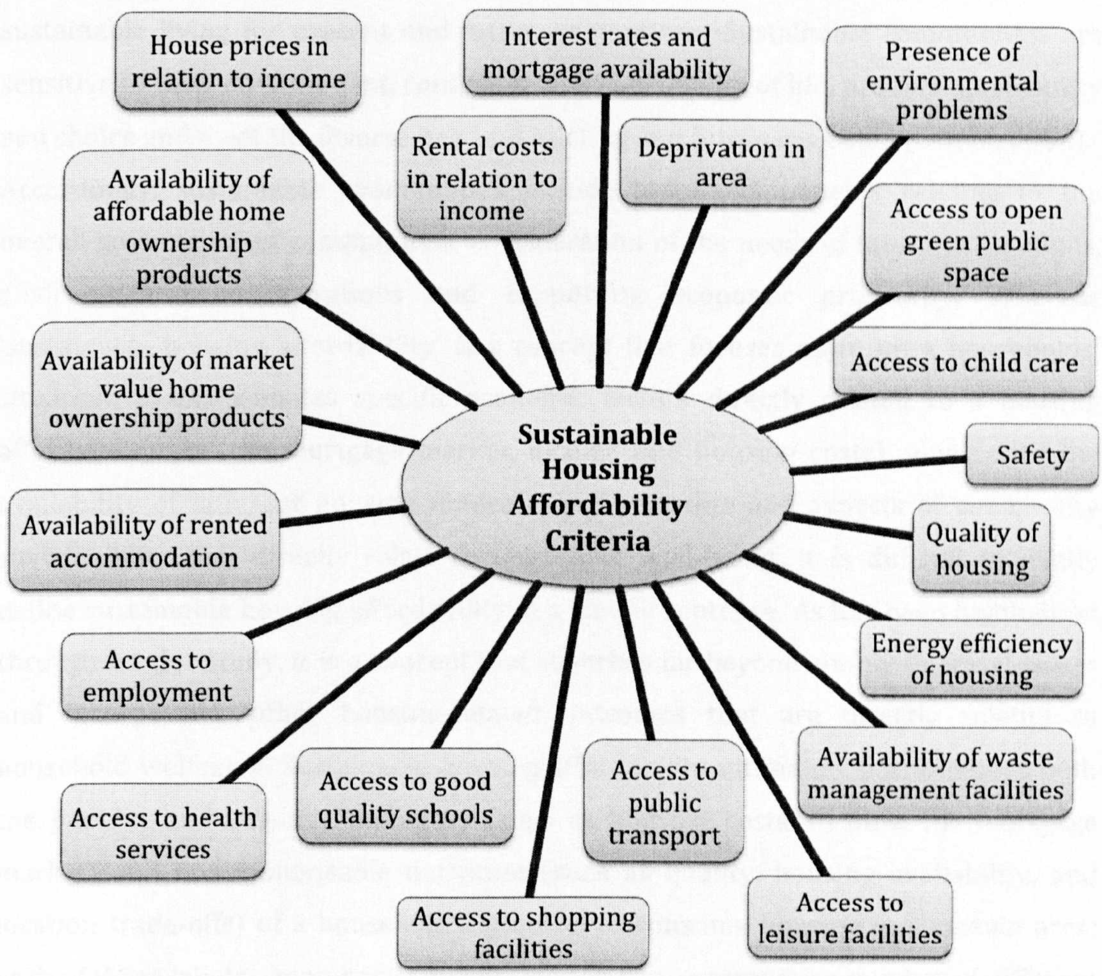
	2005b); Winston (2010).	households to feel venerable inside and outside of their homes and may negatively impact on affordability. Households who live in areas with high crime levels may need to spend extra income on security and safety measures in comparison with those households who live in areas with low crime levels. Furthermore, for housing to be sustainable it should be located in a safe residential environment (Winston, 2010).
C_8. Access to employment opportunities	Fisher *et al.* (2009); ODPM (2005a; 2005b); Pollard (2010); Whitehead *et al.*, (2009); Winston (2010); Interviews	The availability of employment opportunities is an extremely important factor in making an area a good place to live and to assist in creating sustainable housing/communities (Fisher *et al.*, 2009; ODPM, 2005a; 2005b; Winston, 2010). Having access to employment opportunities is an important factor to consider as it can have a direct impact on household income. The level of employment available in an area will determine the levels of wages paid and will influence households' tenure, size and location of housing (Whitehead *et al.*, 2009). Having little or no job opportunities in an area may put increasing strains on the ability to afford housing, but also, commuting long distances to jobs will negatively impact on income and the environment. In addition, it has been suggested that individuals who live in locations with poor accessibility to jobs are less likely to be employed in the future (Aslund *et al.*, 2006).
C_9. Access to public transport	CLG (2007a); CTOD and CNT (2006); ODPM (2005a; 2005b); Pollard (2010); Winston (2010); Interviews	Access to good transport services is essential in order to make an area a good place to live and to create a thriving community (CLG, 2007a; ODPM, 2005a; 2005b). Sustainability demands that housing be located close to good public transport (Winston, 2010). Additionally research suggests that transportation costs directly impact on housing affordability; in the majority of cases a transit-rich environment can have a positive effect on a household's disposable income (CTOD and CNT, 2006; Pollard, 2010).
C_{10}. Access to good quality schools	CLG (2007a); Fisher *et al.* (2009); ODPM (2005a; 2005b); Samuels (2005); Zhu *et al.* (2005); Interviews	Successful and sustainable communities ought to have good access to schools (CLG, 2007a; ODPM, 2005a; 2005b). Access to good schools has been shown to be a characteristic that individuals care about when deciding on an area to live (Fisher *et al.*, 2009; Samuels, 2005; Zhu *et al.*, 2005). The availability of a good education may also directly affect an individual's future prospects and quality of life.
C_{11}. Access to shopping facilities	ODPM (2005a; 2005b); Samuels (2005); Zhu *et al.*	Shopping facilities have been identified as an important factor for creating a thriving community (ODPM, 2005a; 2005b). For home buyers, the presence of shops has been found to enhance the attractiveness of a housing location (Samuels,

	(2005).	2005; Zhu *et al.*, 2005).
C_{12}. Access to health services (e.g. hospitals, pharmacies and GP's)	CLG (2007a); ODPM (2005a; 2005b); Zhu *et al.* (2005).	Access to health care services has been shown to be an important factor for potential home buyers when considering a housing location (Zhu *et al.*, 2005). Additionally, the availability of health services has been identified as a significant attribute in making an area a good place to live and for creating sustainable communities (CLG, 2007a; ODPM, 2005a).
C_{13}. Access to child care	ODPM (2005a; 2005b).	Sustainable communities should have access to early years child care (ODPM, 2005a; 2005b). Poor access to child care facilities may negatively impact on affordability since households may subsequently have to travel greater distances to access such services or it may ultimately affect a parents' ability to seek employment if such services are inaccessible.
C_{14}. Access to leisure facilities	ODPM (2005a; 2005b).	The ODPM (2005a; 2005b) suggests that sustainable communities should have access to leisure facilities. It is important for households, both adults and children, to have access to areas where they can spend their free time and participate in activities that support a healthy lifestyle. Such facilities may also contribute to increased community cohesion.
C_{15}. Access to open green public space	CLG (2007a); Maliene and Malys (2009); ODPM (2005a; 2005b); Winston (2010); Zhu *et al.* (2005).	Zhu *et al.* (2005) identified access to parks as one of the factors that potential home buyers' consider when choosing a housing location. Households should have access to good quality public areas where they can relax and interact (Maliene and Malys, 2009). Furthermore, for housing to be sustainable and in order to create thriving communities, households should have access to green spaces (CLG, 2007a; ODPM, 2005a; 2005b; Winston, 2010).
C_{16}. Quality of housing	CLG (2006a); Maliene and Malys (2009); Winston (2010); Interviews.	A principal aim of the UK government's affordable housing policy is to provide high quality homes (CLG, 2006a). There was a general consensus in the interviews carried out with local authorities that affordable housing must meet certain quality standards. Also, for housing to be sustainable it should be of a high quality (Maliene and Malys, 2009; Winston, 2010).
C_{17}. Presence of Environmental Problems (e.g. litter/rubbish)	CLG (2007a); Maliene and Malys (2009); ODPM (2005a); Winston (2010); WHO (2004).	Adequate shelter requires suitable environmental quality (WHO, 2004). Furthermore, sustainable development demands locating housing in attractive and clean residential environments (CLG, 2007a; Maliene and Malys, 2009; ODPM, 2005a; Winston, 2010).

C_{18}. Energy efficiency of housing	ACF and VCOSS (2008); Maliene and Malys (2009); Winston (2010); Interviews.	Research suggests that housing affordability ought to take into account a broad range of costs facing households, e.g. energy costs (ACF and VCOSS, 2008). Making improvements to the energy efficiency of housing can provide ongoing economic benefits for lower-income households in the long term. Additionally, for housing to be sustainable it must be energy efficient (Maliene and Malys, 2009; Winston, 2010). Interviews revealed that new affordable housing must meet certain sustainability criteria; new affordable housing in England must currently meet Code 3 of the Code for Sustainable Homes.
C_{19}. Waste management	Maliene and Malys (2009); ODPM (2005b); Winston (2010).	Sustainable communities should minimise waste and dispose of it according to good practice (ODPM, 2005b). For housing to be sustainable it must be designed for sustainable usage, including waste management facilities (Maliene and Malys, 2009; Winston, 2010).
C_{20}. Deprivation in area	ODPM (2004); PMSU and ODPM (2005).	Living in deprived areas can adversely affect people's life chances (PMSU and ODPM, 2005). Those that live in deprived areas are less likely to be in employment, have lower life expectancy, are likely to receive poorer education and health services, more likely to live in poorer housing located in unattractive local environments with high levels of antisocial behaviour (ibid). Deprivation is thus important to consider as it will directly affect community sustainability (ODPM, 2004) and negatively impact on many of the criteria considered above.

Source: Self study

Figure 15. Criteria for sustainable housing affordability assessment

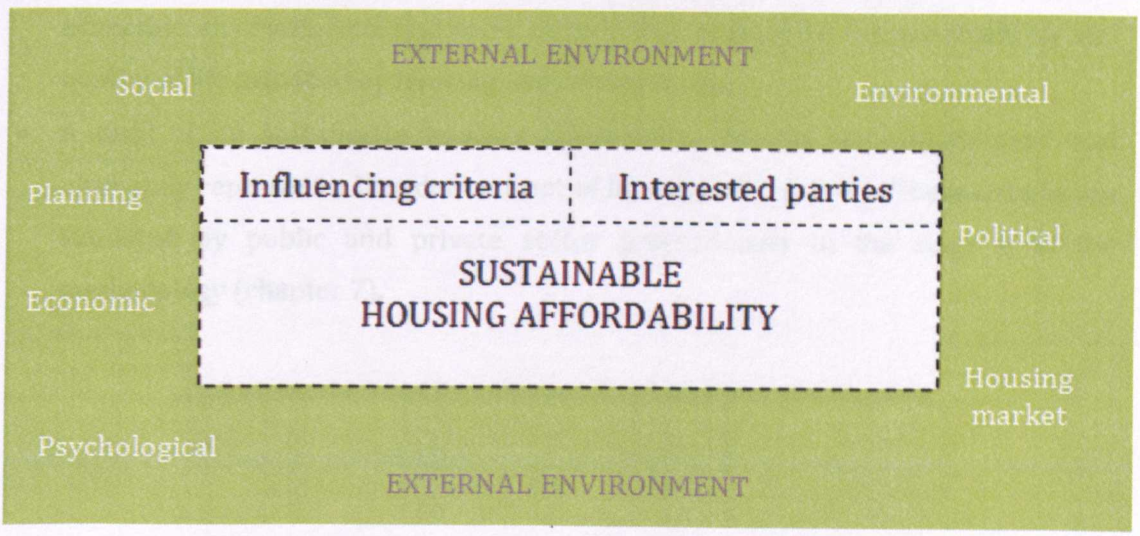


Source: Self study

It may appear that the 'sustainable housing affordability' concept is similar to that of 'sustainable communities' discussed in 3.2.1. One of the intentions of this study is to better align the traditional notion of housing affordability (i.e. the ability to pay for housing) with more qualitative aspects and the sustainable communities concept. Therefore, the line between these two terms becomes blurred, and that is the intention of the study. However, 'sustainable communities' is a much broader concept that generally refers to interacting localities and neighbourhoods that promote sustainable living for present and future generations. Sustainable communities are sensitive to their environment, contribute to a high quality of life, provide opportunity and choice and meet the diverse needs of existing and future residents (ODPM, 2004). Accordingly, sustainable communities include broad components relating to the overall governance of communities, consideration of the needs of future generations, environmental considerations and supporting economic prosperity. Whereas 'sustainable housing affordability' is a concept that focuses more on a households' situation; it amalgamates specific economic factors directly related to a housing affordability (i.e. the mortgage market, income and housing costs), along with the availability of different housing tenures, quality factors and aspects of community sustainability that directly relate to household well-being. It is difficult to neatly define sustainable housing affordability in a simple sentence. As has been highlighted throughout this study, it is a concept that stretches far beyond simply financial issues and incorporates other housing-related outcomes that are directly related to household wellbeing. Sustainable housing affordability ultimately encompasses both the positive and negative monetary (such as housing costs, income, the mortgage market) and non-monetisable outcomes (such as quality, housing availability, and location trade-offs) of a household's decision to consume housing in a certain area; each of those labels - monetary and non-monetary - encompass a number of different criteria. Accordingly, a holistic criteria system has been created to summarise a broader, more sustainable concept of housing affordability which could be used as a guideline to define and asses the issue in a more complex way (figure 15).

The sustainable housing affordability criteria illustrated in figure 15 represent the 'influencing criteria' that will be included within the final assessment model. Figure 16 demonstrates the way in which these criteria, along with the interested parties identified in figure 2, will be included within the final sustainable housing affordability assessment model.

Figure 16. Component for inclusion within the sustainable housing affordability assessment model



Source: Self study

6.5 Chapter summary

- This chapter has presented the qualitative data analysis from stage 1 of the research methodology.
- A comprehensive set of sustainable housing affordability assessment criteria were established via a combination of literature review and professional opinion (interviews).
- The analysis of six semi-structured interviews conducted with local authority professionals was presented, which sought to gain a background understanding of how affordability is currently conceived and assessed in practice and, primarily, identify criteria for inclusion within the criteria system. The interview data

created a foundation for the sustainable housing affordability criteria system, which was supplemented via literature review.

- Overall, the interviews and supplementary literature review allowed for the identification of a holistic criteria system for sustainable housing affordability. The established criteria system seeks to conceive affordability not only in terms of housing costs and incomes, but by also taking into consideration a wide range of economic, environmental and social criteria that account for the sustainability and quality of life provided by housing and communities.
- A total of 20 sustainable housing affordability criteria were established and ultimately represent a broader concept of housing affordability. These criteria are validated by public and private sector professionals in the stage 2 of the methodology (chapter 7).

Chapter 7

Data analysis stage 2: Quantitative analysis of questionnaire survey

7.1 Introduction

This chapter discusses the results of the data collection for stage 2 of the research methodology which sought to validate the sustainable housing affordability assessment criteria, identified in stage 1 of the methodology, and establish criteria weights (significance) via a questionnaire survey (quantitative) with professionals. A rating scale was used to rate the criteria along a scale of importance (see 5.6.4 for further details). Rating scales, even when capturing subjective opinions with numbers, are quantitative. Therefore, quantitative analysis was conducted to analyse the data gathered.

7.2 Response rate

7.2.1 Pilot survey

A pilot survey was conducted initially with housing and planning professionals in the North West region of England. The survey was distributed via email to a total of 110 professionals, in which 58 responses were obtained, giving a response rate of 53%.

As well as testing the design of the survey, the pilot study gave respondents the opportunity to suggest any additional criteria that they felt could be added to the criteria system for sustainable housing affordability (pilot questions can be found in Appendix 2). Only one notable criterion was recommended by respondents: 17 respondents (29%) suggested that a balanced housing market with different levels of housing and different sizes and types of housing to meet identified needs of residents is an important factor to consider. Accordingly it was deemed necessary to add 'availability of market value home ownership products' (C_6) to the set of assessment criteria. This factor was not initially included within the criteria system, but the addition of this criterion now means that the criteria system takes full account of a variety of different housing tenures and products, including market value and social properties that are both rented and owner occupied. Comparisons between the findings of the pilot survey and final survey are presented in 7.4.

7.2.2 Final survey

A link to the final questionnaire, created using BOS, was sent via email to housing and planning professionals across all regions of the UK. The survey was sent to a total of 600 professionals, in which 337 responses were obtained, giving a response rate of 56%.

The gender of the survey respondents is detailed below in table 15, while the age of the survey respondents is shown in table 16.

Table 15. Gender profile of survey respondents

Gender	%	Count
Male	51.0	172
Female	49.0	165

Table 16. Age profile of survey respondents

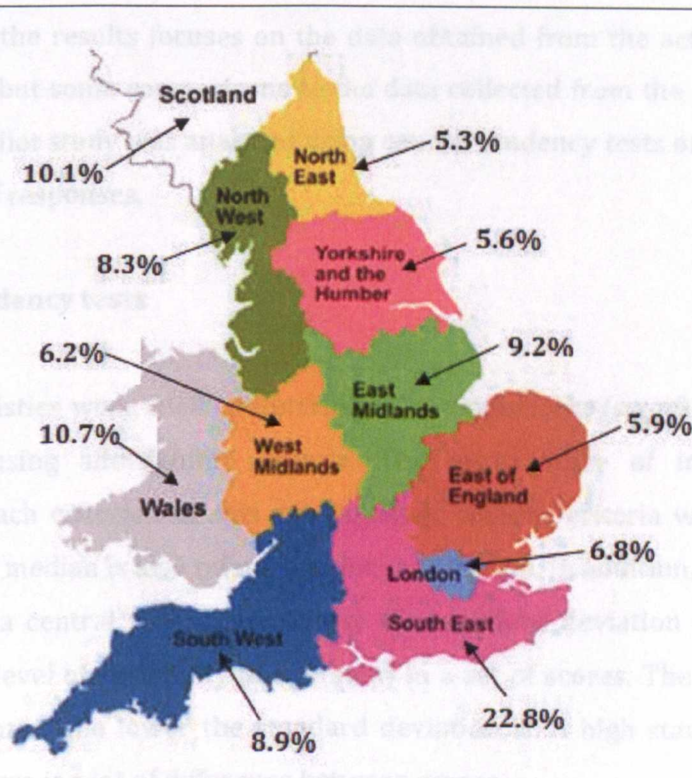
Age	%	Count
18-25	2.7	9
26-35	29.4	99
36-45	26.7	90
46-55	32.9	111
56+	8.3	28

The respondent's type of employment is detailed below in table 17 and the region of the UK in which the respondents were based in is shown in figure 17.

Table 17. Employment profile of survey respondents

Type of employment	%	Count
Housing association	12.5	42
Local authority - planning	25.5	86
Local authority - housing services	46.6	157
Urban regeneration	3.3	11
Housing developer	3.6	12
Property/affordable housing Consultant	3.6	12
Other	5.0	17

Figure 17. Survey responses obtained from different regions of the UK



Source: Self study

7.3 Analysis procedure for questionnaire data

The analysis procedure was undertaken using SPSS, in which the following statistical tests (described in more detail in 5.6.6) were used to analyse the final survey data:

- *Central tendency tests* - to determine average ratings of criteria importance and to subsequently calculate criteria weights;
- *Kolmogorov-Smirnov test* - to identify whether the data are normally distributed;
- *Mann-Whitney U test* - to identify if any significant differences exist between two groups' opinion on criteria importance;
- *Kruskal Wallis test* - to identify if any significant differences exist between three or more groups' opinion on criteria importance. The Mann-Whitney U test was subsequently used as a post hoc analysis on significant results.

The analysis of the results focuses on the data obtained from the actual study (final questionnaire), but some comparisons to the data collected from the pilot study data are made. The pilot study was analysed using central tendency tests only owing to the small number of responses.

7.4 Central tendency tests

Descriptive statistics were used to determine the importance/significance of the 20 sustainable housing affordability criteria. The mean score of importance was calculated for each criterion as this subsequently allowed criteria weightings to be established. The median is also referred to for comparison. In addition, in order to test the strength of a central tendency estimate the standard deviation was calculated. This shows the level of variability (dispersion) in a set of scores. The mean becomes more representative the lower the standard deviation is. A high standard deviation indicates that there is a lot of difference between scores.

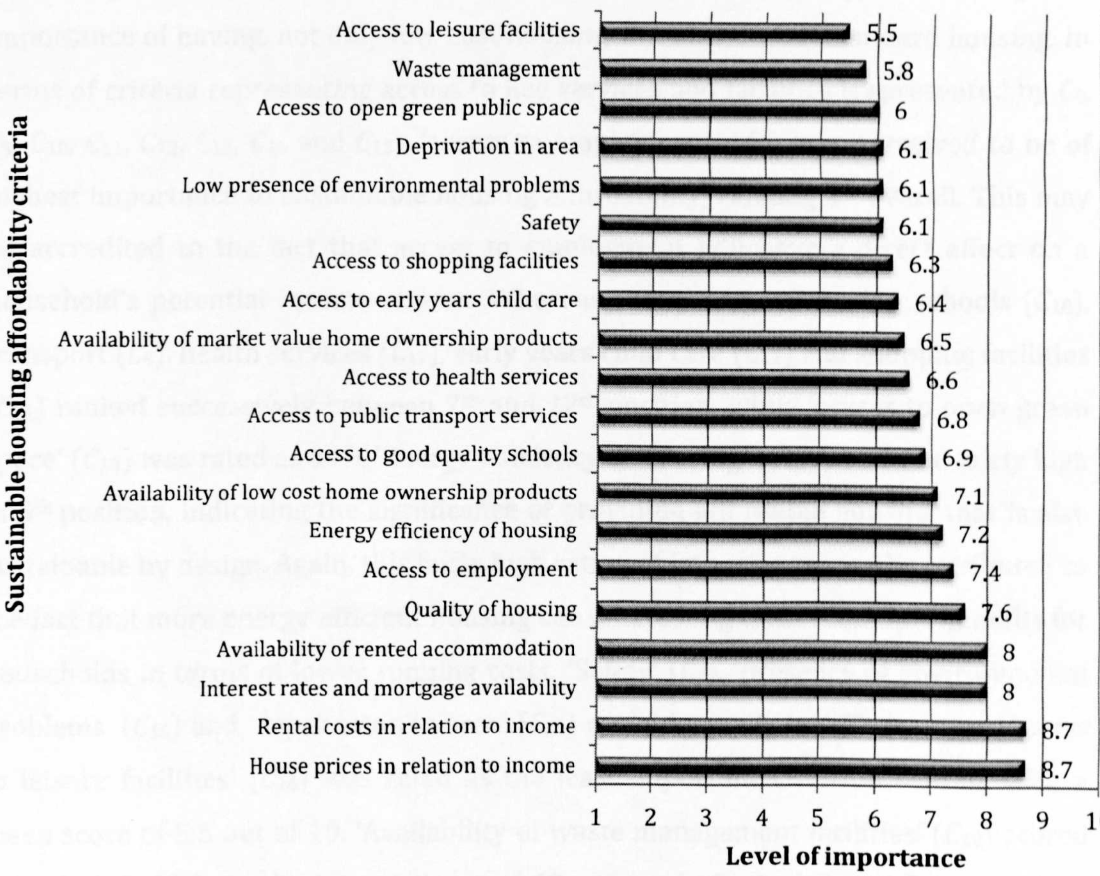
Table 17 displays the mean and median scores of importance, along with the standard deviation obtained for each criterion. The scores are obtained from a scale of importance ranging from 1 to 10, where 1 = 'not important' to sustainable housing affordability and 10 = 'most important' to sustainable housing affordability. The criteria in table 18 are arranged in overall rank order of importance (determined by mean scores), with a higher rank showing higher importance of the criterion to sustainable housing affordability. Importantly, the results reveal that all 20 criteria (identified by the literature review and/or interview process) are perceived to be important to a certain degree to sustainable housing affordability. Therefore, all 20 criteria were validated by the survey data gathered from professionals.

Table 18. Rank order and average score of importance of sustainable housing affordability criteria

Rank	Sustainable housing affordability criteria	Mean	Median	Standard deviation
1	C_1. House prices in relation to income	8.7	9	1.5
1	C_2. Rental costs in relation to income	8.7	9	1.4
2	C_3. Interest rates and mortgage availability	8	8	1.6
2	C_4. Availability of rented accommodation (private and social)	8	8	1.6
3	C_{17}. Quality of housing	7.6	8	1.9
4	C_8. Access to employment	7.4	8	1.8
5	C_{18}. Energy efficiency of housing	7.2	8	2
6	C_5. Availability of low cost home ownership products	7.1	7	1.9
7	C_{10}. Access to good quality schools	6.9	7	1.9
8	C_9. Access to public transport	6.8	7	1.9
9	C_{12}. Access to health services	6.6	7	1.9
10	C_6. Availability of market value home ownership products	6.5	7	1.9
11	C_{13}. Access to early years child care	6.4	6	1.9
12	C_{11}. Access to shopping facilities	6.3	6	1.9
13	C_7. Safety (crime)	6.1	6	2.1
13	C_{16}. Low presence of environmental problems	6.1	6	2
13	C_{20}. Deprivation in area	6.1	6	2.1
14	C_{15}. Access to open green public space	6	6	2
15	C_{19}. Waste management	5.8	6	2.3
16	C_{14}. Access to leisure facilities	5.5	6	2

Figure 18 illustrates the mean score of importance obtained for each criterion, arranged in overall order of importance. In terms of the overall rank order of the criteria, the results reveal that the professionals perceived 'house prices in relation to income' (C_1) and 'rental costs in relation to income' (C_2) to be the most important criteria, ranking equally 1st. Although, 'rental costs in relation to income' (C_2) had the least amount of deviation, the highest consensus, among amongst participant's weightings of the 20 criteria.

Figure 18. Mean scores of importance for sustainable housing affordability criteria



Source: Self study

It is not surprising that these criteria were rated highest overall considering that affordability is habitually defined and assessed by such financial attributes. 'Interest rates and mortgage availability' (C_3) ranked 2nd overall, along with 'availability of rented accommodation' (C_4) which ranked equally. In comparison to C_4, 'availability of low cost home ownership products' (C_5) ranked in 6th position overall, while 'availability of market value home ownership products' (C_6) ranked as 10th. The ordering of importance of C_4, C_5 and C_6 could reflect the current economic climate, where rental properties (social and private) are often necessary to meet affordable housing need, since home ownership products are increasingly out of reach for many wishing to get onto the housing ladder. 'Quality of housing' (C_{17}) was ranked as the 3rd most important criterion to sustainable housing affordability, confirming the importance of having, not only low-cost housing, but also decent standard housing. In terms of criteria representing access to key services and facilities (represented by C_8, C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14} and C_{15}), 'access to employment' (C_8) was perceived to be of highest importance to sustainable housing affordability, ranking 4th overall. This may be accredited to the fact that access to employment will have a direct affect on a household's potential income stream. Whereas access to good quality schools (C_{10}), transport (C_9), health services (C_{12}), early years child care (C_{13}) and shopping facilities (C_{11}) ranked successively between 7th and 12th position, while 'access to open green space' (C_{15}) was rated as 14th. 'Energy efficiency of housing' (C_{18}) was rated fairly high in 5th position, indicating the significance of providing affordable housing that is also sustainable by design. Again, this fairly high rating of importance may be attributed to the fact that more energy efficient housing can create long term economic benefits for households in terms of lower running costs. 'Safety' (C_7), 'presence of environmental problems' (C_{16}) and 'deprivation in area' (C_{20}) ranked equally in 13th position. 'Access to leisure facilities' (C_{14}) was rated as the least important criterion overall, with a mean score of 5.5 out of 10. 'Availability of waste management facilities' (C_{19}) scored only slightly higher, obtaining 5.8 out of 10, although C_{19} had the highest standard deviation (2.3), indicating least consensus, out of all 20 criteria.

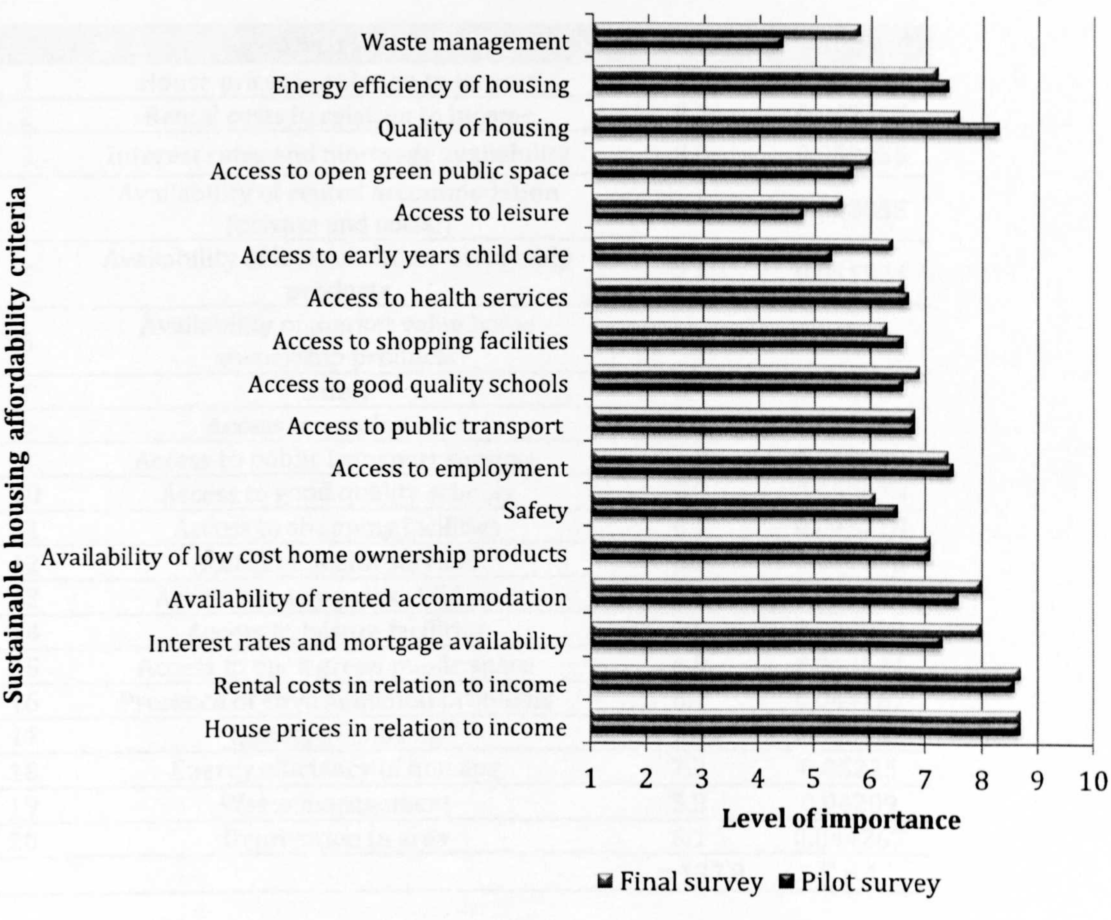
Table 19 compares the mean scores of criteria importance obtained from the pilot survey with that of the final survey, indicating the percentage increase or decrease between scores. The pilot survey is representative of professionals from the North West region of England only, whereas the final survey is representative of professionals from all regions across the UK. There was no mean data available from the pilot survey for C_6 (availability of market value home ownership products), C_{16} (low presence of environmental problems) or C_{20} (deprivation in area) as these criteria were added after the pilot study was embarked upon (C_6 was recommended in the pilot study, while C_{16} and C_{20} were established via further literature review). Thus comparisons between such criteria could not been made.

Table 19. Comparison of criteria importance between pilot and final surveys

	Sustainable housing affordability criteria	Pilot survey mean	Final survey mean	Change
1	House prices in relation to income	8.7	8.7	0%
2	Rental costs in relation to income	8.6	8.7	+ 1.2%
3	Interest rates and mortgage availability	7.3	8.0	+ 9.6%
4	Availability of rented accommodation (private and social)	7.6	8.0	+ 5.3%
5	Availability of low cost home ownership products	7.1	7.1	0%
6	Availability of market value home ownership products	n/a	6.5	n/a
7	Safety	6.5	6.1	- 6.2%
8	Access to employment	7.5	7.4	- 1.3%
9	Access to public transport	6.8	6.8	0%
10	Access to good quality schools	6.6	6.9	+ 4.5%
11	Access to shopping facilities	6.6	6.3	- 4.5%
12	Access to health services	6.7	6.6	- 1.5%
13	Access to early years child care	5.3	6.4	+ 20.8%
14	Access to leisure facilities	4.8	5.5	+ 14.6%
15	Access to open green public space	5.7	6.0	+ 5.3%
16	Low presence of environmental problems	n/a	6.1	n/a
17	Quality of housing	8.3	7.6	- 8.4%
18	Energy efficiency of housing	7.4	7.2	- 2.7%
19	Waste management	4.4	5.8	+ 31.8%
20	Deprivation in area	n/a	6.1	n/a

Figure 19 illustrates the difference between the pilot and final survey mean scores. The results show that for C_1 (house prices in relation to income), C_5 (availability of low cost home ownership products) and C_9 (access to public transport) there was actually no change in the rating of criteria importance between surveys. For the remaining criteria, the change between scores of the two surveys was generally not very large, with the exception of C_{19} (waste management) which had the largest difference between ratings of criteria importance, followed by C_{13} (access to early years child care) and C_{14} (access to leisure facilities) consecutively.

Figure 19. Comparison of final survey with pilot survey



Source: Self study

7.4.1 Criteria weighting

The 20 assessment criteria identified (via literature review and/or interviews with professionals) in stage 1 of the research differ in terms of their relative importance to sustainable housing affordability. Weighting of the criteria is required to reflect criteria importance and to facilitate the use of MCDM methods. In order to calculate criteria weights, the mean ranking of importance obtained for each criterion (by the final survey) was divided by the sum of the mean scores, as such it ensures the total of all weights is equal to 1. Table 20 displays the mean score obtained for each criterion and its corresponding weight.

Table 20. Weight of sustainable housing affordability evaluation criteria

	Criteria	Mean	Weight
1	House prices in relation to income	8.7	0.063135
2	Rental costs in relation to income	8.7	0.063135
3	Interest rates and mortgage availability	8.0	0.058055
4	Availability of rented accommodation (private and social)	8.0	0.058055
5	Availability of low cost home ownership products	7.1	0.051524
6	Availability of market value home ownership products	6.5	0.04717
7	Safety	6.1	0.044267
8	Access to employment	7.4	0.053701
9	Access to public transport services	6.8	0.049347
10	Access to good quality schools	6.9	0.050073
11	Access to shopping facilities	6.3	0.045718
12	Access to health services	6.6	0.047896
13	Access to early years child care	6.4	0.046444
14	Access to leisure facilities	5.5	0.039913
15	Access to open green public space	6.0	0.043541
16	Presence of environmental problems	6.1	0.044267
17	Quality of housing	7.6	0.055152
18	Energy efficiency of housing	7.2	0.05225
19	Waste management	5.8	0.04209
20	Deprivation in area	6.1	0.044267
		= 137.8	$\sum = 1$

Source: Self study

7.5 Kruskal-Wallis test

The Kruskal-Wallis Test was used to compare for differences between groups in order to answer the questions detailed below in figure 20.

Figure 20. Use of the Kruskal-Wallis test

Groups compared	Research question
• Employment type	➢ Does opinion on criteria importance differ depending on the professionals' type of employment?
• Region of employment	➢ Does opinion on criteria importance differ depending on the region of the UK in which the professional is based?
• Age	➢ Does opinion on criteria importance differ depending on the professionals' age?

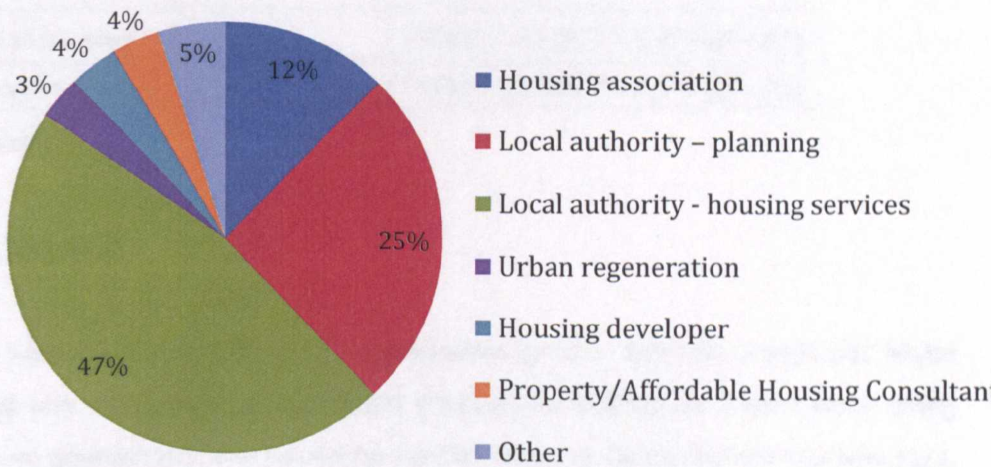
Source: Self study

7.5.1 Kruskal-Wallis test results for differences between 'employment type' groups

In order to identify if the respondents' particular employment type had any influence on the rankings of criteria importance given, the Kruskal-Wallis test was conducted. Respondents were assigned to one of seven 'employment type' groups (the response rate from each group is illustrated in figure 21):

1. Housing association
2. Local authority - planning
3. Local authority - housing
4. Urban regeneration
5. Housing developer
6. Property/affordable housing Consultant
7. Other

Figure 21. Survey respondents type of employment



Source: Self study

The Kruskal-Wallis test found that there was a statistically significant difference between groups' ratings of criteria importance for 13 out of 20 criteria, significant results are detailed in table 21.

Table 21. Significant results for Kruskal-Wallis test (comparing employment groups)

Criterion	Kruskal-Wallis test result
C_1: House prices in relation to income	$H(6) = 21.821, P = 0.001\ (P < .01)$
C_2: Rental costs in relation to income	$H(6) = 17.114, P = 0.009\ (P < .01)$
C_4: Availability of rented accommodation	$H(6) = 18.502, P = 0.005\ (P < .01)$
C_7: Safety	$H(6) = 14.510, P = 0.024\ (P < .05)$
C_8: Access to employment	$H(6) = 15.032, P = 0.020\ (P < .05)$
C_9: Access to public transport services	$H(6) = 13.190, P = 0.040\ (P < .05)$
C_{10}: Access to good quality schools	$H(6) = 15.950, P = 0.014\ (P < .05)$
C_{11}: Access to shopping facilities	$H(6) = 21.263, P = 0.002\ (P < .01)$
C_{12}: Access to health services	$H(6) = 16.806, P = 0.010\ (P < .05)$

C_{13}: Access to early years child care	$H(6) = 17.184, P = 0.009$ ($P < .01$)
C_{14}: Access to leisure facilities	$H(6) = 19.929, P = 0.003$ ($P < .01$)
C_{17}: Quality of housing	$H(6) = 17.028, P = 0.009$ ($P < .01$)
C_{20}: Deprivation in area	$H(6) = 19.209, P = 0.004$ ($P < .01$)

Source: Self study

- **Post Hoc test**

In order to identify which particular employment groups differed, a post hoc Mann Whitney test was conducted on significant criteria, controlling for Type I error using the Bonferroni adjustment (see 5.6.6.4 for further details). Using the formula k(k-1)/2, where k is the number of groups, the number of comparisons required for the post hoc Mann-Whitney test was determined:

- Number of comparisons required: 7(7-1)/2 = 21
- Bonferroni adjustment: 0.05/21 = 0.0024 (new alpha/significance level)

Following post hoc Mann Whitney tests on C_1 (house prices in relation to income), C_2 (rental costs in relation to income), C_7 (safety), C_8 (access to employment), C_9 (access to public transport services), C_{10} (access to good quality schools), C_{12} (access to health services) and C_{17} (quality of housing), no significant results were found between employment groups at the new significance level of 0.0024. However, the post hoc Mann-Whitney test revealed that for C_4 'availability of rented accommodation' there was a statistically significant difference between employment group 2 (local authority planning) and 3 (local authority housing). Respondents working within local authority housing gave statistically significantly higher rankings of importance to 'availability of rented accommodation' compared to those working within local authority planning at sig .001 ($P < 0.0024$) (figure 22).

Figure 22. Significant Mann-Whitney test in SPSS for C_4

Ranks

	Employment	N	Mean Rank	Sum of Ranks
	Local authority - planning	86	102.26	8794.50
C_4	Local authority - housing	157	132.81	20851.50
	Total	243		

A higher mean rank means that there are a greater number of high scores in the local authority - housing group.

Test Statistics[a]

	C_4
Mann-Whitney U	5053.500
Wilcoxon W	8794.500
Z	-3.310
Asymp. Sig. (2-tailed)	.001

a. Grouping Variable: Employment

This shows that the test is significant as the figure is below the significance level $P < 0.0024$.

Source: Self study

The post hoc Mann-Whitney test revealed that for C_{11} 'access to shopping facilities' there was a statistically significant difference between employment group 1 (housing associations) and group 3 (local authority housing). Respondents working within housing associations gave statistically significantly higher rankings of importance to 'access to shopping facilities' compared to those working within local authority housing at sig .002 ($P < 0.0024$) (figure 23).

Figure 23. Significant Mann-Whitney test in SPSS for C_{11}

Ranks

	Employment	N	Mean Rank	Sum of Ranks
	Housing association	42	124.26	5219.00
C_{11}	Local authority - housing	157	93.51	14681.00
	Total	199		

Test Statistics[a]

	C_{11}
Mann-Whitney U	2278.000
Wilcoxon W	14681.000
Z	-3.126
Asymp. Sig. (2-tailed)	.002

a. Grouping Variable: Employment

Source: Self study

The post hoc Mann-Whitney test revealed that for C_{14} 'access to leisure facilities' there was a statistically significant difference between employment group 2 (local authority planning) and group 3 (local authority housing). Respondents working within local authority planning gave statistically significantly higher rankings of importance to 'access to leisure facilities' compared to those working within local authority housing at sig .001 ($P = < 0.0024$) (figure 24).

Figure 24. Significant Mann-Whitney test in SPSS for C_{14}

Ranks

	Employment	N	Mean Rank	Sum of Ranks
C_{14}	Local authority - planning	86	141.22	12145.00
	Local authority - housing	157	111.47	17501.00
	Total	243		

Test Statistics[a]

	C_{14}
Mann-Whitney U	5098.000
Wilcoxon W	17501.000
Z	-3.195
Asymp. Sig. (2-tailed)	.001

a. Grouping Variable: Employment

Source: Self study

The post hoc Mann-Whitney test revealed that for C_{20} 'deprivation in area' there was a statistically significant difference between employment group 1 (housing associations) and group 2 (local authority planning). Respondents working within housing associations gave statistically significantly higher rankings of importance to 'deprivation in area' compared to those working within local authority planning at sig .000 ($P = < 0.0024$) (figure 25).

Figure 25. Significant Mann-Whitney test result in SPSS for C_{20} (group 1 and 2)

Ranks

	Employment	N	Mean Rank	Sum of Ranks
C_{20}	Housing association	42	81.94	3441.50
	Local authority - planning	86	55.98	4814.50
	Total	128		

Test Statistics[a]

	C_{20}
Mann-Whitney U	1073.500
Wilcoxon W	4814.500
Z	-3.751
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Employment

Source: Self study

The post hoc Mann-Whitney test revealed that for C_{20} 'deprivation in area' there was also a statistically significant difference between employment group 2 (local authority planning) and group 3 (local authority housing). Respondents working within local authority housing gave statistically significantly higher rankings of importance to 'deprivation in area' compared to those working within local authority planning at sig .001 ($P = < 0.0024$) (figure 26).

Figure 26. Significant Mann-Whitney test result in SPSS for C_{20} (group 2 and 3)

Ranks

	Employment	N	Mean Rank	Sum of Ranks
C_{20}	Local authority - planning	86	101.94	8767.00
	Local authority - housing	157	132.99	20879.00
	Total	243		

Test Statistics[a]

	C_{20}
Mann-Whitney U	5026.000
Wilcoxon W	8767.000
Z	-3.333
Asymp. Sig. (2-tailed)	.001

a. Grouping Variable: Employment

Source: Self study

Significant post hoc results using the Mann-Whitney test are summarised in table 22. The 'employment type' column indicates the way in which the groups' opinion differed (i.e. which group had the higher mean scores), the 'criterion' column indicates which criterion their opinion differed on, and the 'Mann-Whitney result' column shows the test result.

Table 22. Significant results for Mann-Whitney U test (comparing 'employment type' groups)

Employment type	Criterion	Mann-Whitney result
Local authority housing gave higher rankings than local authority planning	C_4: availability of rented accommodation	$U = 5054$, $Z = -3.310$, $P = 0.001$ ($P < .0024$)
Housing associations gave higher rankings than local authority housing	C_{11}: access to shopping facilities	$U = 2278$, $Z = -3.126$, $P = 0.002$ ($P < .0024$)
Local authority planning gave higher rankings than local authority housing	C_{14}: access to leisure facilities	$U = 5098$, $Z = -3.195$, $P = 0.001$ ($P < .0024$)

Housing associations gave higher rankings than local authority planning	C_{20}: deprivation in area	$U = 1074$, $Z = -3.751$, $P = 0.000$ ($P < .0024$)
Local authority housing gave higher rankings than local authority planning	C_{20}: deprivation in area	$U = 5026$, $Z = -3.333$, $P = 0.001$ ($P < .0024$)

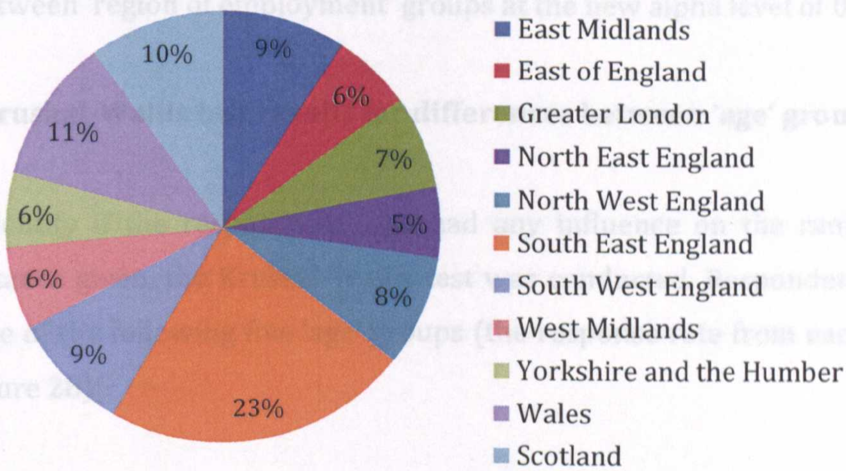
Source: Self study

7.5.2 Kruskal-Wallis test results for differences between 'region of employment' groups

In order to identify if the respondents' particular region of employment within the UK had any influence on the rankings of criteria importance given, the Kruskal-Wallis test was conducted. Respondents were assigned to one of the following 11 'region of employment' groups (the response rate from each group is shown in figure 27):

1. East Midlands
2. East of England
3. Greater London
4. North East England
5. North West England
6. South East England
7. South West England
8. West Midlands
9. Yorkshire and the Humber
10. Wales
11. Scotland

Figure 27. Survey respondents region of employment



Source: Self study

The Kruskal-Wallis test revealed that there was a statistically significant difference between the region of employment groups for the following criteria:

- C_4 'availability of rented accommodation' ($H(10) = 18.799$, $P = 0.043$) at $P < .05$; and
- C_{13} 'access to early years child care' ($H(10) = 19.506$, $P = 0.034$) at $P < .05$.

➢ **Post Hoc test**

In order to identify which particular region of employment groups differed, a post hoc Mann Whitney test was conducted on the two significant criteria. Using the formula k(k-1)/2, where k is the number of groups, the number of comparisons required for the post hoc Mann-Whitney test was determined as follows:

- Number of comparisons required: 11(11-1)/2 = 55

- Bonferroni adjustment: 0.05/55 = 0.0009 (new alpha level)

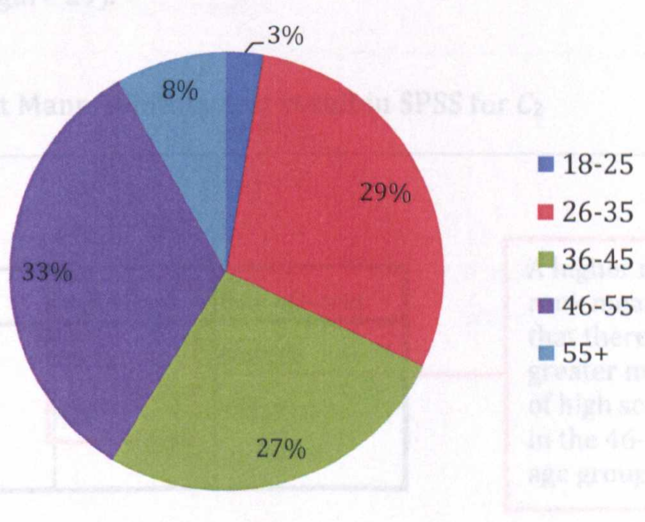
After conducting post hoc Mann Whitney tests on C_4 and C_{13}, no significant results were found between 'region of employment' groups at the new alpha level of 0.0009.

7.5.3 Kruskal-Wallis test results for differences between 'age' groups:

In order to identify if the respondents' age had any influence on the rankings of criteria importance given, the Kruskal-Wallis test was conducted. Respondents were assigned to one of the following five 'age' groups (the response rate from each group is shown in figure 28):

1. 18-25
2. 26-35
3. 36-45
4. 46-55
5. 56+

Figure 28. Age of survey respondents



Source: Self study

The Kruskal-Wallis test revealed that there was a statistically significant difference between age groups for only one criterion: C_2 'rental costs in relation to income' ($H(4) = 15.127$, $P = 0.004$) at $P < .01$.

- **Post Hoc test**

In order to identify which particular age groups differed, a post hoc Mann Whitney test was conducted on the significant criterion. Using the formula k(k-1)/2, where k is the number of groups, the number of comparisons required for the post hoc Mann-Whitney test was determined:

- Number of comparisons required: 5(5-1)/2 = 10
- Bonferroni adjustment: 0.05/10 = 0.005 (new alpha level)

The post hoc Mann-Whitney test revealed that for C_2 'rental costs in relation to income' there was a statistically significant difference between age group 2 (26-35) and 4 (46-55). 46-55 year olds gave statistically significantly higher rankings of importance to 'rental costs in relation to income' compared to 26-35 year olds at sig 0.000 ($P < 0.005$) (figure 29).

Figure 29. Significant Mann-Whitney test result in SPSS for C_2

Ranks

	Age	N	Mean Rank	Sum of Ranks
C_2	26-35	99	89.12	8823.00
	46-55	111	120.11	13332.00
	Total	210		

A higher mean rank means that there are a greater number of high scores in the 46-55 age group.

Test Statistics[a]

	C_2
Mann-Whitney U	3873.000
Wilcoxon W	8823.000
Z	-3.832
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Age

This shows that the test is significant as the figure is below the significance level $P<0.005$.

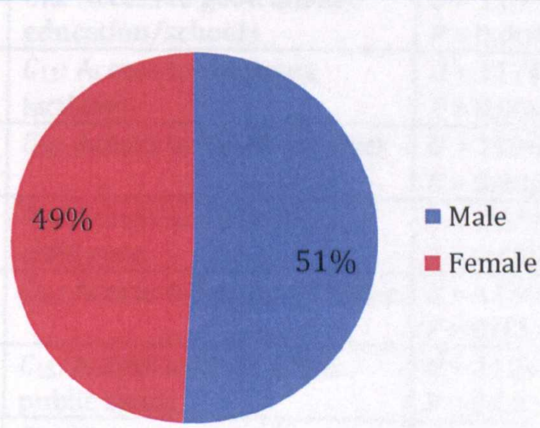
Source: Self study

7.6 Mann-Whitney U test

The Mann-Whitney U test was applied in order to identify if the respondents' gender had any influence on the rankings of criteria importance given (further details on this test are provided in 5.6.6.3). Respondents were assigned to one of two 'gender' groups (the response rate from each group is shown in figure 30):

1. Male
2. Female

Figure 30. Gender of survey respondents



Source: Self study

The significant results of the Mann-Whitney U test are displayed in table 23. The 'gender' column indicates the way in which the groups' opinion differed (i.e. which group had the higher mean scores), the 'criterion' column indicates which criterion their opinion differed on, and the 'Mann-Whitney result' column shows the test result, including the P value. For 14 out of the 20 sustainable housing affordability criteria statistically significant results were found; females gave statistically significantly higher rankings of importance than males on all 14 of the criteria. Females placed statistically significantly more importance on all criteria representing accessibility to amenities and facilities (C_8; C_9; C_{10}; C_{11}; C_{12}; C_{13}; C_{14}; C_{15}) and general neighbourhood/housing quality criteria (C_{16}; C_{17}; C_{18}; C_{19}; C_{20}) in comparison to males. Interestingly, the six criteria that were not found to be statistically significant for this test where those representing economic criteria (C_1; C_2; C_3) and availability of different housing tenures (C_4, C_5, C_6).

Table 23. Significant results for Mann-Whitney U test (comparing 'gender' groups)

Gender	Criterion	Mann-Whitney result
Females gave higher rankings than males	C_7: Safety	$U = 11470$, $Z = -3.075$, $P = 0.002$ ($P < .01$)
Females gave higher rankings than males	C_8: Access to employment	$U = 11074$, $Z = -3.541$, $P = 0.000$ ($P < .01$)
Females gave higher rankings than males	C_9: Access to public transport services	$U = 11052$, $Z = -3.560$, $P = 0.000$ ($P < .01$)
Females gave higher rankings than males	C_{10}: Access to good quality education/schools	$U = 11660$, $Z = -2.868$, $P = 0.004$ ($P < .01$)
Females gave higher rankings than males	C_{11}: Access to shopping facilities	$U = 11744$, $Z = -2.776$, $P = 0.006$ ($P < .01$)
Females gave higher rankings than males	C_{12}: Access to health services	$U = 11066$, $Z = -3.542$, $P = 0.000$ ($P < .01$)
Females gave higher rankings than males	C_{13}: Access to early years child care	$U = 10790$, $Z = -3.855$, $P = 0.000$ ($P < .01$)
Females gave higher rankings than males	C_{14}: Access to leisure facilities	$U = 11587$, $Z = -2.944$, $P = 0.003$ ($P < .01$)
Females gave higher rankings than males	C_{15}: Access to open green public space	$U = 11246$, $Z = -3.331$, $P = 0.001$ ($P < .01$)
Females gave higher rankings than males	C_{16}: Low presence of environmental problems	$U = 11480$, $Z = -3.070$, $P = 0.002$ ($P < .01$)

Females gave higher rankings than males	C_{17}: Quality of housing	$U = 11481, Z = -3.081, P = 0.002$ ($P < .01$)
Females gave higher rankings than males	C_{18}: Energy efficiency of housing	$U = 11705, Z = -2.824, P = 0.005$ ($P < .01$)
Females gave higher rankings than males	C_{19}: Waste management	$U = 11031, Z = -3.564, P = 0.000$ ($P < .01$)
Females gave higher rankings than males	C_{20}: Deprivation in area	$U = 12193, Z = -2.259, P = 0.024$ ($P < .05$)

Source: Self study

7.7 Chapter Summary

- This chapter has presented the quantitative data analysis for stage 2 of the research methodology. The aim of which was to validate and weight the 20 sustainable housing affordability assessment criteria identified in stage 1 of the methodology. Furthermore, the analysis sought to identify if any differences in opinion regarding criteria importance existed between a number of different groups (age, gender, employment type, region of employment).
- Firstly, all 20 sustainable housing affordability criteria were validated by the survey data gathered from UK housing and planning professionals. Therefore the removal of any criteria identified by the literature and/or interview process (stage 1) was not required. Predominantly, the quantitative questionnaire data presented in this chapter allowed all 20 criteria to be weighted, reflecting the significance of the criteria to sustainable housing affordability.
- Further analysis of the questionnaire data was conducted, using non-parametric statistics (the Mann-Whitney and Kruskal Wallis tests), to test for any statistically significant differences between a number of groups' opinion (rating) of criteria importance. The main questions that were asked and the subsequent findings are summarised as follows:
  - *Does opinion on criteria importance differ depending on the professionals' type of employment?* The results indicate that the respondents' employment type did influence the rankings of criteria importance given for four (20%) out of the 20

sustainable housing affordability criteria, namely 'availability of rented accommodation', 'access to shopping facilities', 'access to leisure facilities' and 'deprivation in area'. Although, for 16 (80%) out of the 20 criteria the results indicate that the respondents' type of employment had no influence on the rankings of criteria importance given.

- *Does opinion on criteria importance differ depending on the region of the UK in which the professional is based?* Initially, the Kruskal Wallis test revealed that there were statistically significant differences between groups rating of criteria importance for two (10%) out of the 20 sustainable housing affordability criteria. However, after conducting post hoc Mann-Whitney tests, controlling for Type 1 error using the Bonferroni adjustment, no significant results were found between groups. Therefore, the analysis of the data in this study suggests that opinion on criteria importance did not differ, with statistical significance, depending on the region of the UK in which the expert was based.
- *Does opinion on criteria importance differ depending on the expert's age?* For 19 (95%) out of the 20 criteria the results suggest that the professionals' age had no influence on the rankings of criteria importance given. The statistical analysis concluded that for one (5%) out of the 20 criteria, age did affect the ranking of criteria importance given. Specifically, for 'rental costs in relation to income' 46-55 year olds gave statistically significantly higher rankings of importance compared to 26-35 year olds.
- *Does opinion on criteria importance differ depending on the expert's gender?* Overall the results demonstrated that there was a statistically significant difference in opinion regarding criteria importance, with females placing statistically significantly more importance on 14 (70%) out of the 20 sustainable housing affordability criteria, in comparison to males. Statistically significant differences were found on all criteria representing accessibility to amenities and facilities. Accordingly, the results of this study indicate that the respondents' gender did influence the rankings of criteria importance given for a large amount of the housing affordability criteria considered.

- The fact that no significant results were found when comparing opinions on criteria importance by the region of the UK in which the expert is based can be seen as promising for the research. This indicates that the ratings of criteria importance (weights) are consistent across different regions of the UK and they can be used with certainty within the sustainable housing affordability assessment model. The criteria weightings established can thus be deemed relevant for all regions within the UK.

Chapter 8

Data analysis stage 3: Model development

8.1. Introduction

This chapter presents the data collected for the development of the sustainable housing affordability assessment model. The stages of the methodology remaining for the development and validation of the model are as follows:

1. Define measurement tools for the assessment criteria
2. Case study assessment:
    a. Select alternative areas for comparison
    b. Calculate criteria values for each alternative
    c. Comparative analysis and selection of MCDM method for the assessment
    d. Carry out MCDM assessment using chosen method

Stage 2d, the validation of the model, is presented in chapter 9. This chapter concerns the prior stages.

8.2 Criteria measurement tools

The first stage required in order to validate the model is to establish the way in which the 20 sustainable housing affordability assessment criteria (identified in stage 1) can be measured. It is essential to define measurement tools for each assessment criterion so as to facilitate the use MCDM methods, not only in the case study assessment but also for potential commercial use.

For some criteria data was available that could be used directly for their measurement. However, this was not possible for all criteria; it was thus necessary to develop measurement scales in order to assess certain criteria. This chapter explains the measurement tools that have been identified or developed for each criterion.

The measurements of the criteria are discussed from the perspective of assessing an area, at electoral ward level (see 5.10.1).

The measurement tools identified and developed for the 20 sustainable housing affordability assessment criteria are as follows:

- **C_1: house prices in relation to income**

This criterion is assessed by equating the average house price to income ratio for the area under assessment. The ratio is calculated by dividing the house price by household income. House prices are calculated by taking an average price of different tenures (detached, semi detached, terraced and flats) that have been sold within the area under assessment.

C_1 has a negative influence, i.e. a higher score is worse for the housing affordability assessment.

- **C_2: rental costs in relation to income**

This factor is assessed by calculating the average percentage (%) of income spent on rent for the area under assessment. Average rental costs within the area under assessment (calculated by the average of one, two, three and four bed properties) and average household income are used.

C_2 has a negative influence, i.e. a higher score is worse for the housing affordability assessment.

- C_3: **interest rates and mortgage availability**

This criterion is assessed in two parts: Part A) 'interest rates' and Part B) 'mortgage availability'.

Part A) is assessed using the UK (Bank of England) Base Rate (%) plus the typical variable mortgage rate (%). Once the overall rate of interest is established it is subsequently multiplied by a coefficient of five. Such a coefficient is used because a buyer on average saves for around five years in order to pay a mortgage deposit. The quoted interest rate on the mortgage is per year. Therefore, to make the weight of the interest rate and mortgage availability (part B) even within the analysis, the interest rate is multiplied by five. This figure could obviously change depending on the local situation.

Part B) is assessed by determining the average loan-to-value (TLV) ratio (%) for house purchasers. Once this is determined the average LTV ratio is subtracted from a potential 100% ratio in order to obtain a negative value, i.e. the percentage remaining that the purchaser would need to cover by a deposit in order to obtain a mortgage.

Subsequently, the values calculated for Part A (interest rates) and Part B (mortgage availability) are combined in order to obtain a final score for this criterion.

C_3 has a negative influence, i.e. a higher score is worse for the housing affordability assessment.

- C_4: **availability of (private and social) rented accommodation**

This factor is assessed in two parts: Part A) 'availability of private rented housing' and Part B) 'availability of social rented housing'.

Part A) is assessed by determining the quantity of private rented properties available on the market within the area to be assessed. Then the value is expressed as a percentage of the total residential stock in the area under assessment.

Part B) is also assessed by determining the quantity of social rented properties available on the market within the area to be assessed. Then the value is expressed as a percentage of the total residential stock in the area under assessment.

The values for part A and part B are then combined in order to obtain an overall score for this factor.

C_4 has a positive influence, i.e. a higher score is better for the housing affordability assessment.

➢ **C_5: availability of low cost home ownership products**

Availability of low cost home ownership products is assessed by determining the quantity of properties available on the market within the area to be assessed. Subsequently, the quantity (number of available properties) is converted into a corresponding score as follows:

Quantity of low cost home ownership properties	Score
0	1
1-2	2
3-5	3
6-9	4
10+	5

This scoring system was developed because in some areas it is likely that no (zero) 'low cost home ownership products' will be available. However, the use of zero (0) values within MCDM assessments can sometimes be problematic. Where possible, it is therefore better to establish a scoring system so as to eliminate the use of zero values.

C_5 has a positive influence, i.e. a higher score is better for the housing affordability assessment.

- **C_6: availability of market value home ownership properties**

Availability of market value home ownership properties is assessed by determining the quantity of properties available on the market within the area to be assessed. Subsequently the value is expressed as a percentage of the total residential stock in the area under assessment.

C_6 has a positive influence, i.e. a higher score is better for the housing affordability assessment.

- **C_7: safety/crime**

This attribute is measured by the crime rate within the area under assessment. The rate is for 'all crime per 1,000 persons'.

C_7 has a negative influence, i.e. a higher score is worse for the housing affordability assessment.

- **C_8: access to employment**

This factor is assessed by examining the distance to employment opportunities. Distance to employment opportunities is calculated by determining access to key employment sites by public transport (an indicator developed by the Department for Transport (DfT) and used by local authorities for accessibility planning) based on the following accessibility scale and associated value:

Distance key employment sites	Associated score
High – Key employment site within 15 minutes by public transport	3
Moderate – Key employment site within 30 minutes by public transport	2
Low – Key employment site over 30 minutes away by public transport	1

Employment deprivation is also important to consider for C_8. For example looking at claimants of jobseeker's allowance, a benefit paid to people who are unemployed, but who are available for, and actively seeking work. However, this aspect is covered by the measurement tool used for C_{20} which considers several aspects of area deprivation, including employment deprivation.

C_8 has a positive influence, i.e. a higher score is better for the housing affordability assessment.

- **C_9: access to public transport facilities**

Access to public transport is assessed in two parts: Part A) 'access to bus stops' and Part B) 'access to railway stations'. Access to each service is assessed separately then the values are combined to obtain a final score for the area under assessment. In line with the DFT guidance and accessibility standards specified in 'Shaping Neighbourhoods' by Barton *et al.* (2003), a distance of 400m (5 minutes walk) to a bus stop and 800m (10 minutes walk) to a rail station are indicators of good accessibility to public transport services. On the basis of such standards, the following accessibility scales were determined:

Part A) Access to bus stops:

Access	Associated score
High – Bus stop within 400m	3
Moderate – Bus stop within 800m	2
Low – Bus stop over 800m away	1

Part B) Access to railway stations:

Access	Associated score
High – Railway within 800m	3
Moderate – Railway within 1200m	2
Low – Railway over 1200m away	1

C_9 has a positive influence, i.e. a higher score is better for the housing affordability assessment.

- ***C_{10}*: access to good quality schools**

This criterion is assessed in two parts: Part A) 'proximity to good quality primary schools' and Part B) 'proximity to good quality secondary schools'. Both parts are assessed using separate accessibility scales and then the scores are combined to obtain an overall value for this criterion. Furthermore, Ofsted evaluation data is used to determine the quality of the schools. Ofsted inspects all state schools in England and provides an overall assessment of a school's performance. Ofsted makes judgements of school quality on a four point scale: 1 = outstanding, 2 = good, 3 = satisfactory, 4 = inadequate. Only outstanding and good quality rated schools are considered in the assessment. Consequently, if an area under assessment has access to schools (within the boundaries shown in the access tables below) that are rated as satisfactory or inadequate quality then they would not be included.

The following access scales have been established on the basis of the neighbourhood accessibility standards laid out by Barton *et al.* (2003):

Part A) Proximity to good quality primary schools:

Access to primary	Associated score
High – Outstanding/good quality schools within 800m *	3

Moderate – Outstanding/good quality schools within 1200m	2
Low – Outstanding/good quality schools over 1200m away	1

* Barton *et al.* (2003)

Part B) Proximity to good quality secondary schools:

Access to secondary	Associated score
High – Outstanding/good quality schools within 1200m*	3
Moderate – Outstanding/good quality schools within 2000m	2
Low – Outstanding/good quality schools over 2000m away	1

* Barton *et al.* (2003)

Education attainment is also important to consider for C_{10}. However, this aspect is covered by the measurement tool used for C_{20} which considers several aspects of area deprivation. Incorporated within the assessment of deprivation is 'education, skills and training deprivation' which includes an analysis of education attainment for both primary and secondary education.

C_{10} has a positive influence, i.e. a higher score is better for the housing affordability assessment.

➢ **C_{11}: access to shopping facilities**

This factor is assessed by considering access to local or district centres. Local centres are defined as having a supermarket and/or a range of small food shops, a newsagent, chemist and post office. District Centres contain at least one supermarket or superstore, a range of non-retail services, such as banks and restaurants, a post office, a chemist, as well as local public facilities such as a library. Good accessibility to a local centre or supermarket is considered to be 800m (10 minutes walk) (Barton *et al.*, 2003). Using this as a basis for good accessibility, the following access scale was developed:

Access to shops	Associated score
High – Local/district centre within 800m	3
Moderate – Local/district centre within 1200m	2
Low – Local/district centre over 1200m away	1

C_{11} has a positive influence, i.e. a higher score is better for the housing affordability assessment.

- **C_{12}: access to health care**

This criterion is measured in three parts: Part A) 'access to GPs', Part B) 'access to pharmacies' and Part C) 'access to hospitals'. Each service is assessed separately and then the three scores are combined to obtain an overall value for this criterion. The following access scales were developed based on accessibility scales used in Barton *et al.* (2003) and DFT (2010):

Access scale for Part A and Part B:

Access to GPs and pharmacies	Associated score
High – Amenity within 800m*	3
Moderate – Amenity within 1200m	2
Low – Amenity over 1200m away	1

* Barton *et al.* (2003)

The core national accessibility indicators, developed by central government, examine access to hospitals by the 'percentage of households within 30 minutes and 60 minutes from a hospital by public transport' (DFT, 2010). Accordingly, in order to develop an accessibility scale for Part C a distance of 30 minutes by public transport was used as an indication of good accessibility to hospitals. Subsequently the following access scale was developed:

Access scale for Part C:

Access to hospitals	Associated score
High – Hospital within 30minutes by public transport	3
Moderate – Hospital within 60minutes by public transport	2
Low – Hospital over 60minutes away by public transport	1

C_{12} has a positive influence, i.e. a higher score is better for the housing affordability assessment.

- ***C*₁₃: access to child care**

This criterion is assessed in two parts: Part A) 'child care sufficiency' and Part B) 'access to child care'. Each is scored separately and then the two scores are combined to obtain a final value. Part A is assessed using Childcare Sufficiency Assessment data. Local authorities are required to carry out Childcare Sufficiency Assessments under the Childcare Act 2006. Local authorities must ensure that there is sufficient, quality, flexible, and sustainable childcare for parents and carers (LCC, 2011b). Childcare sufficiency is defined as 'sufficient to meet the requirements of parents in the area who require childcare in order for them to take up or remain in work or to undertake education or training which could reasonably be expected to assist them to obtain work' (ibid, p.1). Childcare sufficiency is rated as 'green', 'amber' or 'red': where 'green' is 'sufficient' and 'red' is 'limited'. Accordingly the following measurement scale was developed:

Part A) Child care sufficiency:

Sufficiency	Associated score
Sufficient	3
Potential for undersupply	2
Limited	1

Part B is assessed by determining the distance to children's centres and day nurseries. Barton *et al.* (2003) stipulate that 600m is an indication of reasonable accessibility to a nursery. Accordingly, on that basis the following access scale was developed:

Part B) Access to child care (children's centre/nursery):

Access to child care	Associated score
High – amenities within 600m	3
Moderate – amenities within 1000m	2
Low – amenities over 1000m away	1

C_{13} has a positive influence, i.e. a higher score is better for the housing affordability assessment.

- **C_{14}: access to leisure facilities**

Access to leisure facilities is evaluated in two parts: Part A) 'access to children's playgrounds/play areas' and Part B) 'access to fitness/leisure centres'. Each is scored separately and then the values are combined to achieve a final score.

For Part A, government guidance suggests that children's play facilities should be within 400m from home (Mayor of London, 2004). Accordingly, the following accessibility scale was developed:

Part A) Access to play areas:

Access to play areas	Associated score
High – play area within 400m	3
Moderate – play area within 800m	2
Low – play area over 800m away	1

For Part B, accessibility standards in Barton *et al.* (2003) indicate that households should have access to a leisure centre within around 1500m from home. Accordingly, the following access scale was developed:

Part B) Access to fitness/leisure centres:

Access to fitness/leisure	Associated score
High – facilities within 1500m	3
Moderate – facilities within 2000m	2
Low – facilities over 2000m away	1

C_{14} has a positive influence, i.e. a higher score is better for the housing affordability assessment.

- **C_{15}: access to open green public space**

This factor is evaluated by determining the distance to publically accessibly open green spaces. Guidance used by local authorities suggests that all residents should have access to an area of publically accessible open space within 400m from home (Barton *et al.*, 2003; CABE, 2009). Therefore, the following access scale and scoring system was developed:

Access to open space	Associated score
High – Public park/green space within 400m	3
Moderate – Public park/green space within 800m	2
Low – Public park/green space over 800m away	1

C_{15} has a positive influence, i.e. a higher score is better for the housing affordability assessment.

➢ **C_{16}: presence of environmental problems**

This criterion is assessed using an indicator that represents environmental conditions and liveability. The indicator used is the 'rate (%) of dwellings with environmental problems present'. This data is published within local authorities' house condition surveys, a requirement by the government. Environmental problems of liveability are specifically related to:

- *Upkeep* - The upkeep, management or misuse of private and public space and buildings. Specifically, the presence of: scruffy or neglected buildings, poor condition housing, graffiti, scruffy gardens or landscaping, rubbish or dumping, vandalism, dog or other excrement, nuisance from street parking;
- *Utilisation* - Abandonment or non-residential use of property. Specifically: vacant sites, vacant or boarded up buildings, intrusive industry;
- *Traffic* - Road traffic and other forms of transport. Specifically the presence of: intrusive motorways and main roads, railway or aircraft noise, heavy traffic and poor ambient air quality (LCC, 2011d, p. 113).

C_{16} has a negative influence, i.e. a higher score is worse for the housing affordability assessment.

- ➢ **C_{17}: quality of housing**

The measurement of housing conditions is conducted within the decent homes framework. A decent home is one that satisfies all of the following four criteria (LCC, 2011d):

- It meets the current statutory minimum standard for housing;
- It is in a reasonable state of repair;
- It has reasonably modern facilities and services;
- It provides a reasonable degree of thermal comfort.

This criterion is analysed in two parts: Part A) 'the rate (%) of private sector properties meeting Decent Homes Standard' (within the area to be assessed); and Part B) 'the rate (%) of social housing meeting Decent Homes Standard' (within the area to be assessed). An average of the two figures is then taken in order to establish an overall housing quality value (%) for the area under assessment.

C_{17} has a positive influence, i.e. a higher score is better for the housing affordability assessment.

- ➢ **C_{18}: energy efficiency of housing**

The value for this criterion is determined by using Standard Assessment Procedure (SAP) ratings. SAP ratings are used to measure the energy efficiency of a home by taking into account factors such as property type, construction materials, insulation and the efficiency of heating systems. The SAP index is based on calculated annual space and water heating costs for a standard heating regime. The SAP rating is expressed on a scale of 1 - 100 where a rating of 1 has poor energy efficiency (high costs) and a dwelling with a rating of 100 represents a completely energy efficient dwelling (zero net energy costs per year).

C_{18} has a positive influence, i.e. a higher score is better for the housing affordability assessment.

- **C_{19}: availability of waste management facilities**

This criterion is assessed using the national performance indicator (NI 192): 'percentage (%) of household waste sent for recycling, composting or reuse', a sustainable communities indicator used in the Egan Review: Skills for Sustainable Communities (ODPM, 2004). The national performance indicators were set up to measure local authorities' performance and report to central UK government.

C_{19} has a positive influence, i.e. a higher score is better for the housing affordability assessment.

- **C_{20}: deprivation in area**

Deprivation is measured by the 'percentage of the area (under assessment) in the most deprived 10% nationally' using the Index of Multiple Deprivation (IMD). The IMD combines a range of economic, social and housing indicators to provide a comprehensive picture of deprivation and identify the most disadvantaged areas in England (CLG, 2011b). Deprivation is assessed by examining factors such as income deprivation, employment deprivation, health deprivation and disability, education, skills and training deprivation, barriers to housing and services, crime and living environment deprivation (ibid).

C_{20} has a negative influence, i.e. a higher score is worse for the housing affordability assessment.

8.2.1 Summary of criteria measurement tools

A summary of the measurement tools that have been established and developed to assess the 20 sustainable housing affordability assessment criteria are provided in table 24. Where access scales have been developed, geographic information systems (GIS) can be used in order to assist in measuring accessibility. For example, GIS or other mapping facilities could be used to aid in the assessment of the following criteria (representing access to key services and facilities):

- C_8. Access to employment
- C_9. Access to public transport
- C_{10}. Access to schools
- C_{11}. Access to shopping facilities
- C_{12}. Access to health services
- C_{13}. Access to child care
- C_{14}. Access to leisure facilities
- C_{15}. Access to open green public spaces

Table 24. Summary of measurement tools for sustainable housing affordability assessment criteria

	Criteria	+/-	Measurement tool
1	House prices in relation to income	-	House price-to-income ratio
2	Rental costs in relation to income	-	% of income spent on rent
3	Interest rates and mortgage availability	-	Part A) UK (Bank of England) base rate (%) + typical variable mortgage rate (%); and Part B) Average LTV ratio (%)
4	Availability of rented accommodation (private and social)	+	Quantity available on the market (expressed as a % of total residential stock)
5	Availability of low cost home ownership products	+	Quantity available on the market
6	Availability of market value home ownership products	+	Quantity available on the market (expressed as a % of total residential stock)
7	Safety/crime	-	Crime rate per 1000 population

8	Access to employment	+	Proximity to key employment using access scale
9	Access to public transport services	+	Part A) Access to bus stops; and Part B) Access to railway stations
10	Access to good quality education/schools	+	Proximity to outstanding and good quality rated schools (using Ofsted) using access scale: Part A) Access to primary; and Part B) Access to secondary
11	Access to shopping facilities	+	Proximity to local/district centres using access scale
12	Access to health services	+	Proximity to GP's, pharmacies and hospitals using access scales
13	Access to early years child care	+	Part A) Childcare sufficiency; and Part B) Proximity to child care using access scale
14	Access to leisure facilities	+	Proximity to leisure using access scale: Part A) Fitness centres; and Part B) Children's play areas
15	Access to open green public space	+	Proximity to open green public space using access scale
16	Presence of environmental problems	-	% of dwellings with environmental problems present
17	Quality of housing	+	Part A) % of private sector properties compliant with Decent Homes Standard; and Part B) % of social housing compliant with Decent Homes Standard
18	Energy efficiency of housing	+	Average SAP rating of housing stock
19	Waste management	+	% of household waste sent for reuse, recycling and composting
20	Deprivation in area	-	% of area in most deprived 10% nationally (using the Index of Multiple Deprivation)

* The sign (+/-) indicates that a greater/lesser criterion value satisfies sustainable housing affordability

8.3 Data required for case study assessment

In order to provide a case study assessment of sustainable housing affordability using MCDM methodology, there are a number of data requirements that must be met. The data collection required for the use of MCDM methods was summarised in figure 9. The first two stages have already been achieved; the data required for the remaining stages are considered in this section.

8.3.1 Stage 1: Determine sustainable housing affordability criteria

A total of 20 sustainable housing affordability assessment criteria were identified via literature review and interviews with professionals, a summary of the assessment criteria is provided in table 13.

8.3.2 Stage 2: Determine criteria weights

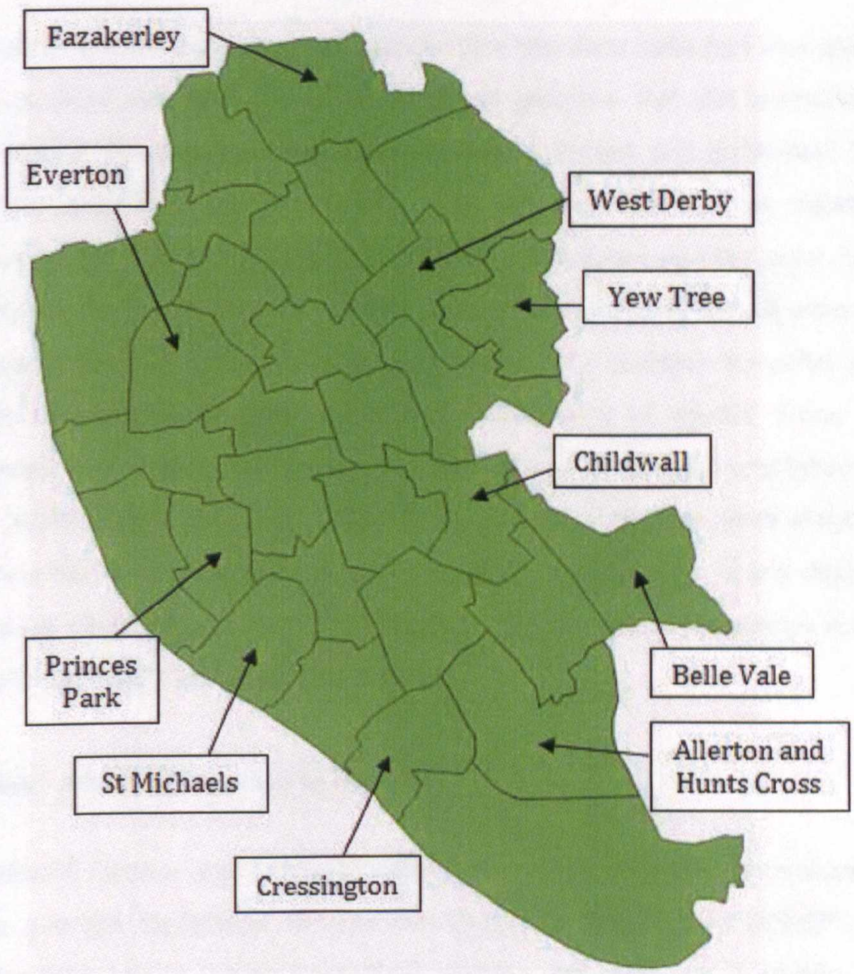
Individual criteria weights, reflecting significance of the criteria, were elicited by professionals and are detailed in table 19.

8.3.3 Stage 3: Selecting alternatives for comparison

In this study the 'alternatives' represent the different areas that are being compared and assessed to determine their sustainable housing affordability. To provide a practical example of the assessment model, a number of different areas (wards) within Liverpool were selected for a case study comparison. 10 areas (wards) were randomly selected, from the 30 wards that comprise Liverpool, to be used within the case study assessment. The selected case study areas are illustrated on a map of Liverpool (figure 31) and satellite images of each area can be found in Appendix 7. For reference purposes the case study areas are numbered as follows:

1. Everton
2. Childwall
3. West Derby
4. Cressington
5. Allerton and Hunts Cross
6. Yew Tree
7. Belle Vale
8. Princes Park
9. Fazakerley
10. St Michaels

Figure 31. Map of Liverpool showing case study areas



Source: Self study

8.3.4 Stage 4: Calculating criteria values for each alternative

The measurement tools that can be used in order to calculate values for the 20 sustainable housing affordability assessment criteria are explained in 8.2. This section adopts such measurement tools in order to calculate criteria values for each alternative area (ward) within the case study assessment. Note that the use of '+ve' and '-ve' signs next to calculated criteria scores indicates whether a greater (+ve) or lesser (-ve) value has a positive effect on the sustainable housing affordability assessment/needs of the decision maker.

For each criterion efforts were made to ensure that the data collected was obtained from reliable sources and that it was as timely as possible. For the overwhelming majority of criteria, the data that was sourced was collected and published during 2011-2012. The only instance where this was not possible was in relation to household income (used to asses C_1 and C_2) where a 2010 figure was the most reliable and recent that could be obtained. Criterion values were sourced for all alternative areas on the same day and using the same data source. For example, for criteria such as 'availability of rented accommodation' and 'availability of market value home ownership properties' it is possible that the quantity of properties available could change daily. Accordingly, data was collected on the same day for each alternative area to ensure a fair data collection as far as possible. Accordingly, if any data were lagging then each alternative area would be affected in the same manner so it would create no bias in the final ranking of alternatives.

- **C_1: House prices in relation to income**

Average household income and average house prices were required to evaluate this criterion. The average household income for Liverpool (2010) was £29,285 (LCC, 2012). Unfortunately more recent household income data was not available at the time of the case study analysis. House prices were complied by taking an average price from different tenures (detached, semi detached, terraced and flats) sold within the area.

The average household income figure for Liverpool (£29,285) was used in order to calculate the average house price to income ratio for each case study area as follows:

Area	Average house price*	Ratio (-ve)
1. Everton	£103,208	3.5
2. Childwall	£142,039	4.9

3. West Derby	£137,326	4.7
4. Cressington	£144,446	4.9
5. Allerton and Hunts Cross	£150,529	5.1
6. Yew Tree	£116,804	4
7. Belle Vale	£139,241	4.8
8. Princes Park	£106,581	3.6
9. Fazakerley	£110,964	3.8
10. St Michaels	£138,334	4.7

*Source: Land Registry, as cited by Rightmove, March/April 2012 (Land Registry provides the most accurate house price data in England and Wales)

➢ C_2: **Rental costs in relation to income**

As the average household income for Liverpool is £29,285 (LCC, 2012) then the average monthly household income can therefore be calculated as roughly £2,440 (£29,285/12 = £2440). Using this average monthly household income figure, the average percentage of income spent on rental costs was calculated as follows for each area:

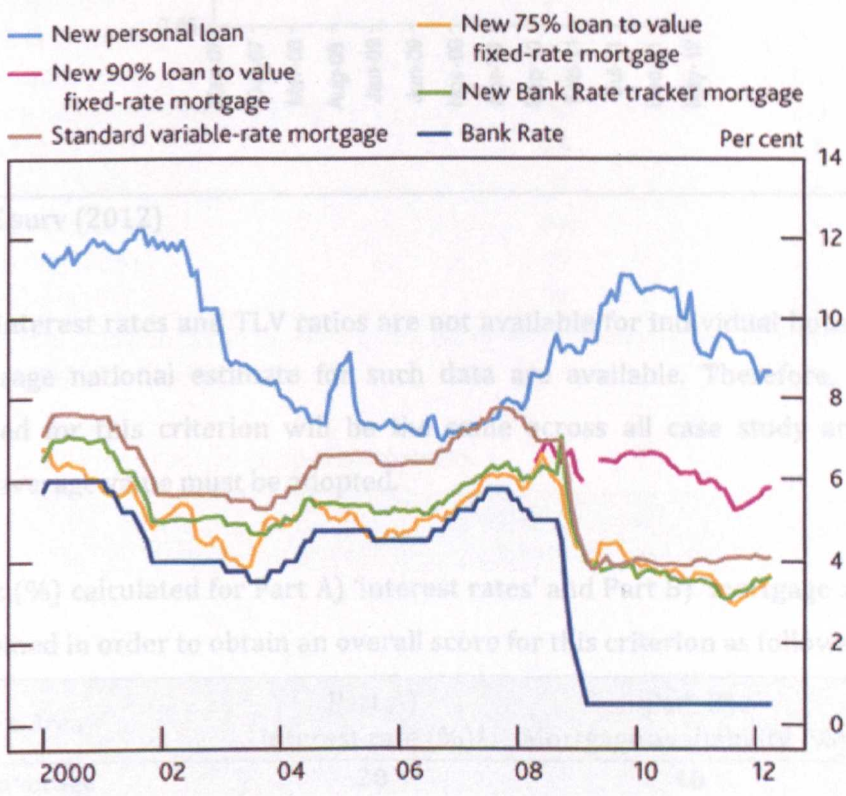
Area	Average rent*	% income spent on rent (-ve)
1. Everton	£462	19
2. Childwall	£742	30
3. West Derby	£582	24
4. Cressington	£685	28
5. Allerton and Hunts Cross	£673	28
6. Yew Tree	£576	24
7. Belle Vale	£705	29
8. Princes Park	£734	30
9. Fazakerley	£561	23
10. St Michaels	£619	25

*Source: www.nestoria.co.uk, April 2012

➢ C_3: **Interest rates and mortgage availability**

Part A) Interest rates: At the time of writing the UK Bank of England base rate is 0.5%, while typical standard variable rate mortgages are around 3.5% above the base rate (Bank of England, 2012). Figure 32 displays the Bank of England bank rate and average quoted interest rates on household borrowing. The interest rate data quoted by the Bank of England (2012) are weighted averages of rates from a sample of banks and building societies. Accordingly, the overall average rate of interest on standard variable rate mortgages is approximately 4% (as of summer 2012). The interest rate is then multiplied by a coefficient of 5. Accordingly, the total rate of interest is 20% (4% x 5).

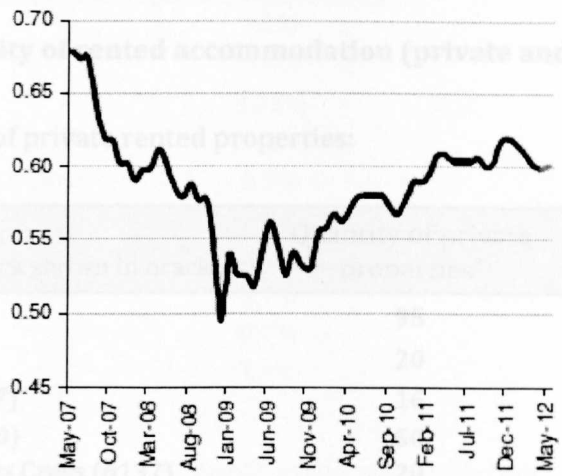
Figure 32. Bank Rate and average quoted interest rates on household borrowing



Source: Bank of England (2012)

Part B) Mortgage availability: At the time of writing the average loan-to-value (LTV) ratio on home purchases is around 60% (figure 33). Accordingly, deducting this figure from a potential 100% mortgage (100% - 60%) means that there is on average 40% remaining on the value of a property which needs to be covered by the purchaser.

Figure 33. Average loan-to-value (LTV) ratio for home purchases



Source: E.surv (2012)

Data on interest rates and TLV ratios are not available for individual housing wards; only average national estimate for such data are available. Therefore, the values established for this criterion will be the same across all case study areas as the national average value must be adopted.

The rates (%) calculated for Part A) 'interest rates' and Part B) 'mortgage availability' are combined in order to obtain an overall score for this criterion as follows:

Area	Part A) Interest rate (%)[1]	Part B) Mortgage availability (%)[2]	Score (-ve)
National average	**20**	**40**	**60**
1. Everton	20	40	60
2. Childwall	20	40	60

3. West Derby	20	40	60
4. Cressington	20	40	60
5. Allerton and Hunts Cross	20	40	60
6. Yew Tree	20	40	60
7. Belle Vale	20	40	60
8. Princes Park	20	40	60
9. Fazakerley	20	40	60
10. St Michaels	20	40	60

[1]Source: Bank of England (2012)
[2]Source: E.surv (2012)

➢ **C_4: Availability of rented accommodation (private and social)**

Part A) Availability of private rented properties:

Area (total residential stock shown in brackets)	Quantity of private properties*	% of total stock
1. Everton (8248)	95	1.2
2. Childwall (5699)	20	0.4
3. West Derby (6157)	16	0.3
4. Cressington (6540)	50	0.8
5. Allerton and Hunts Cross (6137)	20	0.3
6. Yew Tree (7138)	35	0.5
7. Belle Vale (6644)	8	0.1
8. Princes Park (9107)	94	1.0
9. Fazakerley (6861)	49	0.7
10. St Michaels (6777)	96	1.4

*Source: www.rightmove.co.uk, June 2012 (over 90% of all UK estate agents advertise their properties on Rightmove)

Part B) Availability of social rented properties:

Area (total residential stock shown in brackets)	Quantity of social properties*	% of total stock
1. Everton (8248)	5	0.1
2. Childwall (5699)	0	0
3. West Derby (6157)	1	0.02
4. Cressington (6540)	1	0.02
5. Allerton and Hunts Cross (6137)	0	0
6. Yew Tree (7138)	8	0.1
7. Belle Vale (6644)	0	0

8. Princes Park (9107)	7	0.1
9. Fazakerley (6861)	0	0
10. St Michaels (6777)	0	0

*Source: www.propertypool.org.uk, June 2012 (all available social properties in Liverpool are detailed on PropertyPool)

To obtain an overall value for C_4 the values from part A and part B are combined:

Area	Overall score (+ve)
1. Everton	1.3%
2. Childwall	0.4%
3. West Derby	0.32%
4. Cressington	0.82%
5. Allerton and Hunts Cross	0.3%
6. Yew Tree	0.6%
7. Belle Vale	0.1%
8. Princes Park	1.1%
9. Fazakerley	0.7%
10. St Michaels	1.4%

➢ **C_5: Availability of low cost home ownership products**

Area	Quantity of properties available on the market	Score (+ve)
1. Everton	2	2
2. Childwall	0	1
3. West Derby	1	1
4. Cressington	0	1
5. Allerton and Hunts Cross	1	2
6. Yew Tree	1	2
7. Belle Vale	3	3
8. Princes Park	3	3
9. Fazakerley	0	1
10. St Michaels	1	2

Source: www.homeshub.co.uk, June 2012 (HomesHub is the affordable homes specialist for Merseyside and Cheshire)

➢ **C_6: Availability of market value home ownership products**

Area (total residential stock shown in brackets)	Quantity of properties available on the market	% of total stock (+ve)
1. Everton (8248)	90	1.1
2. Childwall (5699)	160	2.8
3. West Derby (6157)	140	2.3
4. Cressington (6540)	177	2.7
5. Allerton and Hunts Cross (6137)	163	2.7
6. Yew Tree (7138)	176	2.5
7. Belle Vale (6644)	89	1.3
8. Princes Park (9107)	97	1.1
9. Fazakerley (6861)	161	2.3
10. St Michaels (6777)	206	3

Source: www.rightmove.co.uk, June 2012 (over 90% of all homes for sale in the UK are listed on Rightmove)

➢ **C_7: Safety**

Area	Crime rate per 1,000 Population (2010/11) (-ve)
1. Everton	135
2. Childwall	39
3. West Derby	58
4. Cressington	41
5. Allerton and Hunts Cross	57
6. Yew Tree	56
7. Belle Vale	65
8. Princes Park	135
9. Fazakerley	89
10. St Michaels	75

Source: LCC (2011a)

➢ **C_8: Access to employment opportunities**

Area	Accessibility to key employment sites*	Score (+ve)
1. Everton	High	3
2. Childwall	High	3
3. West Derby	High	3

4. Cressington	High	3
5. Allerton and Hunts Cross	High	3
6. Yew Tree	Moderate	2
7. Belle Vale	High	3
8. Princes Park	High	3
9. Fazakerley	High	3
10. St Michaels	High	3

* Source: Merseyside Transport Partnership (2011) (see figure 34)

Figure 34. Map showing accessibility to key employment sites by public transport across Merseyside

➢ C_9: **Access to public transport services**

Area	Buses*	Rail*	Overall score (+ve)
1. Everton	3	1	4
2. Childwall	2	1	3
3. West Derby	3	1	4
4. Cressington	2	3	5

5. Allerton and Hunts Cross	2	2	4
6. Yew Tree	3	1	4
7. Belle Vale	3	1	4
8. Princes Park	3	2	5
9. Fazakerley	2	3	5
10. St Michaels	3	3	6

*Source: Self study using GIS maps (Appendix 8)

Determining criteria values for C_9 entailed making some subjective assessments where areas were between scores. For example, for access to buses, Everton, Yew Tree and St Michaels scored high (3 points) for the majority of the ward, but there were some parts of the areas that only scored as moderate (2 points). However, in St Michaels, for example, a large part of the area not covered by the 400m bus route and 800m train station boundaries consists of parks and green space, as opposed to residential properties. Accordingly the area was given a high score (3 points) instead of moderate (2 points). Similarly, for Yew Tree a large part of the area not covered by the 400m bus route boundary consists of a golf course, as opposed to residential properties. Consequently the ward was also given a high score (3 points) instead of moderate (2 points).

➢ **C_{10}: Access to good quality schools**

Area	Part A) Access to primary	Part B) Access to secondary	Overall score (+ve)
1. Everton	3	2	5
2. Childwall	3	3	6
3. West Derby	3	2	5
4. Cressington	3	2	5
5. Allerton and Hunts Cross	2	2	4
6. Yew Tree	2	2	4
7. Belle Vale	2	1	3
8. Princes Park	3	2	5
9. Fazakerley	3	3	6
10. St Michaels	3	3	6

Source: Self study using GIS maps (Appendix 9)

It should be noted that in some of the areas under assessment that achieved a 'moderate' (2) or 'low' (1) score, there were primary and secondary schools located within the 'high' accessibility boundary in terms of distance. However, if such schools were only rated as satisfactory or poor quality they were not considered because the assessment focuses on access to good and outstanding quality schools only. For example, a number of the schools (both primary and secondary) mapped for Belle Vale were only satisfactory quality. Thus, although they were within the 'high' accessibility boundary, they were not considered since such schools did not meet the required quality rating.

- ***C*$_{11}$: Access to shopping facilities**

Area	Local centre within ward	District centre within ward	Access	Score (+ve)
1. Everton	Yes	Yes	High	3
2. Childwall	No	No	Low	1
3. West Derby	Yes	No	Moderate	2
4. Cressington	No	On boundary	Moderate	2
5. Allerton and Hunts Cross	Yes	On boundary	High	3
6. Yew Tree	No	No	Low	1
7. Belle Vale	No	Yes	Moderate	2
8. Princes Park	Yes	On boundary	High	3
9. Fazakerley	No	No	Low	1
10. St Michaels	No	Yes	High	3

Source: Self study using GIS maps (Appendix 10)

- ***C*$_{12}$: Access to health services**

Area	Part A) GPs	Part B) Pharmacies	Part C) Hospitals	Overall score (+ve)
1. Everton	3	3	3	9
2. Childwall	3	3	3	9
3. West Derby	3	3	3	9
4. Cressington	3	3	3	9
5. Allerton and Hunts Cross	3	3	3	9

6. Yew Tree	3	3	3	9
7. Belle Vale	3	3	3	9
8. Princes Park	3	3	3	9
9. Fazakerley	3	3	3	9
10. St Michaels	3	3	3	9

Source: Self study using GIS maps (Appendix 11)

➢ ***C_{13}*: Access to early years child care**

Part A) Child care sufficiency:

Area	Sufficiency*	Score (+ve)
1. Everton	Sufficient	3
2. Childwall	Sufficient	3
3. West Derby	Sufficient	3
4. Cressington	Sufficient	3
5. Allerton and Hunts Cross	Sufficient	3
6. Yew Tree	Sufficient	3
7. Belle Vale	Sufficient	3
8. Princes Park	Sufficient	3
9. Fazakerley	Sufficient	3
10. St Michaels	Sufficient	3

*Source: LCC (2011c)

Part B) Access to child care:

Area	Children's centre*	Day nurseries*	Access	Score (+ve)
1. Everton	Yes	Yes	High	3
2. Childwall	Yes	Yes	High	3
3. West Derby	Yes – On boundary	Yes	High	3
4. Cressington	No	Yes	Moderate	2
5. Allerton and Hunts Cross	Yes	Yes	High	3
6. Yew Tree	Yes	Yes	High	3
7. Belle Vale	Yes	Yes	High	3
8. Princes Park	Yes	Yes	High	3
9. Fazakerley	Yes	Yes	High	3
10. St Michaels	Yes – On boundary	Yes	High	3

*Source: LCC (2011c)

To obtain an overall score for C_{13} the values for part A and part B are combined:

Area	Part A) Sufficiency	Part B) Access	Overall score (+ve)
1. Everton	3	3	6
2. Childwall	3	3	6
3. West Derby	3	3	6
4. Cressington	3	2	5
5. Allerton and Hunts Cross	3	3	6
6. Yew Tree	3	3	6
7. Belle Vale	3	3	6
8. Princes Park	3	3	6
9. Fazakerley	3	3	6
10. St Michaels	3	3	6

➢ **C_{14}: Access to leisure facilities**

Area	Part A) Access to children's play areas[1]	Part B) Access to leisure centres[2]	Overall score (+ve)
1. Everton	3	3	6
2. Childwall	1	2	3
3. West Derby	2	3	5
4. Cressington	2	3	5
5. Allerton and Hunts Cross	2	2	4
6. Yew Tree	2	3	5
7. Belle Vale	2	2	4
8. Princes Park	2	3	5
9. Fazakerley	1	3	4
10. St Michaels	2	2	4

[1]Source: LCC (2005)

[2]Source: Self study using GIS maps (Appendix 12)

➢ **C_{15}: Access to open green public space**

Area	Access to green space	Score (+ve)
1. Everton	High	3
2. Childwall	High	3
3. West Derby	High	3
4. Cressington	High	3
5. Allerton and Hunts Cross	High	3
6. Yew Tree	High	3

7. Belle Vale	High	3
8. Princes Park	High	3
9. Fazakerley	High	3
10. St Michaels	High	3

Source: Self study using GIS maps (Appendix 13)

➢ **C_{16}: Presence of Environmental Problems**

Area	Environmental problems present (% of dwellings) (-ve)
1. Everton	24
2. Childwall	1.5
3. West Derby	29.3
4. Cressington	4
5. Allerton and Hunts Cross	21.1
6. Yew Tree	19.4
7. Belle Vale	15.9
8. Princes Park	13
9. Fazakerley	46.6
10. St Michaels	30.5

Source: LCC (2011d)

➢ **C_{17}: Quality of housing**

An overall score is established for this factor by taking an average of Part A) 'the rate of social housing meeting decent homes standard' and Part B) 'the rate of private housing compliant with decent homes standard':

Area	A) Decency of social housing (% of dwellings)[1]	B) Decency of private housing (% of dwellings)[2]	Overall score (average of A and B) (+ve)
1. Everton	92.6	52.1	72.4
2. Childwall	63	77.6	70.3
3. West Derby	91.4	46.8	69.1
4. Cressington	76.3	82.4	79.4
5. Allerton and Hunts Cross	88.2	84.2	86.2
6. Yew Tree	96.5	83.2	89.9
7. Belle Vale	94.8	60.1	77.5

8. Princes Park	90.1	55.4	72.8
9. Fazakerley	94.2	84	89.1
10. St Michaels	92.6	73.2	82.9

[1]Source: LCC (2011d)

[2]Source: Data provided by Liverpool Asset Management Project (LAMP) (2011)

- **C_{18}: Energy efficiency of housing**

Area	Average SAP rating of housing stock (+ve)
1. Everton	60
2. Childwall	55
3. West Derby	57
4. Cressington	53
5. Allerton and Hunts Cross	57
6. Yew Tree	64
7. Belle Vale	63
8. Princes Park	66
9. Fazakerley	61
10. St Michaels	68

Source: LCC (2011d)

- **C_{19}: Waste management**

Data on the 'percentage of household waste sent for reuse recycling and composting' was only available for Liverpool City Council as a whole. Therefore, a value for individual housing wards could not be obtained and hence the value for this criterion is the same across all case study areas:

Area	% household waste sent for reuse recycling and composting (2010/11) (+ve)
Liverpool City Council	**35**
1. Everton	35
2. Childwall	35
3. West Derby	35
4. Cressington	35
5. Allerton and Hunts Cross	35

6. Yew Tree	35
7. Belle Vale	35
8. Princes Park	35
9. Fazakerley	35
10. St Michaels	35

Source: DEFRA (2011)

➢ **C_{20}: Deprivation in area**

Area	% of area in most deprived 10% nationally (-ve)
1. Everton	97.6
2. Childwall	5
3. West Derby	5.2
4. Cressington	3.1
5. Allerton and Hunts Cross	0
6. Yew Tree	38.8
7. Belle Vale	83.5
8. Princes Park	93.7
9. Fazakerley	62.1
10. St Michaels	22.1

Source: LCC (2011a)

➢ **Measuring access to key services and facilities**

GIS mapping, provided by Liverpool City Council, was used in order to assist in measuring access to the following key service and facilities:

- C_9. Access to public transport services (example in Appendix 8)
- C_{10}. Access to schools (example in Appendix 9)
- C_{11}. Access to shopping facilities (example in Appendix 10)
- C_{12}. Access to health services (example in Appendix 11)
- C_{14}. Access to leisure facilities (example in Appendix 12)
- C_{15}. Access to open green public spaces (example in Appendix 13)

8.3.5 Stage 5: Create a decision making matrix

The next stage of the data collection for the use of MCDM methods is the creation of the initial decision making matrix (table 24). The matrix comprises all of the information needed for MCDM analysis, including the criteria describing the alternatives, criteria values, and criteria weights ωi, $i = 1, ..., m; j = 1, ..., n$, where m is the number of criteria (in this case, m = 20) and n is the number of the decision alternatives (areas) (in this case, n = 10).

8.3.6 Stage 6: Problem solving using appropriate MCDM method

Succeeding the construction of the initial matrix (table 24), a suitable MCDM method must be selected and applied to the data in order to process the values and prioritise the alternative areas. However, different MCDM methods can occasionally yield different results when applied to the same problem (Salminen *et al.*, 1998; Zanakis *et al.*, 1998). Accordingly, it was deemed necessary to test and compare several methods in order to aid in selecting an appropriate MCDM method for the sustainable housing affordability assessment model.

8.4 Comparisons of MCDM methods

A wide selection of methods exists for solving MCDM problems and a number of comparative studies have been presented in the literature (see 4.6). However, it must be acknowledged that selecting a suitable MCDM method will always be contingent on the structure of the particular decision problem concerned. Consequently, only methods that appeared appropriate for the problem under consideration were compared.

The comparative performance of a number of MCDM methods - the weighted sum model (WSM), the weighted product model (WPM), the revised AHP, TOPSIS, COPRAS and a modified version of COPRAS - was investigated. These techniques were applied to the practical case study data contained in the initial decision making matrix (table 25).

Table 25. Initial matrix for MCDM

	Criteria i	z	Measurement	Weight	Alternatives j									
					A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
1	House prices in relation to income	-	Ratio	0.063135	3.5	4.9	4.7	4.9	5.1	4	4.8	3.6	3.8	4.7
2	Rental costs in relation to income	-	%	0.063135	19	30	24	28	28	24	29	30	23	25
3	Interest rates and mortgage availability	-	%	0.058055	60	60	60	60	60	60	60	60	60	60
4	Availability of rented accommodation	+	%	0.058055	1.3	0.4	0.32	0.82	0.3	0.6	0.1	1.1	0.7	1.4
5	Availability of low cost homeownership products	+	Points	0.051524	2	1	1	1	2	2	3	3	1	2
6	Availability of market value home ownership products	+	%	0.04717	1.1	2.8	2.3	2.7	2.7	2.5	1.3	1.1	2.3	3
7	Crime	-	Rate	0.044267	135	39	58	41	57	56	65	135	89	75
8	Access to employment	+	Points	0.053701	3	3	3	3	3	2	3	3	3	3
9	Access to public transport	+	Points	0.049347	4	3	4	5	4	4	4	5	5	6
10	Access to good quality schools	+	Points	0.050073	5	6	5	5	4	4	3	5	6	6
11	Access to shopping facilities	+	Points	0.045718	3	1	2	2	3	1	2	3	1	3
12	Access to health services	+	Points	0.047896	9	9	9	9	9	9	9	9	9	9
13	Access to child care	+	Points	0.046444	6	6	6	5	6	6	6	6	6	6
14	Access to leisure	+	Points	0.039913	6	3	5	5	4	5	4	5	4	4
15	Access to open green public space	+	Points	0.043541	3	3	3	3	3	3	3	3	3	3
16	Presence of environmental problems	-	%	0.044267	24	1.5	29.3	4	21.1	19.4	15.9	13	46.6	30.5
17	Quality of housing in area	+	%	0.055152	72.4	70.3	69.1	79.4	86.2	89.9	77.5	72.8	89.1	82.9
18	Energy efficiency of housing in area	+	Rating	0.05225	60	55	57	53	57	64	63	66	61	68
19	Waste management in area	+	%	0.04209	35	35	35	35	35	35	35	35	35	35
20	Deprivation in area	-	%	0.044267	97.6	5	5.2	3.1	0	38.8	83.5	93.7	62.1	22.1

* The sign (+/-) indicates that a greater/lesser criterion value satisfies sustainable housing affordability

For each method, the aim is to determine the relative significance of each alternative under assessment, as well as establishing the priority order of the alternatives in respect of one another. The selected methods for the comparative analysis differ in their basic principles, the type of data normalization process and the way they combine the criteria values and the criteria weights into the evaluation procedure. The WSM, WPM, revised AHP and COPRAS methods are fairly similar in their normalisation procedure, although TOPSIS is somewhat different. These methods and algorithms have been discussed in more detail in chapter 4, though a simple summary of the methods is provided in this section.

8.4.1 WSM

The WSM generally only deals with positive criteria. Accordingly, for the use of this method it was necessary for negative (minimizing) criteria to be transformed into positive (maximizing) ones prior to normalization. The transformation of negative criteria into positive ones can be achieved by a simple process: for each negative criterion, add the maximum criterion value to the minimum criterion value and then subtract the criterion value under consideration. For example, using the data contained in the initial matrix for both positive and negative criteria (table 25), for C_1/A_3 the maximum criterion value of the row is 5.1, the minimum criterion value for the row is 3.5, while the value for A_3 is 4.7. Accordingly, the calculation would be as follows:

$$3.5 + 5.1 - 4.7 = 3.9$$

Succeeding such a transformation, the lowest criterion value becomes the largest and the largest value becomes the lowest; a higher value is now better for the decision maker. Following this transformation on negative criteria, a new initial matrix was created using only positive criterion values (table 26). Using the data contained in the new matrix (table 26), the normalized matrix can be created by dividing each criterion value by the sum of its row (see Appendix 14). Then each criterion value is multiplied by its corresponding weight. Finally, all the weighted normalized criteria values for each alternative are added together to obtain a final score. The alternative with the highest score is best.

8.4.2 WPM

Like for use of the WSM, the WPM also requires negative criteria to be transformed into positive ones prior to normalization. The remaining procedure for WPM is akin to the WSM, except the difference is there is multiplication of the weighted normalized criteria values - instead of addition - in order to obtain a final score for each alterative. However, the use of the WPM initially proved problematic owing to the '0' (zero) value assigned to C_{20}/A_5 within the initial matrix (table 25). This method does not seem to function well where criterion values of zero are used. Accordingly, in order to proceed and allow testing of this method the '0' value assigned to C_{20}/A_5 was changed to a value of '0.1' within the initial matrix (this figure was only amended for the use of this method). The subsequent stages of WPM were then carried out as normal on the amended data; i.e. the initial criteria (with the new value) were transformed into all positive criteria, then the normalized matrix was formed (Appendix 15) and finally the weighted normalized matrix was created (Appendix 16), allowing the calculation of the results.

8.4.3 Revised AHP (RAHP)

Only the final stages of the revised AHP, i.e. the processing of the numerical values, were required in this study. That is to say, the prior stage - the use of pairwaise comparisons to ascertain criteria weights (see 4.3.3) – was not necessary as weights had already been established. The RAHP method was tested in two different ways:

1. **First approach (RAHP 1)** – The first approach uses only positive criteria values within the assessment. Thus, as with the WSM and WPM, negative criteria were transformed into positive ones prior to normalization of the matrix (table 26).

This is the standard way of handling negative criteria with the AHP methods (Millet and Schoner, 2005).

2. **Second approach (RAHP 2)** - The second approach uses both positive and negative criteria values. Negative criteria were kept within the analysis by incorporating them as negative weights within the initial matrix (Appendix 18). In order to do so, weights for negative criteria were multiplied by -1.

The remaining stages of the RAHP process were the same for both approaches. The normalisation procedure of the RAHP involves dividing each relative criterion value by the maximum value of the relative values. Thus, the largest criterion value in each row will achieve a score of 1 in the normalised matrix (see Appendix 17 and 18). Subsequently, each normalised value is multiplied by its weight. Then, the sum of all the weighted normalised criteria values for each alternative is computed to obtain a final score for the alternative. The alternative with the highest score is best.

8.4.4 COPRAS and modified COPRAS

The COPRAS methods allow for both positive and negative criteria to be used within the analysis. In order to create a weighted normalized matrix each criterion value is multiplied by its weight and divided by the sum of its row (Appendix 19). For example, looking at the initial matrix (table 25), for C_1/A_1 the criterion value is 3.5, the criterion weight is 0.063135, while the sum of the row is 44. Accordingly, for C_1/A_1 the weighted normalised value is calculated as:

$$\overline{} \quad 0.00502$$

Subsequently, positive criteria values and negative criteria values are summed up separately for every alternative. The next stage is the calculation of the significance (Q_j) of each alternative; this is where COPRAS and the modified version differ.

Table 26. Initial matrix with all positive criteria

	Criteria i	Z	Weight	Alternatives j									
				1	2	3	4	5	6	7	8	9	10
1	House prices in relation to incomes	+	0.063135	5.1	3.7	3.9	3.7	3.5	4.6	3.8	5	4.8	3.9
2	Rental costs in relation to incomes	+	0.063135	30	19	25	21	21	25	20	19	26	24
3	Interest rates and mortgage availability	+	0.058055	60	60	60	60	60	60	60	60	60	60
4	Availability of rented accommodation	+	0.058055	1.3	0.4	0.32	0.82	0.3	0.6	0.1	1.1	0.7	1.4
5	Availability of low cost homeownership products	+	0.051524	2	1	1	1	2	2	3	3	1	2
6	Availability of market value home ownership products	+	0.04717	1.1	2.8	2.3	2.7	2.7	2.5	1.3	1.1	2.3	3
7	Crime	+	0.044267	39	135	116	133	117	118	109	39	85	99
8	Access to employment	+	0.053701	3	3	3	3	3	2	3	3	3	3
9	Access to public transport	+	0.049347	4	3	4	5	4	4	4	5	5	6
10	Access to good quality schools	+	0.050073	5	6	5	5	4	4	3	5	6	6
11	Access to shopping facilities	+	0.045718	3	1	2	2	3	1	2	3	1	3
12	Access to health services	+	0.047896	9	9	9	9	9	9	9	9	9	9
13	Access to child care	+	0.046444	6	6	6	5	6	6	6	6	6	6
14	Access to leisure	+	0.039913	6	3	5	5	4	5	4	5	4	4
15	Access to open green public space	+	0.043541	3	3	3	3	3	3	3	3	3	3
16	Presence of environmental problems	+	0.044267	24.1	46.6	18.8	44.1	27	28.7	32.2	35.1	1.5	17.6
17	Quality of housing in area	+	0.055152	72.4	70.3	69.1	79.4	86.2	89.9	77.5	72.8	89.1	82.9
18	Energy efficiency of housing in area	+	0.05225	60	55	57	53	57	64	63	66	61	68
19	Waste management in area	+	0.04209	35	35	35	35	35	35	35	35	35	35
20	Deprivation in area	+	0.044267	0	92.6	92.4	94.5	97.6	58.8	14.1	3.9	35.5	75.5

The formula for the calculation of Q_j in the original COPRAS method is shown in 4.3.5. For modified COPRAS an alternative formulation of Q_j (compared to that used in COPRAS) is used, where a simple subtraction of the sum of the negative criteria from the sum of the positive criteria is performed. In both approaches, the higher the significance value (Q_j) the better the alternative.

8.4.5 TOPSIS

TOPSIS begins with the normalization of criteria values, where each criterion value in the decision matrix is divided by its own norm. The norm represents the square root of the sum of the squares of all attribute values in the range. Step 2 is to create the weighted normalized decision matrix V (Appendix 20). This is achieved by multiplying each normalized matrix value r_{ij} with the assigned weight w_j. Then the distance (separation measure) from the ideal/best (A*) solution (Appendix 21) and the distance from the negative-ideal/worst (A-) solution (Appendix 22) is determined. The option that is closest to the ideal point is the best one. These stages are calculated according to the formulas laid out in 4.3.7.

8.5 Results of MCDM comparison

The final results obtained by applying the six MCDM methods (WSM, WPM, revised AHP (approach 1 and 2), TOPSIS, COPRAS and modified COPRAS) to the case study data are presented in table 27. The rank/priority order of the alternatives is compared in table 28; in order to easily identify and demonstrate where different methods have acted in the same way with regard to the prioritisation of alternatives, highlighting has been used.

Although it is not usual to adopt the second approach within the RAHP method, i.e. incorporating negative criteria as negative weights, the final ranking/priority order of the alternatives was actually equivalent using both approaches (table 27).

Accordingly, this approach could be a valid option for future studies that wish to incorporate negative criteria within AHP methods.

All six tested methods produced identical rankings for A_{10} (St Michaels) and A_4 (Cressington), which ranked 1st and 2nd consecutively. Accordingly, all MCDM methods consistently concluded that the optimal alternative was A_{10} (St Michaels). Four of the approaches, all except TOPSIS and WPM, concluded that A_7 (Belle Vale) was the worst performing alternative, followed by A_9 (Fazakerley), ranking 10th and 9th consecutively. Whereas TOPSIS and WPM ranked A_7 (Belle Vale) in 9th priority. In addition, four of the methods - WSM, WPM, COPRAS and modified COPRAS - produced identical priorities for A_5 (Allerton and Hunts Cross), which ranked in 3rd priority overall.

The WSM and modified COPRAS method acted in very similar manner, producing equal rankings for 9 out of the 10 (90%) alternatives under assessment. The COPRAS method acted rather similarly to WSM and modified COPRAS, with the three methods ranking six of the alternatives (60%) in identical positions. The revised AHP and modified COPRAS ranked five alternatives (50%) in equal positions. The WPM was the most inconsistent with the other methods tested, in terms of the prioritisation of alternatives. Although, out of all the methods considered, WPM acted most correspondingly to WSM, with the two methods prioritising four of the alternatives (40%) in identical positions. TOPSIS acted most correspondingly to the revised AHP, with the two methods prioritising five of the alternatives (50%) in identical positions. However, the two methods also produced some rather contrasting results, for example, in relation the prioritisation of A_2 (Childwall) which ranked 3rd by TOPSIS and 8th by the revised AHP. In fact, A_2 produced rather unstable rankings by the different methods tested, along with A_1 and A_8. A visual comparison of the ranking/prioritisation of the alternatives obtained by the six different MCDM methods is displayed in figure 35.

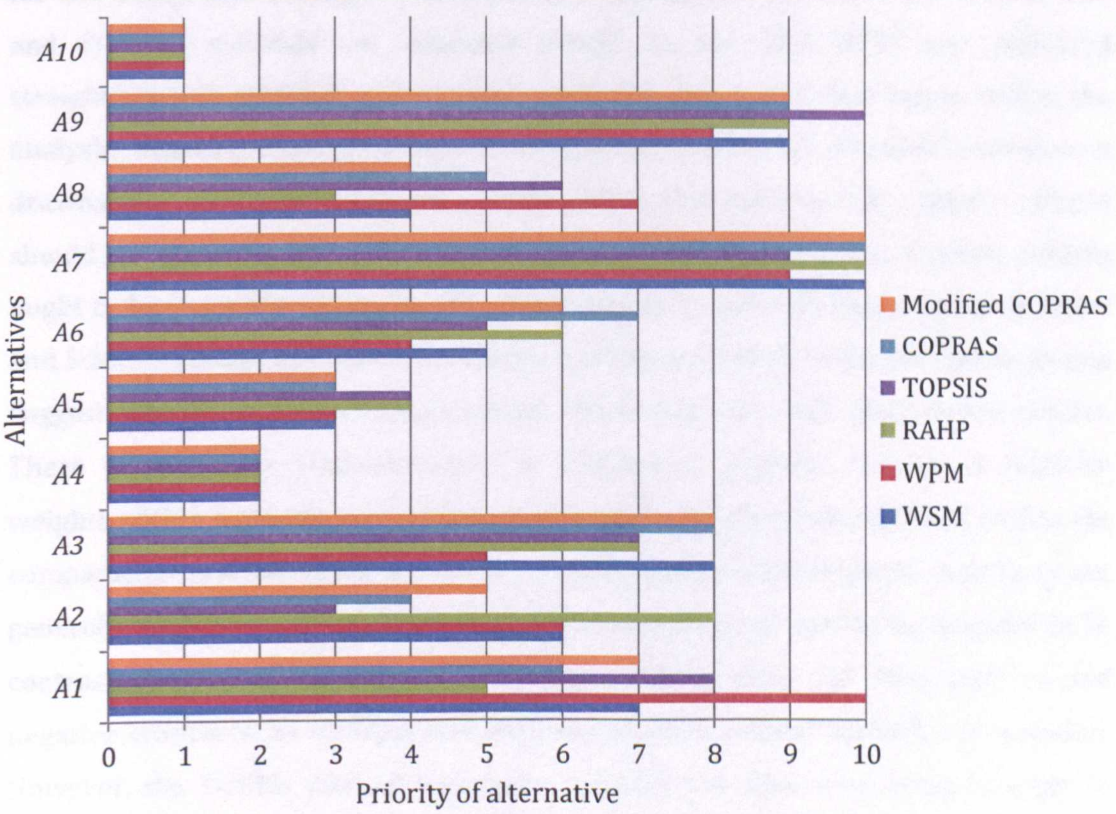
Table 27. Data obtained by calculating the efficiency of the alternatives using different MCDM methods

Method	Alternatives									
	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
WSM	0.10147	0.10254	0.10060	0.11065	0.10646	0.10369	0.09280	0.10446	0.09756	0.11914
Rank	7	6	8	2	3	5	10	4	9	1
WPM	0.07646	0.09563	0.09654	0.10659	0.10160	0.10068	0.08406	0.09390	0.08650	0.11449
Rank	10	6	5	2	3	4	9	7	8	1
RAHP 1	0.80191	0.78117	0.78159	0.83200	0.81206	0.79366	0.74067	0.81315	0.76820	0.88837
Rank	5	8	7	2	4	6	10	3	9	1
RAHP 2	0.92222	0.84337	0.84451	0.98236	0.92783	0.87751	0.73264	0.93080	0.80793	1.13647
Rank	5	8	7	2	4	6	10	3	9	1
TOPSIS	0.47130	0.62904	0.48892	0.79087	0.61475	0.54445	0.29903	0.52705	0.25199	0.80918
Rank	8	3	7	2	4	5	9	6	10	1
COPRAS	0.11487	0.11782	0.11151	0.12728	0.11853	0.11406	0.10345	0.11717	0.10584	0.13037
Rank	6	4	8	2	3	7	10	5	9	1
Modified COPRAS	0.04070	0.04245	0.03897	0.05189	0.04579	0.04159	0.03039	0.04299	0.03178	0.05805
Rank	7	5	8	2	3	6	10	4	9	1

Table 28. Rank /priority of alternatives determined using different MCDM methods

Priority of alternatives	Method used					
	WPM	WSM	RAHP (approach 1+2)	TOPSIS	COPRAS	Modified COPRAS
1	A_{10}	A_{10}	A_{10}	A_{10}	A_{10}	A_{10}
2	A_4	A_4	A_4	A_4	A_4	A_4
3	A_5	A_5	A_8	A_2	A_5	A_5
4	A_6	A_8	A_5	A_5	A_2	A_8
5	A_3	A_6	A_1	A_6	A_8	A_2
6	A_2	A_2	A_6	A_8	A_1	A_6
7	A_8	A_1	A_3	A_3	A_6	A_1
8	A_9	A_3	A_2	A_1	A_3	A_3
9	A_7	A_9	A_9	A_7	A_9	A_9
10	A_1	A_7	A_7	A_9	A_7	A_7

Figure 35. Comparison of the prioritisation of the alternatives using different MCDM methods



Source: Self study

8.6 Selection of an appropriate MCDM method

The decision making situation proposed in this study requires the assessment of a number of alternative areas in respect of their sustainable housing affordability. Therefore, a ranking (prioritisation) of alternative areas is the objective of the problem in question. Accordingly a method with the ability to provide a complete ranking of alternatives, indicating the position of each alternative, is necessary. Additionally, the method must have the ability to handle criteria of both positive and negative influence and those of a quantitative and qualitative nature. Furthermore, it is important to make sure the technique is easy to use and understand so that any interested parties can easily adopt the proposed method.

The comparative analysis of several MCDM methods - WSM, WPM, revised AHP, TOPSIS, COPRAS and modified COPRAS - assisted in selecting an appropriate method for this study. The testing of these methods highlighted that the WSM, revised AHP and COPRAS methods are relatively simple to use. The WPM also appeared straightforward, although it was problematic with the use of zero values within the analysis, meaning that any values of zero would need to be amended. However, a drawback of the WSM, WPM and revised AHP is that positive and negative criteria should not generally be used within the analysis at the same time. Negative criteria ought to be transformed into positive criteria prior to normalisation. However, Millet and Schoner (2005) discussed this transformation in relation to the AHP methods and suggest that it can cause computational complexity and elicit inconsistent results. There is an option, mathematically, to incorporate negative criteria as negative weights within methods such as the revised AHP. This was demonstrated within the comparative analysis. However, such a way of dealing with negative criteria is not generally adopted in practice and thus the results may not always be acceptable. In contrast, the TOPSIS method and COPRAS methods allow for both positive and negative criteria to be incorporated with one analysis without difficulty or question. However, the TOPSIS method was more complex and time consuming to apply in comparison to COPRAS. Dyer *et al.* (1992) warn that the complexity of many MCDM methods can prevent their application in practice. Moreover, the findings of several comparative studies actually suggest that simpler evaluation techniques are often superior (Chang and Yeh, 2001; Mahmoud and Garcia, 2000; Zanakis *et al.*, 1998).

After conducting the comparative analysis it was established that the original COPRAS method would be the most suitable methodology to adopt for the sustainable housing affordability assessment model. The COPRAS method was chosen owing to the following factors:

- COPRAS can provide a complete ranking of the alternatives so that the priority of each area under consideration can be compared.
- The method can deal with both quantitative and qualitative criteria within one assessment.
- COPRAS has the ability to account for both positive (maximizing) and negative (minimizing) evaluation criteria, which can be assessed separately within one evaluation process. Some of the more basic MCDM methods, such as WSM, require transformation of negative criteria into positive ones (as was found in the comparative analysis). This makes the procedure more complicated and time consuming for potential users and can elicit inconsistent results.
- The method is transparent, simple to use and has a low calculation time in comparison with other MCDM methods, such as the AHP and TOPSIS (Chatterjee *et al.*, 2011). This was also confirmed by the comparative analysis. Therefore, the COPRAS method can more easily be adopted by any interested parties in practice.
- An important feature that makes the COPRAS method superior to other available MCDM methods is that it estimates the utility degree of alternatives, showing, as a percentage, the extent to which one alternative is better or worse than other alternatives taken for comparison.

- Decisions yielded by the COPRAS method were found to be more efficient and less bias than those yielded by TOPSIS and SAW (also known as WSM) (Simanaviciene and Ustinovicius, 2012).
- Furthermore, the COPRAS method has been frequently and successfully applied to a range of property, planning and sustainability related problems (see 4.5). Accordingly, it is an accepted method in practice.

8.7 Chapter Summary

- This chapter has presented part of the data analysis for stage 3 of the research methodology, assisting in the development of the model for the analysis of sustainable housing affordability and collecting data for a case study assessment.
- Details on the measurement tools that can be used to assess the 20 sustainable housing affordability criteria were provided.
- The required data collection for the case study assessment of sustainable housing affordability using MCDM was presented, which included the selection of 10 alternative areas for comparison within Liverpool, UK. Criteria values were then calculated for each alternative area using the specified measurement tools.
- A comparative analysis of six MCDM methods - WSM, WPM, revised AHP, TOPSIS, COPRAS and modified COPRAS – was investigated using practical case study data.
- Following the comparative analysis COPRAS was selected as the most appropriate method for this study, to be used with the complex model for the assessment of sustainable housing affordability.

Chapter 9

Model validation

This chapter concludes stage 3 of the data analysis by presenting the overall complex model for the analysis of sustainable housing affordability and validating the model using a case study. Validation refers to a somewhat subjective assessment of likely suitability in the intended environment (ODC 1986). Accordingly, validation confirms that an inquiry conforms to its declared purpose (Pescatore, 1995). Thus, the practical case study tests the applicability of the model for the assessment of sustainable housing affordability and confirms the suitability of the model for its intended purpose.

A case study analysis of sustainable housing affordability is presented using the COPRAS method, which was selected as the most suitable MCDM method for this particular study in chapter 8. Data required for the case study assessment of sustainable housing affordability has been collected and explained in 8.3. This section elaborates on the way in which the COPRAS method processes the data and discusses the results generated by the analysis.

9.1 Presenting the complex model for the analysis of sustainable housing affordability

The complex model for the analysis of sustainable housing affordability has been developed throughout this study and is presented in figure 36. The model is based on a broader concept of affordability that is better aligned with sustainability and household wellbeing. The model covers the criteria influencing sustainable housing affordability, interested parties whose goals can be attained through the application of the model, the external environment (including political, social, economic, environmental, housing market, planning, psychological, etc) and the multiple criteria analysis methodology. All aspects of the model have been developed and explained throughout this study and are summarised as follows:

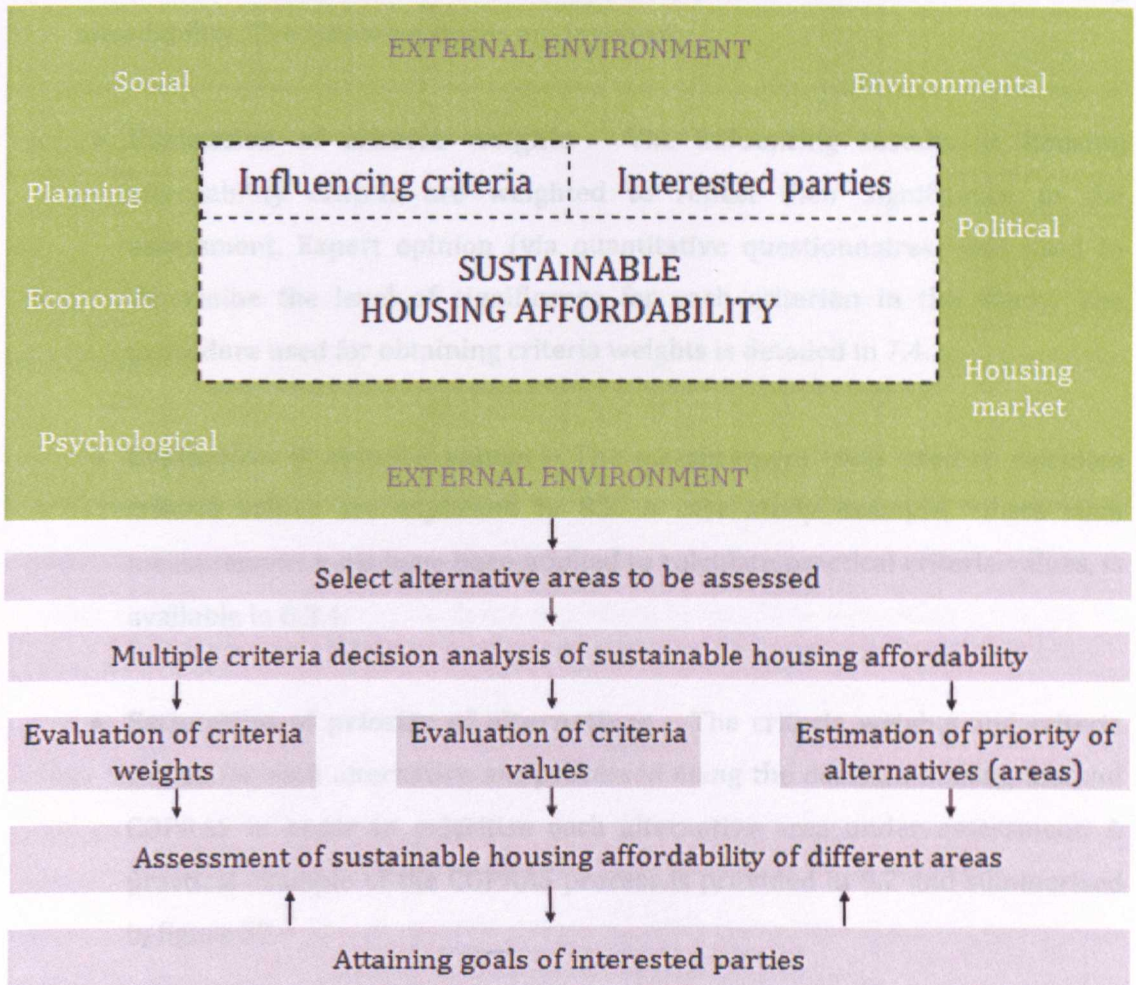
- **Influencing criteria** - The quantitative (e.g. house prices, incomes) and qualitative (e.g. housing quality, environment quality, access to key services and facilities) criteria influencing sustainable housing affordability were established in chapter 6 (summarised in table 14) and verified by professionals in chapter 7.

- **Interested parties** - Interested parties may include, for example, central governments, local authorities, developers, buyers and others. The interested parties are detailed in 1.4.

- **External environment** - The external environment influencing the affordability of housing may include the following factors, for example:

    - political - *housing policy and other public policies, investment in housing, subsidies, construction activities*
    - social - *housing conditions, health, liveability, social capital and cohesion*
    - economic - *loan granting, mortgage availability, interest rates, investment environment, local income, taxation, labour market*
    - environmental - *sustainability of location, environment quality*
    - housing market - *housing supply and demand, house prices, rents*
    - planning - *strategic planning decisions, planning policies, development controls, supply of housing, location of infrastructure in relation to housing*
    - psychological - *preference for housing, psychological satisfaction with housing and community, perception of 'affordability'*

Figure 36. Complex model for the analysis of sustainable housing affordability using multiple criteria decision making



Source: Self study

➢ **Select alternative areas to be assessed** – A number of different areas can be selected as alternatives for the comparative analysis of their sustainable housing affordability using this model. The quantity of areas selected will depend upon the needs of the interested party adopting the model. A case study assessment of 10 alternative areas is presented in 8.3.3

- **Multiple criteria decision analysis of sustainable housing affordability** – The multiple criteria decision making technique COPRAS is used as the methodology to analyse the selected alternative areas in respect of their sustainable housing affordability. The following stages are involved:

  - **Evaluation of criteria weights** – The influencing sustainable housing affordability criteria are weighted to reflect their significance to the assessment. Expert opinion (via quantitative questionnaires) was used to determine the level of significance for each criterion in this study. The procedure used for obtaining criteria weights is detailed in 7.4.1.

  - **Evaluation of criteria values** – The measurement tools used to calculate criteria values are explained in 8.2. A case study example, where such measurement tools have been applied to calculate practical criteria values, is available in 8.3.4.

  - **Estimation of priority of alternatives** – The criteria weights and criteria values for each alternative are processed using the decision making method COPRAS in order to prioritise each alternative area under assessment. A practical example of the COPRAS process is provided in 9.2 and summarised in figure 37.

- **Assessment of sustainable housing affordability of different areas** – Overall the multiple criteria decision making process provides the assessment of sustainable housing affordability for the different areas under consideration. A case study assessment and analysis of results is provided in 9.1.

- **Attaining goals of interested parties in housing affordability** – Ultimately the presented model can meet the needs of a number of interest parties who are associated to the assessment of housing affordability. The potential uses and beneficiaries of the model are considered in 1.4 and discussed further in 10.2.3.

9.2 The COPRAS method of multiple criteria analysis for the assessment of sustainable housing affordability

The COPRAS method of multiple criteria analysis for the complex assessment of sustainable housing affordability comprises a total of seven stages, the first two of which are concerned with the preparation of initial data:

Stage 1: Formation of the set of criteria influencing sustainable housing affordability (table 14).

Stage 2: Identify alternative areas for comparison (8.3.3), establish criteria measurement units (8.2), determine the values of the criteria (8.3.4) and their significance/weight (table 20). The qualitative criteria are generally measured in points and the quantitative criteria are expressed in standard measuring units, e.g. %, ratio.

Stage 3: The next step is the normalisation of the decision-making matrix (table 29). The purpose of this stage is to obtain dimensionless weighted values from comparative alternatives. When the dimensionless weighted values are known, it is possible to compare all the criteria values of different units of measurement, e.g. points, %, ratios, etc. The following formula is used for that purpose:

$$d_{ij} = \frac{q_i}{\sum_{j=1}^{n} x_{ij}} \times x_{ij} \qquad (18)$$

Where x_{ij} is the value of the i-th criterion of the j-th alternative, and q_i is the weight of the i-th criterion. With this transformation, the sum of the dimensionless weighted values d_{ij} of each criterion x_i always equals the weight q_i of this criterion:

$$q_i = \sum_{j=1}^{n} d_{ij} \tag{19}$$

Stage 4: The sums of weighted normalised criteria describing the *j*-th alternative are calculated. The alternatives are described by positive (maximising) criteria S_{+j} and negative (minimising) criteria S_{-j}. The higher the positive (maximising) values are, such as 'quality of housing', the better satisfied is sustainable housing affordability. The lower the negative (minimising) values are, such as 'deprivation in area', the better satisfied is sustainable housing affordability. Sums are calculated according to the formulae:

$$S_j^{+} = \sum_{z_i=+} d_{ij}$$
$$S_j^{-} = \sum_{z_i=-} d_{ij} \tag{20}$$

In any case, the sums of S_{+j} (maximising values) and S_{-j} (minimising values) of all alternatives being compared are always respectively equal to all the sums of the weights of the maximising and minimising criteria:

$$S_{+j} = \sum_{j=1}^{n} S_{+j} = \sum_{i=1}^{m} \sum_{j=1}^{n} d_{+ij};$$
$$S_{-j} = \sum_{j=1}^{n} S_{-j} = \sum_{i=1}^{m} \sum_{j=1}^{n} d_{-ij}, \tag{21}$$
$$i = \overline{1,m}; \quad j = \overline{1,n}.$$

In this way, the calculations can be additionally checked.

Stage 5: The significance of the comparative alternatives is determined on the basis of describing positive (+) and negative (-) qualities that characterise the alternative residential areas. The relative significance Q_j of each alternative A_j is determined according to:

$$Q_j = S_{+j} + \frac{S_{-\min} \cdot \sum_{j=1}^{n} S_{-j}}{S_{-j} \cdot \sum_{j=1}^{n} \frac{S_{-\min}}{S_{-j}}}, \quad j = \overline{1,n}. \tag{22}$$

The first term of Q_j increases for higher positive criteria S^{+}_{j}, whilst the second term of Q_j increases with lower negative criteria S^{-}_{j}. Thus a higher value of Q_j corresponds to better achievement of sustainable housing affordability.

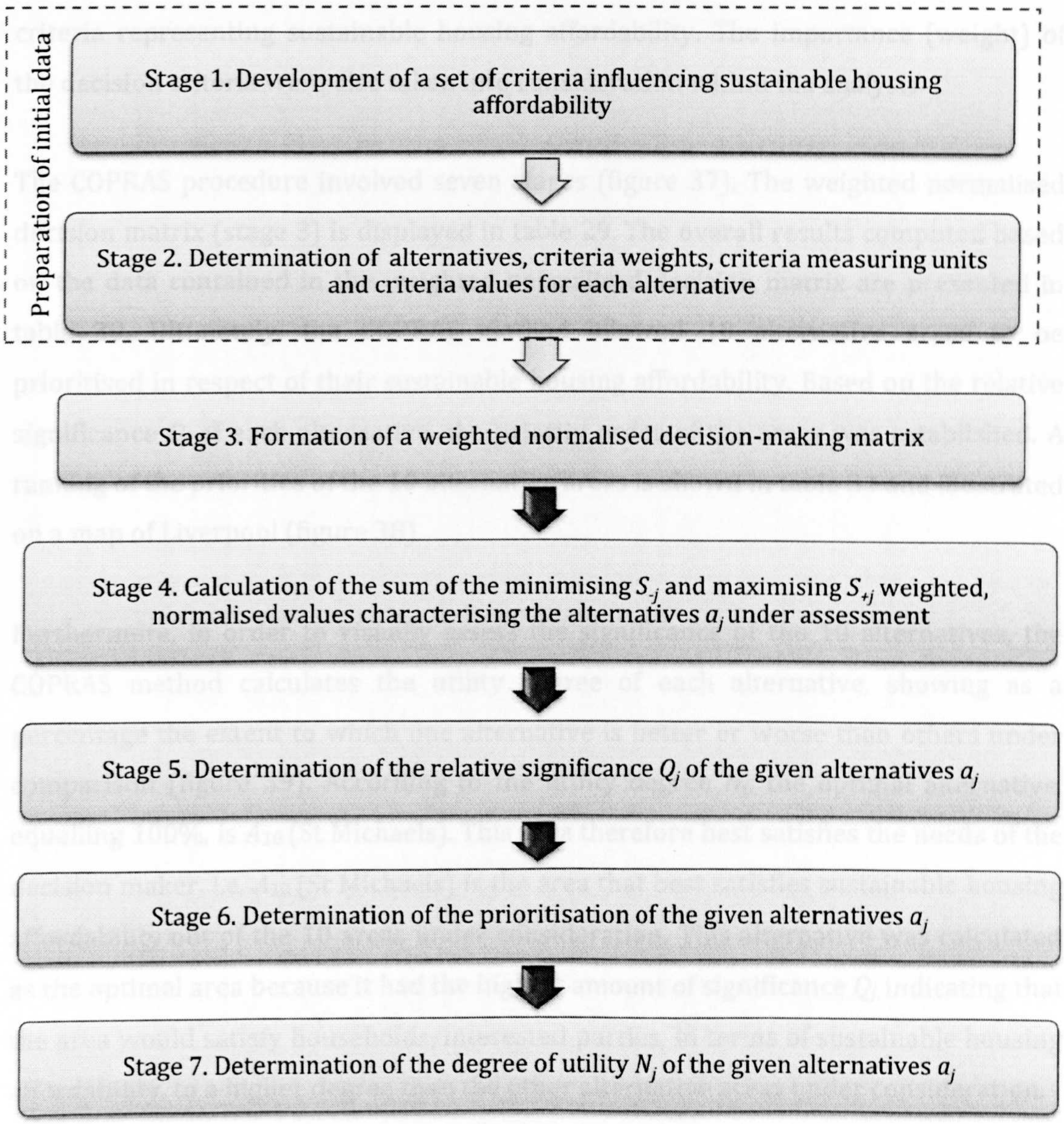
Stage 6: The prioritisation Q_j of the alternative residential areas under consideration is determined in this stage. The greater the value Q_j, the higher the significance of the alternative area. In this case, the significance Q_{max} of the most rational alternative will always be the highest. The determination of the optimal alternative and a rank order, from best to worst, of the alternatives areas under consideration can thus be established.

Stage 7: A supplementary stage of the COPRAS method is the determination of the degree of utility of the alternative areas under consideration. This stage allows visual assessment of the significance of the alternatives. With the increase/decrease of the priority of the analysed alternative, its degree of utility also increases/decreases. The degree of utility is determined by comparing each analysed alternative with the most efficient one. The residential area that best satisfies the sustainable housing affordability criteria is expressed by the highest degree of utility N_j equalling 100%. All utility values related to the considered alternatives will range from 0% to 100%, *between the worst and best alternative out of those under consideration. The degree of utility N_j of the alternative a_j is determined according to the following formula:*

$$N_j = \frac{Q_j}{Q_{\max}} \times 100\% \tag{23}$$

The results of stage 3 through to 7 are available in 9.2. In addition, figure 37 summarises the stages involved in the COPRAS procedure.

Figure 37. Flow chart of the COPRAS method of multiple criteria analysis



Source: Self study

9.2 Results of the case study assessment

This section presents the results of the complex assessment of sustainable housing affordability using the MCDM method COPRAS. The case study analysis compared 10 alternative areas in Liverpool, UK. Each area was assessed based on 20 decision criteria representing sustainable housing affordability. The importance (weight) of the decision criteria were also taken into consideration within the analysis.

The COPRAS procedure involved seven stages (figure 37). The weighted normalised decision matrix (stage 3) is displayed in table 29. The overall results computed based on the data contained in the weighted normalised decision matrix are presented in table 30. Ultimately, the COPRAS method allowed 10 alternative areas to be prioritised in respect of their sustainable housing affordability. Based on the relative significance Q_j of each alternative, the priority order of the areas was established. A ranking of the priorities of the 10 alternative areas is shown in table 31 and illustrated on a map of Liverpool (figure 38).

Furthermore, in order to visually assess the significance of the 10 alternatives, the COPRAS method calculates the utility degree of each alternative, showing as a percentage the extent to which one alternative is better or worse than others under comparison (figure 39). According to the utility degree N_j, the optimal alternative, equalling 100%, is A_{10} (St Michaels). This area therefore best satisfies the needs of the decision maker, i.e. A_{10} (St Michaels) is the area that best satisfies sustainable housing affordability out of the 10 areas under consideration. This alternative was calculated as the optimal area because it had the highest amount of significance Q_j, indicating that the area would satisfy households/interested parties, in terms of sustainable housing affordability, to a higher degree than the other alternative areas under consideration.

Table 29. Weighted normalised decision making matrix for COPRAS (stage 3)

Criteria i		Z	Alternatives j									
			A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
1	House prices in relation to income	-	0.00502	0.00703	0.00674	0.00703	0.00732	0.00574	0.00689	0.00517	0.00545	0.00674
2	Rental costs in relation to income	-	0.00461	0.00728	0.00583	0.00680	0.00680	0.00583	0.00704	0.00728	0.00559	0.00607
3	Interest rates and mortgage availability	-	0.00581	0.00581	0.00581	0.00581	0.00581	0.00581	0.00581	0.00581	0.00581	0.00581
4	Availability of rented accommodation	+	0.01072	0.00330	0.00264	0.00676	0.00247	0.00495	0.00082	0.00907	0.00577	0.01155
5	Availability of low cost homeownership products	+	0.00572	0.00286	0.00286	0.00286	0.00572	0.00572	0.00859	0.00859	0.00286	0.00572
6	Availability of market value home ownership products	+	0.00238	0.00606	0.00498	0.00584	0.00584	0.00541	0.00281	0.00238	0.00498	0.00649
7	Crime	-	0.00797	0.00230	0.00342	0.00242	0.00336	0.00331	0.00384	0.00797	0.00525	0.00443
8	Access to employment	+	0.00556	0.00556	0.00556	0.00556	0.00556	0.00370	0.00556	0.00556	0.00556	0.00556
9	Access to public transport	+	0.00449	0.00336	0.00449	0.00561	0.00449	0.00449	0.00449	0.00561	0.00561	0.00673
10	Access to good quality schools	+	0.00511	0.00613	0.00511	0.00511	0.00409	0.00409	0.00307	0.00511	0.00613	0.00613
11	Access to shopping facilities	+	0.00653	0.00218	0.00435	0.00435	0.00653	0.00218	0.00435	0.00653	0.00218	0.00653
12	Access to health services	+	0.00479	0.00479	0.00479	0.00479	0.00479	0.00479	0.00479	0.00479	0.00479	0.00479
13	Access to child care	+	0.00472	0.00472	0.00472	0.00394	0.00472	0.00472	0.00472	0.00472	0.00472	0.00472
14	Access to leisure	+	0.00532	0.00266	0.00443	0.00443	0.00355	0.00443	0.00355	0.00443	0.00355	0.00355
15	Access to open green public space	+	0.00435	0.00435	0.00435	0.00435	0.00435	0.00435	0.00435	0.00435	0.00435	0.00435
16	Presence of environmental problems	-	0.00517	0.00032	0.00632	0.00086	0.00455	0.00418	0.00343	0.00280	0.01005	0.00658
17	Quality of housing in area	+	0.00506	0.00491	0.00483	0.00555	0.00602	0.00628	0.00541	0.00508	0.00622	0.00579
18	Energy efficiency of housing in area	+	0.00519	0.00476	0.00493	0.00458	0.00493	0.00554	0.00545	0.00571	0.00528	0.00588
19	Waste management in area	+	0.00421	0.00421	0.00421	0.00421	0.00421	0.00421	0.00421	0.00421	0.00421	0.00421
20	Deprivation in area	-	0.01051	0.00054	0.00056	0.00033	0.00000	0.00418	0.00899	0.01009	0.00669	0.00238

* The sign (+/-) indicates that a greater/lesser criterion value satisfies sustainable housing affordability

Table 30. Overall results of COPRAS assessment

COPRAS stages		Alternatives j									
		A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
Stage 4	$Sj+$	0.07415	0.05985	0.06225	0.06795	0.06728	0.06486	0.06217	0.07615	0.06621	0.08200
	$Sj-$	0.03909	0.02328	0.02868	0.02325	0.02784	0.02904	0.03599	0.03912	0.03883	0.03200
Stage 5	Qj	0.09895	0.10149	0.09606	0.10964	0.10210	0.09825	0.08911	0.10093	0.09117	0.11230
Stage 6	Rank	6	4	8	2	3	7	10	5	9	1
Stage 7	Nj %	88.1	90.4	85.5	97.6	90.9	87.5	79.4	89.9	81.2	100

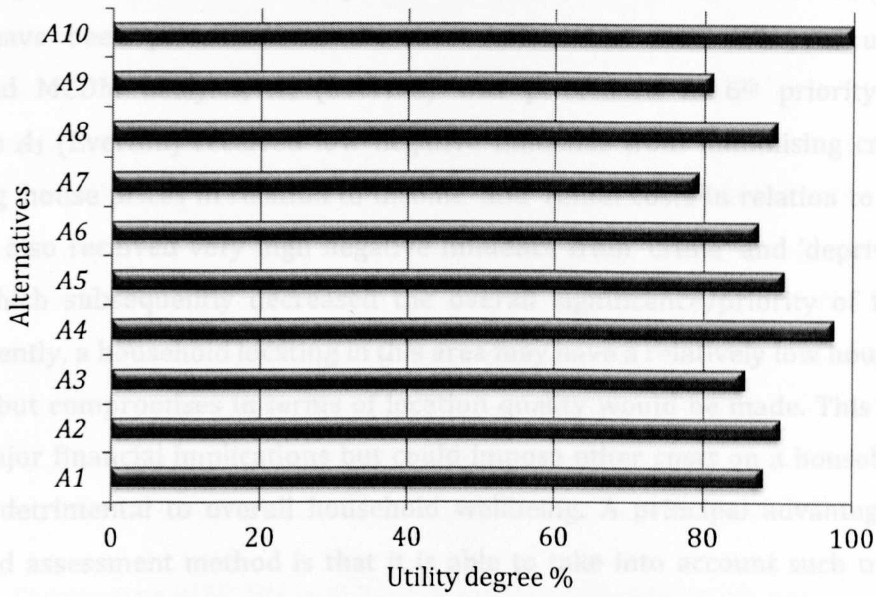
Table 31. Priority order of alternative areas

Priority		Area
Best	1	St Michaels (A_{10})
	2	Cressington (A_4)
	3	Allerton and Hunts Cross (A_5)
	4	Childwall (A_2)
	5	Princes Park (A_8)
	6	Everton (A_1)
	7	Yew Tree (A_6)
	8	West Derby (A_3)
	9	Fazakerley (A_9)
Worst	10	Belle Vale (A_7)

Figure 38. Map of Liverpool indicating priority order of alternatives areas

Source: Self study

Figure 39. Utility degree (percentage achievement) of alternatives



Source: Self study

Of the 10 alternatives under assessment, A_{10} (St Michaels) did not have the lowest housing costs. Although the results reveal that A_{10} (St Michaels) received the highest amount of maximising indices $S+_j$ compared to the other analysed alternatives (table 29). For example, the area received high positive influence from factors including 'availability of rented accommodation', 'availability of market value home ownership products', 'access to public transport', 'access to good quality schools' and 'energy efficiency of housing'. The results indicate that A_7 (Belle Vale) was the worst performing alternative as it had the lowest amount of significance Q_j indicating that this area would satisfy households/interested parties the least. Notably, in comparison to many of the other analysed alternatives, A_7 (Belle Vale) received low positive influence from maximising criteria $S+_j$ including 'availability of rented accommodation', 'availability of market value home ownership products', 'access to good quality schools', whilst also receiving a high negative influence from some minimising criteria S_{-j}, such as 'deprivation in area' and 'rental costs in relation to income'. Contrastingly, if affordability had been assessed in the traditional sense - exclusively on the basis of housing costs in relation to income - then A_1 (Everton) would have been prioritised as the most 'affordable' area. Whereas using the presented MCDM analysis, A_1 (Everton) was prioritised in 6th priority overall. Although A_1 (Everton) received low negative influence from minimising criteria S_{-j} including 'house prices in relation to income' and 'rental costs in relation to income', the area also received very high negative influence from 'crime' and 'deprivation in area', which subsequently decreased the overall significance/priority of the area. Consequently, a household locating in this area may have a relatively low housing cost burden, but compromises in terms of location quality would be made. This may not cause major financial implications but could impose other costs on a household that may be detrimental to overall household wellbeing. A principal advantage of the presented assessment method is that it is able to take into account such trade-offs, both financial and qualitative. Table 32 compares the results (priority order) of the complex MCDM assessment of sustainable housing affordability with that of a traditional house price-to-income ratio assessment of affordability. The substantial shifting of the rankings of some alternatives, for example A_1 (Everton), A_9 (Fazakerely) and A_4 (Cressington), are evident. The house price-to-income ratio assessment places A_9 (Fazakerely) in 3rd position in terms of affordability. Whereas using the sustainable housing affordability analysis, the area decreased to 9th priority overall. A_9 (Fazakerely) received relatively low negative influence from the minimising criteria S_{-j} 'house prices in relation to income' and 'rental costs in relation to income', but the significance/priority of the area decreased because it also received relatively high negative influence from 'crime', 'presence of environmental problems' and 'deprivation in area'. In Contrast, A_4 (Cressington) climbed from 7th priority by the house price-to-income ratio assessment to 2nd using the sustainable housing affordability analysis. The area did not have the lowest housing costs; however, its priority increased as it received the lowest amount of minimising values S_{-j} overall, compared to all the other analysed alternatives. A_4 (Cressington) received very low negative influence from minimising criteria S_{-j} including 'crime', 'presence of environmental problems' and 'deprivation in area'. A household locating in this area may have a relatively higher housing cost burden in comparison to some of the other areas under assessment, although they would secure other benefits from the quality of the location. In addition, table 33 compares the results (priority order) of the complex MCDM assessment of sustainable housing affordability with a simple rent-to-income ratio assessment of affordability. Comparing the results of the traditional methods of assessing affordability with the presented assessment of sustainable housing affordability demonstrates how considering housing costs and income in isolation from other factors can be misleading, as there is no indication of the quality of the environment or housing, for example. The results reveal how the consideration of additional criteria that better reflect housing quality, location and community sustainability - as opposed to focusing exclusively on financial attributes - can provide a more comprehensive and sustainable analysis of the affordability of different areas.

Table 32. Comparison of MCDM results with traditional house price-to-income ratio

Rank order of alternative areas	
House price-to-income ratio	MCDM assessment
1. Everton	1. St Michaels
2. Princes Park	2. Cressington
3. Fazakerley	3. Allerton and Hunts Cross
4. Yew Tree	4. Childwall
5. West Derby St Michaels	5. Princes Park
6. Belle Vale	6. Everton
7. Childwall Cressington	7. Yew Tree
8. Allerton and Hunts Cross	8. West Derby
	9. Fazakerley
	10. Belle Vale

Source: Self study

Table 33. Comparison of MCDM results with traditional rent-to-income ratio

Rank order of alternative areas	
Rent-to-income ratio	MCDM assessment
1. Everton	1. St Michaels
2. Fazakerley	2. Cressington
3. Yew Tree West Derby	3. Allerton and Hunts Cross
4. St Michaels	4. Childwall
5. Allerton and Hunts Cross Cressington	5. Princes Park
6. Belle Vale	6. Everton
7. Princes Park Childwall	7. Yew Tree
	8. West Derby
	9. Fazakerley
	10. Belle Vale

Source: Self study

It should be made explicit that the results generated by this model do not intend to provide a minimum or maximum standard of sustainable housing affordability, i.e. the results generated do not necessarily indicate that the alternative area ranked in priority 1 is the highest possible standard of sustainable housing affordability. Rather, the results provide a relative ranking compared to the other areas under consideration. Although it is possible that a hypothetical alternative, consisting of all the best possible scores for each criterion, could be inserted into the decision making matrix as a benchmark in order to see how the other areas perform against it.

The results derived from the multiple criteria analysis of sustainable housing affordability can help policymakers better understand the affordability of different areas, in a more comprehensive and sustainable manner. The rankings derived from the assessment may be used to support new housing development that will meet the needs of low and moderate income residents in ways that go beyond traditional notions of financial burden, helping to also support high quality of life for households and sustainable communities. For example, an area that scores highly using a house price-to-income ratio assessment, but has decreasing significance using the MCDM analysis for sustainable housing affordability, clearly requires improvements to the quality and sustainability of the location, possibly before targeting housing development within the area. In areas such as A_1 (Everton) and A_9 (Fazakerely), affordability could be improved not by building additional affordable housing but by improving aspects of community quality and sustainability, such as decreasing crime and tackling deprivation, including employment and education deprivation. Whereas A_{10} (St Michaels) was calculated as the optimal alternative and would be more suitable for the development of affordable housing as the quality of the location and access to amenities and facilities is higher. Additionally, housing consumers could utilise the results generated by the model to aid in selecting a housing location appropriate for their needs and preferences for criteria. Using the presented case study results, A_{10} (St Michaels) would be the optimal area for the consumer if the criteria and corresponding weights used within the assessment were appropriate for their needs.

9.3 Chapter summary

- This chapter concludes stage 3 of the research process by illustrating and validating the model for the assessment of sustainable housing affordability using a practical case study.
- The results of a case study assessment on 10 areas in Liverpool, UK, using the MCDM method COPRAS are presented and discussed.
- Furthermore, the overall model for the complex assessment of sustainable housing affordability is illustrated and explained.

Chapter 10

Discussion and conclusions

10.1 Introduction

This chapter presents some overall conclusions to the thesis, indicating research limitations that were encountered and highlighting the significance and originality of the research. This thesis provides a significant contribution to knowledge in the housing affordability assessment subject area and also contributes to sustainable communities research by developing an innovative sustainable housing affordability assessment model based on a broader concept of affordability.

An extensive literature review was undertaken in order to critically justify the chosen research area, and the subsequent research problem, which was that there was no common consensus on how best to conceive and measure housing affordability. More specifically, it became evident that there was a need for a broader and more encompassing understanding of housing affordability, beyond the financial implications experienced by households and better aligned with sustainability concerns and household wellbeing. Accordingly, a need to reconsider the way housing affordability is conceptualised and assessed emerged. In view of this problem, the following research question was proposed:

What is housing affordability and how can the concept be assessed in a comprehensive way, addressing a broad spectrum of criteria that influence the wellbeing of households in communities?

To answer this research question, the following overall research aim was devised:

To develop a complex model for the assessment of sustainable housing affordability, that is capable of considering a broad spectrum of criteria determining housing affordability and the wellbeing of households in communities.

And the following objectives were set to achieve the above aim:

1. ***Background research to investigate the concept of 'housing affordability', critically analysing definitions of the concept and traditional and recent measures used to assess affordability.***

2. ***Highlight the importance of providing affordable housing in the context of sustainable communities.***

3. ***Establish a comprehensive set of criteria by which sustainable housing affordability can be assessed in a holistic and sustainable manner.***

4. ***Validate and determine the significance of the assessment criteria and identify measurement tools for such criteria.***

5. ***Analyse and select an appropriate multiple criteria decision making methodology that can be utilised for the assessment of sustainable housing affordability.***

6. ***Create a model for the assessment of sustainable housing affordability using multiple criteria decision making methodology and conduct a practical case study assessment to test and demonstrate the effectiveness of the model.***

10.2 Summary of conclusions

The aim and objectives were achieved in this study, thus answering the posed research question. The key conclusions from each stage of the research are presented below.

10.2.1 Conclusions from literature review

The first stage of the literature review in this thesis focused on examining definitions of housing affordability and measures used to assess the issue. It was evident that internationally housing affordability is typically defined and assessed by considering economic criteria, primarily by the ratio of housing costs to income. The literature highlighted that, although this is a widely adopted measure of affordability, it is not consistently accepted among academics (Belsky *et al.*, 2005; Fisher *et al.*, 2009; Hancock, 1993; Hulchanski, 1994; Stone, 1993; Thalmann, 2003). Moreover, it was apparent from the literature reviewed that OECD countries are increasingly recognising the need for a broader and more encompassing understanding of housing affordability, rather than simple ratio measures based on housing expenditure and income which cannot deal with issues such as housing adequacy, location quality and access to services, which subsequently impact on household wellbeing (Abelson, 2009; Gabriel *et al.*, 2005; Ndubueze, 2007; Rowley and Ong, 2012). The need for a broader discussion and refinement of the criteria by which affordable housing is judged was emphasised (Fisher *et al.*, 2009). Importantly, literature stressed that housing affordability is not a one-dimensional concept and, accordingly, it should not be analysed using just one concept, measure or definition (Gan and Hill, 2009; Haffner and Heylen, 2011; McCord *et al.*, 2011). A combination of more than one concept will offer better insight into housing affordability (Haffner and Heylen, 2011). It became clear that researchers are beginning to have wider consideration for the factors that influence housing affordability. As well as financial factors, the literature advocated that further criteria may need to be taken into consideration in order to determine true housing affordability (Mulliner and Maliene, 2011). Specifically, housing quality, location and access to services and facilities materialized as important considerations directly related to housing affordability (CTOD and CNT, 2006; Fisher *et al.*, 2009; Pollard, 2010; Rowley and Ong, 2012; Seelig and Phibbs, 2006).

Furthermore, the literature review looked into the importance of linking the notion of housing affordability with sustainable communities. The benefits of sustainable communities to affordable housing, and vice versa, were emphasised. Taking inspiration from other developed countries, it is important that the concept of affordable housing should surpass the financial cost to the household and be linked with the development of sustainable communities in order to achieve successful housing outcomes (Queensland Department of Housing, 2000). The review concluded that housing affordability and sustainability are important topics for research which require close cooperation. A key message emerging from this study is that definitions and assessments of housing affordability must take a broader and more sustainable view of the wide ranging criteria that affect the wellbeing of households, including economic, environmental and social aspects (Mulliner *et al.*, 2013). Such findings motivated the development of the 'sustainable housing affordability' concept used within this research.

10.2.2 Conclusions from stage 1 and 2

Stage 1 of the research methodology aimed to establish a comprehensive set of assessment criteria for the broader notion of housing affordability. This was achieved via a combination of interviews with professionals and literature review. Six semi-structured interview were conducted with housing and planning professionals working with local authorities. It became evident from the interview data that housing affordability is conceptualised and assessed rather narrowly in practice, focusing chiefly on housing costs and incomes. However, interview participants also recognised the importance that a wider range of factors, relating to sustainability and quality, had in relation to affordable housing. A literature review supplemented the interview process and in total 20 criteria were identified as the basis of the sustainable housing affordability assessment model. The established criteria system conceives affordability not only in terms of housing costs and incomes, but by also taking into consideration a wide range of economic, environmental and social criteria that account for the sustainability and quality of life provided by housing and communities.

Subsequently, in stage 2 of the research methodology these criteria were validated and weighted (to reflect their varying levels of importance) via quantitative surveys with housing and planning professionals. 337 responses were obtained from professionals located in all regions across the UK. All 20 decision criteria identified in stage 1 of the research were validated for inclusion within the sustainable housing affordability criteria system. The survey data highlighted that a wide range of criteria are considered to be important, to varying levels of extent, to a broader notion of housing affordability; not only economic criteria, but also criteria reflecting quality, environmental and social issues. The established (and weighted) criteria system ultimately represents a broader concept of housing affordability.

10.2.3 Conclusions from stage 3

Stage 3 of the research methodology involved the development and validation of the model for the assessment of sustainable housing affordability, which is capable of taking into consideration numerous decision criteria. Owing to the numerous conflicting decision criteria determining sustainable housing affordability, a methodology based on MCDM was selected for the basis of the assessment model. These assessment methods were proved to allow the multidimensional character of the sustainable housing affordability evaluation criteria to be taken into account, as well as their varying levels of importance (weight).

In order to select a suitable MCDM method, several approaches were tested and compared. The study examined and applied six MCDM methods - WSM, WPM, revised AHP, TOPSIS, COPRAS and modified COPRAS - to practical case study data. After conducting a comparative analysis of such methods, COPRAS was selected as the most suitable methodology for the sustainable housing affordability assessment model.

The application of the COPRAS method allows one to carry out a complex analysis of sustainable housing affordability. The method is based on the evaluation of the quantitative and qualitative criteria which influence the affordability of housing and community sustainability in particular areas. This includes the calculation of the utility degree of given areas under assessment and their prioritisation in terms of one another.

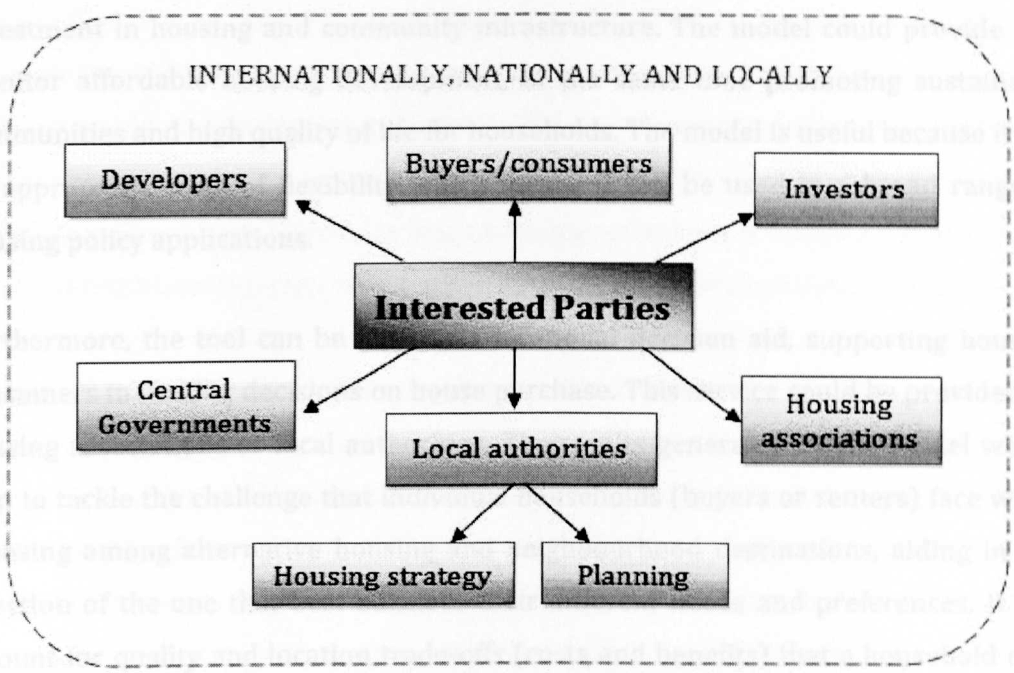
The thesis presented the results of a case study assessment of 10 residential areas in Liverpool, UK as a practical example of the sustainable housing affordability assessment model. This allowed the given areas to be ranked according to a broader concept of affordability. Although applied to areas within Liverpool as a case study, the model is generalizeable and could be applied to other areas. The case study data (alternative areas and criteria values) can be changed and computed for other locations. The criteria system is also flexible; criteria can be added or removed and the weights may be amended to reflect the local situation. The presented model could thus be utilised in other regions, nationally or internationally.

Beneficiaries of model

The presented assessment model can assist international stakeholders in making informed and comprehensive decisions concerning affordability. The method provides a more complex analysis of the criteria that influence the affordability of housing, reflecting the quality and sustainability of a housing location alongside economic factors, rather than focusing exclusively on housing costs and incomes as traditional assessments do.

The model for the assessment of sustainable housing affordability will be beneficial to a number of interested parties, nationally and internationally, including central governments, local authorities, developers, buyers and others (figure 40). With the exception of buyers/consumers, all other interested parties can utilise the model. Buyers/consumers, however, would benefit from the results generated by the model.

Figure 40. Interested parties that will benefit from the sustainable housing affordability assessment model



Source: Self study

In terms of utilising the model, it can be used to aid housing policy decision making at all levels – global, national, local and by community associations. Central/federal governments could use the model to inform decision making on public policy for housing and sustainable communities and to prioritise investment. At a local level, the tool could be utilised as a potential planning indicator for shaping local housing markets. The rankings derived by the assessment model may be used to support new housing development that will meet the needs of low and moderate income residents in ways that go beyond traditional notions of financial burden. For example, local authorities and developers can use the tool to select sites for affordable housing development between competing locations. It would assist in identifying areas that are suitable for affordable housing development, along with areas which may require alternative forms of investment to enhance affordability and create attractive and sustainable communities for wider society to reside in. In certain areas, affordability could be improved not by building additional housing but by improving aspects of community quality and sustainability. Thus, the model can be used for directing investment in housing and community infrastructure. The model could provide and monitor affordable housing development, at the same time promoting sustainable communities and high quality of life for households. The model is useful because it has an appropriate level of flexibility which means it can be used in a broad range of housing policy applications.

Furthermore, the tool can be used as a locational decision aid, supporting housing consumers in making decisions on house purchase. This service could be provided by housing associations or local authorities. The results generated by the model would help to tackle the challenge that individual households (buyers or renters) face when choosing among alternative housing and neighbourhood destinations, aiding in the selection of the one that best balances their different needs and preferences. It can account for quality and location trade-offs (costs and benefits) that a household may make by residing in a particular area. Thus, as well as reflecting financial burdens, the analysis reflects the wider implications of a housing choice in a given location. The criteria and associated weights can be adapted depending on the specific needs of the household. For instance, if access to schools, public transport and open green space are the most important criteria for a particular household, then these criteria could be given more weight. Alternatively, if certain criteria would have no affect on a particular household then those criteria could be given less weight or excluded from the decision making matrix. Therefore, this methodology is flexible and could be applied to meet the needs of a number of different interested parties.

The flexibility of the model means that it can be used by different interested parties on a local, national or international scale. The weighting (importance) of the criteria can be adapted given the requirements of the concerned party and depending on the local situation. Furthermore, the number of alternatives (areas) for consideration may be small or large depending on the decision maker's requirements. The case study used in this study assesses different *areas* in respect of their sustainable housing affordability. However, the presented model could be applied to individual housing *units*, rather than to neighbourhood areas. This would allow the sustainable housing affordability of different units to be compared and ranked. Using the model for this purpose would simply require adaptation of some of the criteria measurement tools. For example, instead of measuring average values for an area (e.g. for housing quality/house prices in relation to income/energy efficiency of housing), actual values for the specific housing units under assessment would need to be determined.

Concern that housing affordability is not a one-dimensional concept and should not be analysed using just one concept or measure was stressed within this study (Gan and Hill, 2009; Haffner and Heylen, 2011; McCord *et al.*, 2011). It is vital to gain a broader understanding of the factors affecting households, beyond financial implications, if housing policy is to improve household wellbeing and address sustainability issues. The presented concept and assessment of sustainable housing affordability meets two broad aspects; it reflects the financial implications of housing choice and also considers more qualitative aspects related to sustainability and wellbeing. The presented model can be applied alongside the traditional and frequently adopted house price-to-income ratio approach in order to gain better insight into the wider implications of housing consumption, such as neighbourhood quality and sustainability, and to compare and contrast results. This would be useful to support informed decision making on housing affordability issues.

10.3 Research limitations and future work

During the study some research limitations were encountered that should be addressed. There were some limitations encountered with the research methodology. The qualitative interviews in stage 1 were conducted with public sector professionals only, as opposed to interviewing professionals from both public and private sectors, as the researcher wanted to gain a fuller understanding of the way in which affordability is defined and assed in practice by local authorities. Also, owing to time and financial constraint the interview respondents were limited to those working within the North West region. Although, the sustainable housing affordability criteria system generated via the interview process was subsequently verified, using a quantitative survey, with a larger scale sample including both public and private professionals across all regions of the UK. The survey in stage 2 was distributed as evenly as possible to professionals in public and private sectors. However, it should be noted that less responses were obtained from the private sector so there is a possibility that the results are more representative of public sector opinion. In addition, the survey focused on data collected from professionals, as opposed to consumers, because the researcher believed their expertise and experience would make the model particularly beneficial and applicable to be applied by professionals to aid decision making on housing policy, development, etc. To develop this work in the future it would be interesting to examine whether the opinions on criteria importance, determined by professional opinion in this study, contrast with a sample obtained from housing consumers. Additionally, a further study could investigate how the broader concept of sustainable housing affordability is perceived by low and moderate income families themselves.

There were some limitations in selecting indicators to assess the sustainable housing affordability criteria and applying them in case study practice:

- The measurement and estimation of criteria values was not possible for the individual residential areas (wards) in some instances as sufficient and accessible data was not available. For the valuation of C_{17} (waste management) data on the 'percentage of household waste sent for recycling, composting or reuse' (the identified measurement tool) was not available at individual housing ward level, data was only accessible for Liverpool city as a whole. Thus, although the criterion was included into the MCDM assessment it actually had no affect on the final ranking of alternatives, as each alternative area had to be given the same value. The criterion was kept within the assessment as it is still an important attribute to take into consideration. Furthermore, if the model is applied in the future to alternative areas located within different local authorities, for example, then the values may then differ.

- For the measurement of C_3 (interest rates and mortgage availability) a similar situation occurred, as this factor generally attains the same average score nationally. In the case study assessment the criterion had no affect on the final ranking of alternatives, as each alternative area had to be given the same value. Although, once more, it is still an important criterion to take into consideration within the model and values may differ among alternatives if the model is applied in future assessments.
- Suitable measurement scales were not already in place for all criteria, consequently some scales had to be developed. Accordingly this could be seen as subjective in some respect:
    - For C_5 (availability of low cost home ownership properties) many of the alternative areas under comparison in the case study actually had no properties available. Hence a zero (0) value would have had to be given for such areas. However, zero values can sometimes be problematic within MCDM assessments. Thus, where possible, it is better to avoid using zero values to measure criteria. In order to eliminate the use of zero values for the measurement of C_5 subjective assessments had to be made. Thus, instead of using the specific 'quantity of properties available' as the measurement tool, a scoring system was established.

- The values calculated for the criteria representing housing market balance - C_4 (availability of rented accommodation), C_5 (availability of low cost homeownership products) and C_6 (availability of market value home ownership products) – could potentially be misleading. For example, high availability in some situations could possibly indicate low desirability of the housing, although this is not certain. An element of subjectivity would be required in order to distinguish between a desirable level of supply of different housing tenures and low desirability. For future work, a measure better reflecting housing market balance – for C_4, C_5 and C_6 – is desired.

10.4 Summary

The findings of this research are hoped to have a positive effect on interested parties by encouraging them to become more focused on sustainability and quality issues in relation to affordable housing, assisting interested parties in implementing a more holistic affordability assessment processes using the presented model (figure 37).

10.4.1 A significant contribution to knowledge

In particular, this thesis has created a significant contribution to new knowledge by:

- Challenging the traditional notion of affordability by drawing closer links with sustainability concerns. The research frames the housing affordability problem as encompassing more than the financial costs of housing and household ability to meet these costs and addresses larger issues of social and environmental sustainability that influence household wellbeing.
- Developing the sustainable housing affordability concept using a holistic set of criteria. The developed concept meets two broad aspects; it reflects the financial implications of housing choice and also considers more qualitative aspects related to sustainability and wellbeing. The study therefore also contributes to the broader definition of housing affordability.

- Validating the sustainable housing affordability criteria with UK professionals and determining weights to reflect the significance of each criterion.
- Exploring the way such criteria can be measured for potential commercial use.
- Presenting an innovative model for the complex assessment of sustainable housing affordability that is capable of considering the wide spectrum of established criteria that impact on the wellbeing of households and communities. Such a model was not developed until now.
- Applying multiple criteria decision making methods for the first time for this particular purpose. The COPRAS method allows quantitative and qualitative factors (having incommensurable units of measure) of both positive and negative influence to be taken into consideration within the assessment of sustainable housing affordability, as well as the varying levels of importance (weights) of the assessment criteria.
- Producing a practical case study assessment of sustainable housing affordability using the proposed model which could be used as a guide by any interested parties on an international scale.

It is hoped that this thesis will help to promote the wider notion and complex assessment of housing affordability in future studies and act as a call for further innovative studies in this area.

Published scientific papers related to the PhD thesis

Scientific papers at peer reviewed academic journals

Mulliner, E., Smallbone, K. and Maliene, V. (2013) An Assessment of sustainable housing affordability using a multiple criteria decision making method, *OMEGA*, 41(2), pp. 270–279 (available online).

Mulliner, E. and Maliene, V. (2012) Austerity and Reform to Affordable Housing Policy, *Journal of Housing and the Built Environment*, Published online first: 11 August 2012, DOI: 10.1007/s10901-012-9305-6.

Mulliner, E. and Maliene, V. (2012) Affordable Housing Policy and Practice in the UK. In: Hepperle, E., Dixon-Gough, R., Maliene, V., Mansberger, R., Paulsson, J. and Pödör, A. (eds.) *Land Management: Potential, Problems and Stumbling Blocks*, Zürich, Switzerland: Vdf Hochschulverlag, pp. 267-277.

Mulliner, E. and Maliene, V. (2011) An introductory review to the Special Issue: Attractive Places to Live, *Urban Design International*, 16, pp. 147–152.

Scientific papers at peer reviewed conference proceedings

Mulliner, E. and Maliene, V. (2012) What attributes determine housing affordability? *In Proceedings: International Conference on Housing and Urban Environments*, 11-12 July, Stockholm, Sweden, World Academy of Science, Engineering and Technology, 67, pp. 695-700.

Mulliner, E. and Maliene, V. (2011) Criteria for Sustainable Housing Affordability. *In Proceedings: 8th International Conference on Environmental Engineering*, 19–20 May, Lithuania: VGTU Press Technika, pp. 966-973.

Mulliner, E. and Maliene, V. (2010) The meaning and measurement of housing affordability: Literature review. *In Proceedings: 2nd International Conference on Advanced Construction*, 11-12 November, Lithuania: Kaunas University of Technology, pp. 172-176.

References

Abelson, P. (2009) Affordable Housing: Concepts and policies, *Economic Papers*, 28(1), pp. 27-38.

ACF and VCOSS (Australian Conservation Foundation and Victorian Council of Social Service). (2008) *Housing affordability: More than rents and mortgages* [online]. Available at: vcoss.org.au/documents/VCOSS%20docs/Housing/REP_ACF_VCOSS%20Housing%20Affordability%20October%202008%20.PDF [Accessed 18th March 2011].

Affordable Homes Partnership. (2007) *Increasing Affordable Housing Supply*, Dublin: Affordable Homes Partnership.

AHNRC (Affordable Housing National Research Consortium). (2001) *Affordable Housing in Australia: Pressing Need, Effective Solution* [online]. Available at: http://communityhousing.org.au/Publications/Submisions/CH_Inquiry/D1%20Affordable%20Housing%20National%20Research%20Consortium.pdf [Accessed on 15th December 2010].

Ananda, J. and Herath, G. (2009) A critical review of multi-criteria decision making methods with special reference to forest management and planning, *Journal of Ecological Economics*, 68(10), pp. 2535–2548.

Antuchevičiene, J., Zavadskas, E.K. and Zakarevičius, A. (2010) Multiple criteria construction management decisions considering relations between criteria, *Technological and Economic Development of Economy*, 16(1), pp. 109-125.

Åslund, O., Östh, J. and Zenou, Y. (2006) How important is access to jobs? Old question - improved answer, *Journal of Economic Geography*, 10(3), pp. 389-422.

Audit Commission. (2011) *Housing Market Renewal: programme review 2010*, London: Audit Commission.

Baer, W.C. (1976) The Evolution of Housing Indicators and Housing Standards: Some Lessons for the Future, *Public Policy*, 24(3), pp. 361-393.

Ball, J. and Srinivasan, V. (1994) Using the Analytic Hierarchy Process in House Selection, *Real Estate Finance and Economics*, 9(1), pp. 69-85.

Banaitienė, N., Banaitis, A., Kaklauskas, A. and Zavadskas, E. K. (2008) Evaluating the life cycle of a building: A multivariant and multiple criteria approach, *Omega*, 36(3), 429-

441.

Bank of England (2012) *Inflation Report May 2012* [online]. Available at: http://www.bankofengland.co.uk/publications/Documents/inflationreport/ir12may.pdf [Accessed on 15th June 2012].

Barker, K. (2004) *Review of Housing Supply: Final Report - Recommendations*, London: HMSO.

Barton, H., Grant, M. and Guise, R. (2003) *Shaping neighbourhoods - a guide for health, sustainability and vitality*, London: Spon.

Belsky E. S., Goodman, J. and Drew, R. (2005) *Measuring the Nation's Rental Housing Affordability Problems*, Cambridge, MA: Joint Center for Housing Studies.

Belton, V. (1986) A comparison of the analytic hierarchy process and a simple multi-attribute value function, *European Journal of Operational Research*, 26(1), pp. 7-21.

Belton, V. and Gear, T. (1983) On a short-coming of Saaty's method of analytic hierarchies, *Omega*, 11(3), pp. 228-230.

Belton, V. and Stewart, T. J. (2002) *Multiple criteria decision analysis: an integrated approach*, Boston: Kluwer Academic Publications.

Bender, A., Din, A, Hoesli, M. and Brocher, S. (2000) Environmental preferences of homeowners: Further evidence using the AHP method, *Journal of Property Investment and Finance*, 18(4), pp. 445 – 455.

Bogdon, A. S. and Can, A. (1997) Indicators of Local Housing Affordability: Comparative and Spatial Approaches, *Real Estate Economics*, 25(1), pp. 43-80.

Bone, J. and O'Reilly, K. (2010) No place called home: the causes and social consequences of the UK housing 'bubble', *British Journal of Sociology*, 61(2), pp. 231-255.

Bouyssou, D. (1996) Outranking relations: Do they have special properties?, *Journal of Multi-Criteria Decision Analysis*, 5(2), pp. 99-111.

Bradshaw, J., Middleton, S., Davis, A., Oldfield, N., Smith, N., Cusworth, L. and Williams, J. (2008) *A minimum income standard for Britain: What people think*, York: Joseph Rowntree Foundation.

Bramley, G. (1990) Access, affordability and housing need. *In Proceedings: ESRC Housing Studies Conference*, University of Surrey, September, mimeo, Bristol: SAUS, University of Bristol.

Bramley, G. (1994) An affordability crisis in British housing: dimensions, causes and policy impact, *Housing Studies*, 9(1), pp. 103-124.

Bramley, G. and Karley, N. K. (2005) How Much Extra Affordable Housing is Needed in England?, *Housing Studies*, 20(5), pp. 685–715.

Brans, J.P. and Vincke, P. (1985) A Preference Ranking Organisation Method (The PROMETHEE Method for Multiple Criteria Decision Making), *Management Science*, 31(6), pp. 647–656.

Brans, J.P., Mareschal, B. and Vincke, P. (1986) How to select and how to rank projects: The PROMETHEE method, *European Journal of Operational Research*, 24(2), pp. 228–238.

Bridgman, P.W. (1992) *Dimensional analysis*, New Haven, CN: Yale University Process.

Brown, T. and Bhatti, M. (2003) Whatever Happened to Housing and the Environment, *Housing Studies*, 18(4), pp. 505-515.

Brownill, S., Sharp, C., Jones, C. and Merrett, S. (1990) *Housing London*, York: Joseph Rowntree Foundation.

Bryman, A. (1988) *Quantity and Quality in Social Research*, London: Routledge.

Bryman, A. (2001) *Social Research Methods*, Oxford: Oxford University Press.

Buchanan, J., Sheppard, P. and Lamsade, D.V. (1999) *Project ranking using Electre III*, Research Report Series 1999-01, University of Waikato, New Zealand: Department of Management Systems.

Burke, T. (2004) *Measuring housing affordability*, Swinburne: Australian Housing and Urban Research Institute.

CABE (Commission for Architecture and the Built Environment). (2009) *Open space strategies, Best practice guidance*, CABE and the Greater London Authority [online]. Available at: www.cabe.org.uk/files/open-space-strategies.pdf [Accessed 15th January 2012].

Carlsson, C. and Fuller, R. (1996) Fuzzy multiple criteria decision making: Recent developments, *Fuzzy Sets and Systems*, 78(2), pp. 139-153.

Carruthers, J. (1990) A Rationale for the Use of Semi-structured Interviews, *Journal of Educational Administration*, 28(1), pp. 63-68.

Carter, K. and Fortune, C. (2007) Sustainable development policy perceptions and practice in the UK social housing sector, *Construction Management and Economics*, 25(4), pp. 399-408.

Caterino, N., Iervolino, I., Manfredi, G., and Cosenza, E. (2009) Comparative analysis of multi-criteria decision-making methods for seismic structural retrofitting, *Computer-Aided Civil and Infrastructure Engineering*, 24(6), pp. 432-445

Chang, Y.H. and Yeh, C.H. (2001) Evaluating airline competitiveness using multiattribute decision making, *Omega*, 29(5), pp. 405–415.

Chaplin, R. and Freeman, A. (1999) Towards and Accurate Description of Affordability, *Urban Studies*, 36(11), pp. 1949-1957.

Chaplin, R., Martin, S., Yang, J.H. and Whitehead, C. (1994) *Affordability: Definitions, Measures and Implications for Lenders,* Discussion Paper 45, Cambridge: Department of Land Economy, University of Cambridge.

Chatterjee, P., Athawale, V.M. and Chakraborty, S. (2011) Materials selection using complex proportional assessment and evaluation of mixed data methods, *Materials and Design*, 32(2), pp. 851–860.

Chen, S.J. and Hwang, C.L. (1992) *Fuzzy Multiple Attribute Decision Making: Methods and Applications*, Berlin: Springer-Verlag.

Choguill, C.L. (2007) The search for policies to support sustainable housing, *Habitat International*, 31(1), pp. 143-149

CLG (Communities and Local Government). (2006a) *Delivering Affordable Housing*, London: The Stationary Office.

CLG (Communities and Local Government). (2006b) *Planning Policy Statement 3 (PPS3): Housing*, London: The Stationary Office.

CLG (Communities and Local Government). (2007a) *Homes for the Future: More Affordable, More Sustainable*, London: The Stationary Office.

CLG (Communities and Local Government). (2007b) *Strategic Housing Market Assessments: Practice Guidance Version 2*, London: CLG.

CLG (Communities and Local Government). (2011a) Planning Policy Statement 3 (PPS3): Housing, London: The Stationary Office.

CLG (Communities and Local Government). (2011b) *English Indices of Deprivation 2010*, London: CLG.

CLG (Communities and Local Government). (2012) *National Planning Policy Framework*, London: CLG.

CLG and HCA (Communities and Local Government and Homes and Communities Agency). (2011) *Affordable Homes Programme 2011-15* [online]. Available at: http://www.homesandcommunities.co.uk/sites/default/files/our-work/affordable-homes-framework.pdf [Accessed on 27th July 2011].

CMHC (Canada Mortgage and Housing Corporation). (2003) *Affordable housing in Canada's urban communities: a literature review, Research Report* [online]. Available at: ftp://ftp.cmhc-schl.gc.ca/chic-ccdh/Research_Reports-Rapports_de_recherche/eng_bilingual/RR%20Affordable%20Housing_FINAL(w).pdf [Accessed on 15th December 2010].

Cole, I. and Nevin, B. (2004) *The Road to Renewal: Early Development of the Housing Market Renewal Programme in England*, York: Joseph Rowntree Foundation.

Creswell, J.W. (2003) *Research design: Qualitative, quantitative, and mixed methods approaches*, 2nd ed, Thousand Oaks, CA: Sage.

CTOD and CNT (Center for Transit-Oriented Development and Center for Neighborhood Technology). (2006) *The Affordability Index: A New Tool for Measuring the True Affordability of a Housing Choice*, Washington: Urban Markets Initiative, The Brookings Institution.

Dacquisto, D.J. and Rodda, D.T. (2006) *Housing impact analysis*, U.S. Department of Housing and Urban Development, Office of Policy Development and Research [online]. Available at: http://www.dca.state.fl.us/fdcp/dcp/affordablehousing/Files/hsgimpact.pdf [Accessed on 2nd January 2010].

De Montis, A., De Toro, P., Droste-Franke, B., Omann, I. and Stagl, S. (2000) Criteria for quality assessment of MCDA methods. *In Proceedings: 3rd Biennial Conference of the European Society for Ecological Economics*, 3–6 May, Vienna.

DEFRA (Department for Environment Food and Rural Affairs). (2011) *Merseyside Waste Private Finance Initiative Project* [online]. Available at: http://archive.defra.gov.uk/environment/waste/localauth/funding/pfi/documents/project-merseyside-feb2011.pdf [Accessed 15th March 2012].

DELG (Department of the Environment and Local Government). (2000) *Planning and Development Act 2000*, Dublin: The Stationery Office.

Denzin, N. and Lincoln, Y. (1998) Entering the Field of Qualitative Research. In: Denzin, N. and Lincoln, Y. (eds.) *Collecting and Interpreting Qualitative Materials*, Sage: London.

DETR (Department of the Environment, Transport and the Regions). (2000) *Quality and Choice: A Decent Home for All, The Housing Green Paper*, London: DETR.

DFT (Department for Transport). (2010) *Core accessibility indicators 2009*, London: DFT.

Disney, J. (2007) *Affordable housing for all*, Impact [online]. Available at: http://search.informit.com.au/documentSummary;dn=352647021245858;res=IELHSS [Accessed on 18th December 2010].

Dyer, J.S., Fishburn, P.C., Steuer, R.E., Wallenius, J. and Zionts, S. (1992) Multiple criteria decision making, multiattribute utility theory: the next ten years, *Management Science*, 38(5), pp. 645–654.

ECOTEC. (2005) *Understanding the Drivers of Housing Market Change in the New Heartlands Housing Market Renewal Area*, Birmingham: ECOTEC.

Edwards, B. and Turrent, D. (2000) *Sustainable Housing: Principles and Practice*, London: E and FN Spon.

E.surv (2012) *E.surv Mortgage Monitor May 2012* [online]. Available at: http://www.templetonlpa.co.uk/_assets/e.surv%20mortgage%20monitor%20-%20june.pdf [Accessed on 25 June 2012].

Evans, G. W., Wells, N. M., Chan, E. and Saltzman, H. (2000) Housing and mental health, *Journal of Consulting and Clinical Psychology*, 68(3), pp. 526–530.

Field, A. (2009) *Discovering statistics using SPSS*, 3rd ed, London: SAGE.

Field, C.G. (1997) Building consensus for affordable housing, *Housing Policy Debate*, 8(4), pp. 801-32.

Fishburn, P. C. (1967) *Additive utilities with incomplete product set: applications to priorities and assignments*, Baltimore, MD: Operations Research Society of America (ORSA).

Fisher, L.M., Pollakowski, H.O. and Zabel, J. (2009) Amenity-Based Housing Affordability Indexes, *Real Estate Economics*, 37(4), pp. 705-746.

Gabriel, M., Jacobs, K., Arthurson, K., Burke, T. and Yates, J. (2005) *Conceptualising and measuring the housing affordability problem*, Research Paper 1, Melbourne: Australian Housing and Urban Research Institute.

Gan, Q. and Hill, R.J. (2009) Measuring housing affordability: Looking beyond the median, *Journal of Housing economics*, 18(2), pp. 115-125.

Gershon, M. and Duckstein, L. (1983) Multiobjective approaches to river basin planning, *Journal of Water Resources Planning and Management*, 109(1), pp. 13-28.

Giannoulis, C. and Ishizaka, A. (2009) A Web-based decision support system with ELECTRE III for a personalised ranking of British universities, *Decision Support Systems*, 48(3), pp. 488-497

Ginevic˘ius, R. and Podvezko, V. (2009) Evaluating the changes in economic and social development of Lithuanian counties by multiple criteria methods, *Technological and Economic Development of Economy*, 15(3), pp. 418–436.

Glaser, E. L. and Gyourko, J. (2002) *The Impact of Zoning on Housing Affordability*, Cambridge, MA: Harvard Institute of Economic Research.

Guitouni, A. and Martel, J.M. (1998) Tentative Guidelines to Help Choosing an Appropriate MCDA Method, *European Journal of Operational Research*, 109, pp. 501 - 521.

Haffner, M. and Heylen, K. (2011) User costs and housing expenses. Towards a more comprehensive approach to affordability, *Housing Studies*, 26(4), pp. 593–614.

Hajkowicz, S.A and Higgins, A. (2008) A Comparison of Multiple Criteria Analysis Techniques for Water Resource Management, *European Journal of Operational Research*, 184, pp. 225–265.

Hajkowicz, S.A., McDonald, G.T. and Smith, P.N. (2000) An evaluation of multiple objective decision support weighting techniques in natural resource management, *Journal of Environmental Planning and Management*, 43(4), pp. 505–518.

Hall, P. and Tewdwr-Jones, M. (2011) *Urban and Regional Planning*, 5th ed, Oxon: Routledge.

Hancock, K.E. (1993) Can pay? Won't pay? Or economic principles of 'affordability', *Urban Studies*, 30(1), pp. 127-145.

Harker, L. (2006) *Chance of a lifetime: the impact of bad housing on children's lives*, London: Shelter.

Harriot, S. and Matthews, L. (2009) *Introducing affordable housing*, Coventry: Chartered Institute of Housing.

HCCPA (House of Commons Committee of Public Accounts). (2008) *Housing Market Renewal: Pathfinders Thirty-fifth Report of Session 2007-08*, London: The Stationery Office.

HM Government. (2005) *Securing the future: delivering UK sustainable development strategy*, London: The Stationery Office.

HNZC (Housing New Zealand Corporation). (2005) *Building the Future: New Zealand Housing Strategy*, Wellington: Housing New Zealand Corporation.

Howard, A.F. (1991) A critical look at multiple criteria decision making techniques with reference to forestry applications, *Canadian Journal of Forest Research*, 21, pp. 1649-1659.

Hui, E.C.M. (2001) Measuring Affordability in Public Housing from Economic Principles: Case Study of Hong Kong, *Journal of Urban Planning and development*, 127(1), pp. 34-49.

Hulchanski, J.D. (1994) *Discrimination in Ontario's Rental Housing Market: The Role of Minimum Income Criteria*, Toronto: Ontario Human Rights Commission.

Hulchanski, J.D. (1995) The concept of housing affordability: Six contemporary uses of the housing expenditure-to-income ratio, *Housing Studies*, 10(4), pp. 471-491.

Hwang, C. and Yoon, K. (1981) *Multiple Attribute Decision Making*, Berlin: Springer.

Jacquet-Lagrèze, E. and Siskos, Y. (2001) Preference disaggregation: 20 years of MCDA experience, *European Journal of Operational Research*, 130(3), pp. 233-245.

Jakimavičius, M. and Burinskienė, M. (2009) Assessment of Vilnius city development scenarios based on transport system modelling and multicriteria analysis, *Journal of Civil Engineering and Management*, 15(4), p. 361-368.

Jakobsson, U. (2004) Statistical Presentation and Analysis of Ordinal Data in Nursing Research, *Scandinavian Journal of Caring Sciences*, 18(4), pp. 437-440.

Johnson, M.P. (2005) Spatial decision support for assisted housing mobility counselling, *Decision Support Systems*, 41(1), pp. 296-312.

Jones, C., Watkins, C. and Watkins, D. (2011) Measuring local affordability: variations between housing market areas, *International Journal of Housing Markets and Analysis*, 4(4), pp. 341-356.

Kaklauskas, A., Zavadskas, E., and Raslanas, S., (2005) Multivariant design and multiple criteria analysis of building refurbishments, *Energy and Buildings*, 37(4), pp. 361–372.

Kaklauskas, A., Zavadskas, E.K., Banaitis, A. and Satkauskas, G. (2007) Defining the utility and market value of a real estate: A multiple criteria approach, *International Journal of Strategic Property Management*, 11(2), pp. 107-120.

Kearns, A. and Turok, I. (2004) *Sustainable communities: dimensions and challenges*, ESRC/Office of the Deputy Prime Minister Postgraduate Research Programme Working Paper 1, London: Office of the Deputy Prime Minister.

Kearns, A., Hiscock, R., Ellaway, A. and Macintyre, S. (2000) "Beyond four walls" - the psycho-social benefits of home: evidence from West Central Scotland, *Housing Studies*, 15(3), pp. 387-410.

Keeney, R. and Raiffa, H. (1976) *Decisions with Multiple Objectives*, New York: Wiley.

Kohlmann, T. and Moock, J. (2009) *How to analyzed your data*. In: Stengel, D., Bhandari, M. and Hanson, B. *Statistics and Data Management: A Practical Guide for Orthopaedic Surgeons*, Stuttgart: Thieme, pp. 93-110.

Köksalan, M., Wallenius, J. and Zionts, S. (2011) *Multiple Criteria Decision Making: From Early History to the 21st Century*, Singapore: World Scientific.

Kutty, N.K. (2005) A New Measure of Housing Affordability: Estimates and Analytical Results, *Housing Policy Debate*, 16(1), pp. 113-142.

LCC (Liverpool City Council). (2005) *Liverpool Open Space Study* [online]. Available at: http://liverpool.gov.uk/council/strategies-plans-and-policies/environment-and-planning/local-development-framework/evidence-monitoring-information/ [Accessed on 5th February 2012].

LCC (Liverpool City Council). (2009) *Liverpool City Council's Housing Strategy Statement 2009-2011* [online]. Available at: http://liverpool.gov.uk/Images/HousingStrategyStatement.pdf [Accessed on 24th January 2011].

LCC (Liverpool City Council). (2011a) *Liverpool Ward Profiles Summary Autumn 2011* [online]. Available at: http://liverpool.gov.uk/Images/allwards.pdf [Accessed on 16th March 2012].

LCC (Liverpool City Council). (2011b) *Childcare Sufficiency Assessment 2011-2014* [online]. Available at: http://liverpool.gov.uk/council/performance-and-spending/auditsinspections-and-assessments/children-and-young-people/childcare-sufficiency-assessment/ [Accessed on 16th March 2012].

LCC (Liverpool City Council). (2011c) *Childcare Sufficiency Assessment 2011 Ward Summaries* [online]. Available at: http://liverpool.gov.uk/Images/CSAWard_reports_FINAL.pdf [Accessed on 16th March 2012].

LCC (Liverpool City Council). (2011d) *Private sector house condition survey 2010* [online]. Available at: http://liverpool.gov.uk/Images/housingconditionsurvey2010.pdf [Accessed on 20th March 2012].

LCC (Liverpool City Council). (2012) *The city of Liverpool Key Statistic Bulletin Issue 12 – January 2012* [online]. Available at: http://liverpool.gov.uk/Images/Key-Statistics-Bulletin-issue-12-Jan2012.pdf [Accessed on 16th March 2012].

Lehtonen, M. (2004) The environmental–social interface of sustainable development: capabilities, social capital, institutions, *Ecological Economics*, 49, pp. 199– 214

Linneman, P. D. and Megbolugbe, I. F. (1992) Housing Affordability: Myth or Reality? *Urban Studies*, 29 (3-4), pp. 369-392.

Lotfi, S. and Solaimani, K. (2009) An assessment of Urban Quality of Life by Using Analytic Hierarchy Process Approach (Case study: Comparative Study of Quality of Life in the North of Iran), *Social Sciences*, 5(2), pp. 123-133.

Lux, M. (2007) The Quasi-normative Approach to Housing Affordability: The Case of the Czech Republic, *Urban Studies*, 44 (5-6), pp. 1109-1124.

MacLennan, D. and Williams, R. (1990) *Affordable housing in Britain and America*, York: Joseph Rowntree Foundation.

MacLennan, D., Gibb, K. and More, A. (1990) *Paying for Britain's Housing*, York: Joseph Rowntree Foundation.

Mahmoud, M.R. and Garcia, L.A. (2000) Comparison of different multicriteria evaluation methods for the Red Bluff diversion dam, *Environmental Modelling and Software*, 15(5), pp. 471-478.

Maliene, V. and Malys, N. (2009) High-quality housing-A key issue in delivering sustainable communities, *Building and Environment*, 44(2), pp. 426-430.

Maliene, V., Howe, J. and Malys, N. (2008) Sustainable Communities: Affordable Housing and Socio-economic Relations, *Local Economy*, 23(4), pp. 267-276.

Malpass, P. (1993) Housing tenure and affordability: the British disease. In: Hallett, G. (eds.) *The New Housing Shortage: Housing Affordability in Europe and the USA*, London: Routledge, pp. 87- 88

Marinoni, O. (2006) A discussion on the computational limitations of outranking methods for land-use suitability assessment, *International Journal of Geographical Information Science*, 20(1), pp. 69–87.

Massam, B.H. (1988) Multi-Criteria Decision Making (MCDM) techniques in planning, *Progress in Planning*, 30(1), pp. 1-84.

Mayor of London (2004) *Guide to preparing Open Space Strategies: Best practice guidance of the London Plan*, London: Greater London Authority.

McCord, M., McGreal, S., Berry, J., Haran, M. and Davis, P. (2011) The implications of mortgage finance on housing market affordability, *International Journal of Housing Markets and Analysis*, 4(4), pp. 394 – 417.

Medineckienė, M., Turskis, Z., Zavadskas, E.K. and Tamošaitienė, J. (2010) Multi-Criteria Selection of the One Flat Dwelling House, Taking into Account the Construction Impact on Environment. *In Proceedings: The 10th International Conference Modern Building Materials, Structures and Techniques*, May 19–21, Lithuania, Vilnius, pp. 455-460.

Merseyside Transport Partnership (2011) *The third Local Transport Plan for Merseyside* [online]. Available at: http://www.letstravelwise.org/files/268958954_Full%20LTP3%20(lo%20res).pdf [Accessed on 7th February 2012].

Miller, D.W. and Starr, M.K. (1969) *Executive Decisions and Operations Research*, Englewood Cliffs, NJ: Prentice-Hall.

Millet, I. and Schoner, B. (2005) Incorporating negative values into the Analytic Hierarchy Process, *Computers and Operations Research*, 32(12), pp. 3163-3173.

Monk, S. and Whitehead, C. (2010) *Making Housing More Affordable: The Role of Intermediate Tenures*, Oxford: Wiley Blackwell.

Mulliner, E. and Maliene, V. (2011) Criteria for Sustainable Housing Affordability. *In Proceedings: 8th International Conference on Environmental Engineering* (*ICEE*), 19–20 May, Lithuania: VGTU Press Technika, pp. 966-973.

Mulliner, E. and Maliene, V. (2012) Affordable Housing Policy and Practice in the UK. In: Hepperle, E., Dixon-Gough, R., Maliene, V., Mansberger, R., Paulsson, J. and Pödör, A.

(eds.) *Land Management: Potential, Problems and Stumbling Blocks*, Zürich, Switzerland: Vdf Hochschulverlag, pp. 267-277.

Mulliner, E., Smallbone, K. and Maliene, V. (2013) An Assessment of Sustainable Housing Affordability Using a Multiple Criteria Decision Making Method, *OMEGA*, 41(2), pp. 270–279.

Myers, D. (2011) *Economics and property: The Estates Gazette Guide*, 3rd ed, London: Elsevier.

Natividade-Jesus, E., Coutinho-Rodrigues, J. and Antunes, C.H. (2007) A multicriteria decision support system for housing evaluation, *Decision Support Systems*, 43(3), pp. 779–790.

Ndubueze, O. (2007) Measuring Housing Affordability: A Composite Approach. *In Proceedings: ENHR International Conference Sustainable Urban Areas*, 25-28 June, Rotterdam.

Nepal, B., Tanton, R. and Harding, A. (2010) Measuring Housing Stress: How Much do Definitions Matter?, *Urban Policy and Research*, 28(2), pp. 211–224.

Nevin, B., Lee, P., Goodson, L., Murie, A. and Phillimore, J. (2001) *Changing Housing Markets and Urban Regeneration in the M62 Corridor*, Birmingham: Centre for Urban and Regional Studies.

Newman, P. (2002) Sustainability and housing: More than a roof over head. *In Proceedings: The 9th F. Oswald Barnett Oration*, 31 October, Melbourne.

NHPAU (National Housing and Planning Advice Unit). (2008) *Affordability still matters* [online]. Available at: http://www.communities.gov.uk/documents/507390/pdf/867681.pdf [Accessed on 17th January 2011].

NHPAU (National Housing and Planning Advice Unit). (2009a) *More homes for more people: building the right homes in the right places* [online]. Available at: http://www.communities.gov.uk/documents/507390/pdf/1276301.pdf [Accessed on 17th January 2011].

NHPAU (National Housing and Planning Advice Unit). (2009b) *Affordability - more than just a housing problem* [online]. Available at: http://www.communities.gov.uk/documents/507390/pdf/1221507.pdf [Accessed 24th October 2011].

NHPAU (National Housing and Planning Advice Unit) (2010) *Housing affordability: a fuller picture* [online]. Available at: http://www.communities.gov.uk/documents/507390/pdf/14657171.pdf [Accessed 24th October 2011].

NWRA (North West Regional Assembly). (2007) *North West Housing Statement 2007*, Wigan: NWRA.

ODC (1986) *Oxford Dictionary of Computing*, 2nd Edition, Oxford: Oxford University Press.

ODPM (Office of the Deputy Prime Minister). (2003) *Sustainable Communities: Building for the Future*, London: ODPM.

ODPM (Office of the Deputy Prime Minister). (2004) *The Egan Review: Skills for Sustainable Communities*, London: RIBA Enterprise.

ODPM (Office of the Deputy Prime Minister). (2005a) *Sustainable Communities: People, Places and Prosperity*, London: The Stationery Office.

ODPM (Office of the Deputy Prime Minister). (2005b) *Sustainable communities: Homes for all*, London: The Stationary Office.

ODPM (Office of the Deputy Prime Minister). (2005c) *Affordability targets: Implications for housing supply*, London: ODPM.

Opricovic, S. and Tzeng, G.-H. (2004) Compromise solution by MCDM methods: a comparative analysis of VIKOR and TOPSIS, *European Journal of Operational Research*, 156(2), pp. 444-5.

Pallant, J. (2005) *SPSS Survival Manual*, 2nd ed, Buckingham: Open University Press.

Paris, C. (2007) International Perspectives on Planning and Affordable Housing, *Housing Studies*, 22(1), pp. 1-9.

Performance Urban Planning (2012), 8th Annual Demographia International Housing Affordability Survey [online]. Available at: http://www.demographia.com/dhi.pdf [Accessed on 8th March 2012].

Pescatore, C (1995) *Validation: the eluding definition*, Radioactive Waste and Environmental Restoration, 20, pp. 13–22.

PMSU and ODPM (Prime Minister's Strategy Unit and Office of the Deputy Prime Minister). (2005) *Improving the prospects of people living in areas of multiple deprivation in England*, London: Cabinet Office.

Pohekar, S.D. and Ramachandran, M. (2004) Application of multi-criteria decision making to sustainable energy planning - a review, *Renewable and Sustainable Energy Reviews*, 8(4), pp. 365–381.

Pollard, T. (2010) *Jobs, Transportation, and Affordable Housing: Connecting Home and Work* (Report), Southern Enivronmental Law Center [online]. Available at: http://www.va-rems.org/connecting_home_and_work.pdf [Accessed 24th February 2012].

Punch, K. (1998) *Introduction to Social Research: Quantitative and Qualitative Approaches*, London: Sage.

Queensland Department of Housing. (2000) *Affordable Housing in Sustainable Communities: Discussion Paper*, Brisbane: Queensland Department of Housing.

Quigley, J.M. and Raphael, S. (2004) *Is Housing Unaffordable? Why Isn't It More Affordable? Journal of Economic Perspectives*, 18(1), pp. 191-214.

Raffestin, C. and Lawrence R. (1990) An ecological perspective on housing, health and well-being, *Journal of Sociology and Social Welfare*, 17(1), pp. 143–160.

Raftery, J., McGeorge, D. and Walters, M. (1997) Breaking up methodological monopolies: a multi-paradigm approach to construction management research, *Construction Management and Economics*, 15(3), pp. 291-297.

Robinson, M., Scobie, G. M. and Hallinan, B. (2006) *Affordability of housing: concepts, measurement and evidence*, Working Paper No. 06/03, Wellington: New Zealand Treasury.

Robson, C. (2002) *Real World Research*, 2nd ed, Oxford: Blackwell Publishing.

Rowley, J. (2012) Conducting research interviews, *Management Research Review*, 35(3), pp. 260-271.

Rowley, S. and Ong, R. (2012) *Housing affordability, housing stress and household wellbeing in Australia*, Melbourne: Australian Housing and Urban Research Institute.

Roy, B. (1991) The outranking approach and the foundations of the ELECTRE methods, *Theory and Decision*, 31(1), pp. 49-73.

Saaty, T.L. (1980) *The Analytical Hierarchy Process*, New York: McGraw-Hill.

Saaty, T.L. (1994) *Fundamentals of Decision-Making and Priority Theory with the AHP*, Pittsburg: RWS Publications.

Salminen, P., Hokkanen, J. and Lahdelma, R. (1998) Comparing multicriteria methods in the context of environmental problems, *European Journal of Operations Research*, 104(3), pp. 485–496.

Samuels, I. (2005) *What home buyers want: Attitudes and decision making among consumers*, London: Commission for Architecture and the Built Environment.

Schniederjans, M., Hoffman, J. and Sirmans, G. (1995) Using goal programming and the analytical hierarchy process in house selection, *Journal of Real Estate Finance and Economics*, 11(2), pp. 167-76.

Scottish Government. (2008) *Housing Need and Demand Assessment Guidance* [online]. Available at: http://www.scotland.gov.uk/Resource/Doc/1125/0057728.pdf [Accessed on 5th December 2010].

Seelig, T. and Phibbs, P. (2006) Beyond the Normative: Low Income Private Renters' Perspectives of Housing Affordability and Need for Housing Assistance, *Urban Policy and Research*, 24(1), pp. 53-66.

Senate Select Committee on Housing Affordability in Australia. (2008) *A good house is hard to find: Housing affordability in Australia*, Canberra: Commonwealth of Australia.

Shaniana, A. and Savadogob, O. (2009) A methodological concept for material selection of highly sensitive components based on multiple criteria decision analysis, *Expert Systems with Applications*, 36(2), pp. 1362-1370.

Shelter. (2006) *ROOF Affordability Index 2006*. London: Shelter.

Shelter. (2011) *Shelter response to CLG consultation: Draft National Planning Policy Framework* [online]. Available at: http://england.shelter.org.uk/__data/assets/pdf_file/0009/387918/Shelter_response_to_draft_NPPF_October_2011_-_FINAL.pdf [Accessed on 17 January 2012].

Sheskin, D. (2007) *Handbook of parametric and nonparametric statistical procedures*, 4th ed, London: Chapman and Hall.

Shostak, L. and Houghton, J. (2008) The credit crunch and the housing shortage – time for a radical new approach to building affordable homes, *Local Economy*, 23(3), pp. 121-126.

Silverman, D. (2010) *Doing Qualitative Research: A Practical Handbook, 3rd ed.*, Sage: London.

Simanaviciene, R. and Ustinovicius, L. (2012) A New Approach to Assessing the Biases of Decisions based on Multiple Attribute Decision making Methods, *Electronics and Electrical Engineering*, 117(1), pp. 29-32.

Stewart, TJ. (1992) A Critical Survey on the Status of Multiple Criteria Decision Making Theory and Practice, *Omega*, 20(5-6), pp. 569-586.

Stone, M.E. (1993) *Shelter Poverty: New Ideas on Housing Affordability*, Philadelphia: Temple University Press.

Stone, M.E. (1994) Comment on Kathryn P. Nelson's "Whose Shortage of Affordable Housing?", *Housing Policy Debate*, 5(4), pp. 443-458.

Stone, M. E. (2005) Housing Affordability: One-Third of a Nation Shelter Poor. In: Bratt, R., Stone, M.E. and Hartman, C.A. *Right to Housing: Foundation for a New Social Agenda*. Philadelphia: Temple University Press, pp. 38-60.

Stone, M.E. (2006a) A Housing Affordability Standard for the UK, *Housing Studies*, 21(4), pp. 453-476.

Stone, M. E. (2006b) What Is Housing Affordability? The Case for the Residual Income Approach, *Housing Policy Debate*, 17(1), pp. 151-183.

Stone, M.E., Burke, T. and Ralston, L. (2011) *The Residual Income Approach to Housing Affordability: The Theory and the Practice* [online]. Available at: http://works.bepress.com/cgi/viewcontent.cgi?article=1009andcontext=michael_stone [Accessed on October 16th 2011].

Talen, E. and Koschinsky, J. (2011) Is subsidized housing in sustainable neighborhoods? Evidence from Chicago, *Housing Policy Debate*, 21(1), pp. 1-28.

Thalmann, P. (2003) 'House poor' or simply 'poor'?, *Journal of Housing Economics*, 12(4), pp. 291-317.

Triantaphyllou, E. (2000) *Multi-Criteria Decision Making Methods: A Comparative Study*, Dordrecht: Kluwer Academic.

Triantaphyllou, E. and Mann, S.H. (1989) An examination of the effectiveness of multi-dimensional decision-making methods: A decision-making paradox, *Decision Support Systems*, 5(3), pp. 303-312.

Triantaphyllou, E. and Mann, S.H. (1995) Using the analytic hierarchy process for decision making in engineering applications: some challenges, *Industrial Engineering: Applications and Practice*, 2(1), pp. 35-44.

Uilaityte, L. and Martinaitis, V. (2010) Search for optimal solution of public building renovation in terms of life cycle, *Journal of Environmental Engineering and Landscape Management*, 18(2), pp. 102-110.

Vilutienė, T. and Zavadskas, E.K. (2003) The application of multi-criteria analysis to decision support for the facility management of a city's residential district, *Journal of Civil Engineering and Management*, 10(4), pp. 241–252.

Viteikienė, M. and Zavadskas, E.K. (2007) Evaluating the sustainability of Vilnius City residential areas, *Civil Engineering and Management*, 13(2), 149-155.

Wang, J-J., Jing, Y-Y., Zhang, C-F. and Zhao J-H. (2009) Review on multi-criteria decision analysis aid in sustainable energy decision-making, *Renewable and Sustainable Energy Reviews*, 13(9), pp. 2263–2278.

Wang, X. and Triantaphyllou, E. (2008) Ranking irregularities when evaluating alternatives by using some ELECTRE methods, *Omega*, 36(1), pp. 45 – 63.

WCED (World Commission on Economic Development). (1987) *Our Common Future*, Oxford: Oxford University Press.

Welsh Assembly Government. (2006) *Local Housing Market Assessment Guide*, Cardiff: Welsh Assembly Government.

Whitehead, C. (1991) From need to affordability: an analysis of UK housing objectives, *Urban Studies*, 28(6), pp. 871-887.

Whitehead, C. (2007) Planning Policies and Affordable Housing: England as a Successful Case Study?, *Housing Studies*, 22(1), pp. 25-44.

Whitehead, C., Monk, S., Clarke, A., Holmans, A. and Markkanen, S. (2009) *Measuring Housing Affordability: A Review of Data Sources*, Cambridge: Cambridge Centre for Housing and Planning Research.

WHO (World Health Organisation). (2004) *Review of Evidence on Housing and Health*, Fourth Ministerial Conference on Housing and Health, background document [online]. Available at: http://www.euro.who.int/document/HOH/ebackdoc01.pdf [Accessed on January 12th 2011].

Winston, N. (2010) Regeneration for Sustainable Communities? Barriers to Implementing Sustainable Housing in Urban Areas, *Sustainable Development*, 18(6), pp. 319–330.

Winston, N. and Eastway, P. (2008) Sustainable Housing in the Urban Context: International Sustainable Development Indicator Sets and Housing, *Social Indicators Research*, 87(2), pp. 11-221.

Witte, R. S. and Witte, J.S. (2009) *Statistics*, 9th ed, Hoboken, NJ: John Wiley and Sons.

Wong, G. (1999) Multi-Criteria Decision-Aid for Building Professionals, *Journal of Building Surveying*, 1(1), pp. 5-10.

Wright, P.A. and Kloos, B. (2007) *Housing environment and mental health outcomes: A levels of analysis perspective, Environmental Psychology*, 27(1), pp. 79–89.

Yates, J. and Milligan, V. (2007) *Housing Affordability: A 21st Century Problem*, final report, Melbourne: Australian Housing and Urban Research Institute.

Zanakis, S.H., Solomon, A., Wishart, N. and Dublish, S. (1998) Multi-attribute decision making: a simulation comparison of select methods, *European Journal of Operations Research*, 107(3), pp. 507–529.

Zavadskas, E. K., Kaklauskas, A. and Kvederyte, N. (2001) Multivariant Design and Multiple Criteria Analysis of a Building Life Cycle, *Informatica*, 12(1), pp. 169–188.

Zavadskas, E.K., Kaklauskas, A., Banaitis, A. and Kvederyte, N. (2004) Housing credit access model: The case for Lithuania, *European Journal of Operational Research*, 155(2), pp. 335-352.

Zavadskas, E.K., Peldschus, F. and Kaklauskas, A. (1994) *Multiple criteria evaluation of projects in construction*, Vilnius: Technika.

Zhu, X., Liu, S. and Yeow, M.C.A. (2005) GIS-Based Multi-Criteria Analysis Approach to Accessibility Analysis for Housing Development in Singapore. *In Proceedings*: *SSC 2005 Spatial Intelligence, Innovation and Praxis: The national biennial Conference of the Spatial Sciences Institute*, September, Melbourne: Spatial Sciences Institute.

Zopounidis, C. (1999) Multicriteria decision aid in financial management, *European Journal of Operational Research*, 119(2), pp. 404-415.

Websites

www.earth.google.com

www.homeshub.co.uk

www.nestoria.co.uk

www.ons.gov.uk

www.propertypool.org.uk

www.rightmove.co.uk

Appendix 1

Outline of semi-structured interview questions

Outline of questions to ask Local Authority professionals:

Q. What policies do you have in place with regard to affordable housing?

a) What is the most desirable tenure?
b) What is the most successful tenure?
c) Which tenure is easiest to deliver?

Q. How do you define affordable housing?

Q. How do you define housing affordability?

Q. Are these definitions specific to your council or are they adopted from other policies, such as government?

Q Do you evaluate affordability and if so what criteria do you use?

Q. Do you think that it is important for affordable housing to be located within sustainable communities?

Q. Do you think that it is important for affordable housing to be of a high quality?

Q. Are there any other criteria that you think affect housing affordability?

Q. What criteria should an ideal affordability assessment take into consideration?

Q. Do you measure the affordability of different neighbourhood areas?

Appendix 2

Copy of pilot questionnaire

Developing a criteria system for affordable and sustainable housing

Emma Mulliner for the School of the Built Environment

The following questionnaire has been designed in order to explore the concept of housing affordability and develop a new criteria system that can be used to assess the affordability of different housing locations in a sustainable manner.

All data collected in this survey will be held securely. Completion of this questionnaire is voluntary. Please can you confirm that you have read the participant information sheet and are happy to complete this questionnaire. Please mark the box with an 'x' if you confirm. [ ]

Q1. Which Local Authority in the North West are you based in? Please specify below.

....

Q2. Which of the following best describes your area of employment? Please mark the appropriate box with an 'X'.

- ➢ Housing association [ ]
- ➢ Local authority [ ]

➢ Urban regeneration [ ]

➢ Housing developer [ ]

➢ Other [ ]

Q3. A criteria system characterising 'sustainable housing affordability' has been suggested in the left hand side of the table below. Considering all of the criteria together (as a whole system), please identify how important you think each criterion is to sustainable housing affordability by assigning it a number from 1 = 'not important' to 10 = 'most important' by marking with an 'X' the appropriate box along the scale of importance.

Criteria system for sustainable housing affordability	Scale of importance								
	1 Not Important	2	3	4	5	6	7	8	9	10 Most Important
1. House prices in relation to income										
2. Rental costs in relation to income										
3. Interest rates and mortgage availability										
4. Availability of rented accommodation (private and social)										
5. Availability of low cost home ownership products (e.g. shared ownership)										
6. Safety (low crime levels)										
7. Access to employment										
8. Access to public transport services										
9. Access to good quality education/schools										
10. Access to shopping facilities										
11. Access to health services (e.g. GPs, hospitals)										
12. Access to early years child care										
13. Access to leisure facilities										

14. Access to open green public space										
15. Quality of housing (*e.g. meeting decent homes standard*)										
16. Energy efficiency of housing										
17. Waste management (e.g. level of recycling, reuse, composting)										

Q4. If there are any additional criteria which you think characterise sustainable housing affordability then please suggest them below.

....

....

....

....

....

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS QUESTIONNAIRE

Appendix 3

Copy of final survey questionnaire

Welcome

You are being invited to take part in a PhD research study. Please take the time to read the following information. If you would like some more information or something is not clear please ask.

The purpose of this study is to explore the concept of housing affordability and develop a new tool that can be used to assess the affordability of different housing locations in a sustainable manner.

You will be asked to complete a short questionnaire which should take no longer than 10-15 minutes. Taking part in the survey is optional and you may withdraw at any point without giving a reason.

No risks have been identified for taking part in this study and full ethical approval from the Liverpool John Moores Research Ethics Committee (REC) has been gained.

All data collected in this survey will be held anonymously and securely. Personal data will not be published. Data from the questionnaires will be kept by the researcher and will not be passed on to third parties. All information you provide will be destroyed by shredding or deleting electronic information within five years of the completion of the study.

Any questions that you have about your participation, withdrawal and role in the study should be addressed to Emma Mulliner who is organizing this study.

Contact details:
Emma Mulliner, School of the Built Environment, Liverpool John Moores University, Henry Cotton Building, 15-21 Webster Street, Liverpool, L3 2ET
Email: E.K.Mulliner@2006.ljmu.ac.uk

For any complaints about the procedure please contact:
Dr. Vida Maliene, Cherie Booth Building, Byrom Street, Liverpool, L3 3AF
Telephone: 0151 2312854
Email: V.Maliene@ljmu.ac.uk

Note that once you have clicked on the CONTINUE button at the bottom of each page you cannot return to review or amend that page.

Determining the criteria that characterise sustainable housing affordability

All questions are **mandatory**.

Note that once you have clicked on the CONTINUE button your answers are submitted and you cannot return to review or amend the page.

About you

1. What gender are you?

- ○ Male
- ○ Female

2. What age are you?

- ○ 18-25
- ○ 26-35
- ○ 36-45
- ○ 46-55
- ○ 56+

3. Which of the following best describes your area of employment?

- ○ Housing association
- ○ Local authority - planning
- ○ Local authority - housing services
- ○ Urban regeneration
- ○ Housing developer
- ○ Property/Affordable Housing Consultant
- ○ Other *(please specify)*:

4. Which region of the UK are you based in?

Select an answer

- Select an answer
- East Midlands
- East of England
- Greater London
- North East England
- North West England
- South East England
- South West England
- West Midlands
- Yorkshire and the Humber
- Wales
- Scotland

5. Which Local Authority are you based in?

Criteria characterising sustainable housing affordability

6. A criteria system characterising 'sustainable housing affordability' is suggested in the table below. Considering all of the criteria together (as a whole system), please identify how important you think each criterion is to sustainable housing affordability by assigning it a number from 1 = 'not important' to 10 = most important' along the scale of importance.

	Scale of Importance								
	1 - Not Important	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10 - Most Important**
a. House prices in relation to income	○	○	○	○	○	○	○	○	○	○
b. Rental costs in relation to income	○	○	○	○	○	○	○	○	○	○
c. Interest rates and mortgage availability	○	○	○	○	○	○	○	○	○	○
d. Availability of rented accommodation (private and social)	○	○	○	○	○	○	○	○	○	○
e. Availability of low cost home ownership products (e.g. shared ownership)	○	○	○	○	○	○	○	○	○	○
f. Availability of market value home ownership products	○	○	○	○	○	○	○	○	○	○
g. Safety (low crime rate)	○	○	○	○	○	○	○	○	○	○
h. Access to employment	○	○	○	○	○	○	○	○	○	○
i. Access to public transport services	○	○	○	○	○	○	○	○	○	○
j. Access to good quality education/schools	○	○	○	○	○	○	○	○	○	○
k. Access to shopping facilities	○	○	○	○	○	○	○	○	○	○
l. Access to health services (e.g. GPs, hospitals)	○	○	○	○	○	○	○	○	○	○
m. Access to early years child care	○	○	○	○	○	○	○	○	○	○
n. Access to leisure facilities	○	○	○	○	○	○	○	○	○	○

o. Access to open green public space	○	○	○	○	○	○	○	○	○	○
p. Presence of environmental problems (e.g. litter, heavy traffic, boarded up buildings)	○	○	○	○	○	○	○	○	○	○
q. Quality of housing (e.g. meeting decent homes standard)	○	○	○	○	○	○	○	○	○	○
r. Energy efficiency of housing	○	○	○	○	○	○	○	○	○	○
s. Waste management (e.g. level of recycling, reuse, composting)	○	○	○	○	○	○	○	○	○	○
t. Deprivation in area (Index of Multiple Deprivation	○	○	○	○	○	○	○	○	○	○

Survey completed

Thank you very much for taking the time to complete this survey. Your responses have now been submitted.

Appendix 4

Example of face-to-face interview transcript

Interview transcript
Interviewee (INT): Housing Strategy Officer at St. Helens Council
Date: 7th October 2010

EM: What policies do you have in place with regard to affordable housing?

INT: What the council have recently introduced was an actual specific affordable housing SPD which we didn't have until, well we started developing it last year and I think it got adopted through the council's sort of committee etc in January. And obviously that then supplements the LDF framework that we have got and we are currently sort of going through the whole core strategy process, which I think there has been some material changes to that recently which my planning colleges are looking at. And obviously given the sort of abolition of the Regional Spatial Strategies it's had a big impact so probably that the most sort of document we refer to in terms of a policy. Obviously affordable housing is picked up in a number of other policies, or strategies should I say, i.e. the council's housing strategy; it's a major element of that. Obviously planning have a material consideration around about when we are seeking affordable housing from developers etc when sites come in through the planning process. You can sort of take that away with you [policy document given] and have a look at that. I know that some councils will have an SPD and some won't, we certainly have developed that over the last couple of years.

EM: So what did you do prior to that for affordable housing?

INT: Basically the way we have approached it, when I came into post at housing strategy a number of years ago, the council on a sort of three, four year basis commissioned a housing needs study. The last time we did that was probably in 2006. There is one just about to commence now which is a more mid-Mersey approach. But basically the last housing needs study was commissioned and really that gives the local authority a picture of the shortfall of affordable housing in the Borough and that then is obviously a material consideration for council strategies and documents and gives us a, well should give you, a robust evidence base to go to developers and say 'look we need affordable housing on that site' and be able to then defend that should it go to a public enquiry. So that is where we are really. And probably before that we had a different approach where we were either trying to restrict development type things, so we had more of a sort of, I think we asked for something like 75% on certain sites. From 2006 that identified that we should be looking for around 30% on sites.

EM: What [percentage] are you looking for now?

INT: Well since that, because that probably came out in 2006 when we were in the boom times so 30% was achievable really on a lot of sites. We've done quite well from that, we have delivered a number of affordable housing schemes in the Borough. You then got to about 2008/2009 and things got a bit tight. We had a lot of permissions with affordable on which would of brought a huge pipeline of affordable housing and those sites have either not happened or stalled or the developer comes back to you saying 'I can't deliver this'. So they obviously start challenging that. So what we did then was we did a one off piece of work with the district valuer, like an economic viability assessment and he went and looked at 20 sites across the Borough to see if 30% could be delivered. Not surprisingly he came back and the vast majority of sites couldn't deliver any. There was scope within that study looking at if the market picked up by 10%, 20% and even if it picked up by 10% the majority of sites still were undeliverable to produce that. But that has not deterred us really we still try to seek 30% on sites. The other thing where we may differ from other authorities is that's not a blanket, we don't say 'it's 30% or nothing'. We have gone down to 10% on larger sites. We accept that certain parts of St. Helens don't need more affordable housing so if a site can deliver 100 units, yet it's in the middle of the biggest social housing unit we have got, we need to do something different in that neighbourhood. So we have gone with an approach of try to bring more apparitional housing in because St. Helens is an interesting place really, it has probably not got huge amounts of aspirational housing, and what we were finding was we were losing people in employment who were migrating out of St. Helens. So what we needed to start thinking about is how do we retain those people in the Borough and by putting more aspirational housing in and around the Borough hopefully we have done that. But certain wards really have got in excess of the national average of social affordable housing in there, the existing stock is affordable, or would have been affordable a few years ago.

EM: Is it desirable though, although it might be affordable?

INT: Well that is the issue isn't it? I think desirable is probably a different issue. I think people have always gone for the traditional two bed terrace in St. Helens, that is probably the majority of stock in the Borough and that is what people have naturally just started on the ladder on really. But yes in some wards we will say 'we don't want 30% on site provision here' and then we will perhaps go down the avenue of looking for a commuted sum. So instead of delivering it on site we would ask for a commuted sum where we could use on a more appropriate site to increase the percentage. So it's not a blanket where it's 30% or nothing which some authorities might go down. We have been pretty pragmatic because what we don't want to do is turn developers away. Because basically if a neighbouring authority have got a different approach developers will just go there and they probably have the same sorts of pieces of land, similar average property values.

EM: What sort of tenure do you find is most successful if you are trying to get developers to build?

INT: Well obviously I think the developers prefer the shared ownership route if anything.

EM: Do you find that successful?

INT: Well that is the difficulty now isn't it and we have recently had an RSL partner who has produced some shared ownership, not too far from the town centre, and they said it has been really popular; they said they could have sold the houses twice over on shared ownership. It is access to mortgages; that is the whole issue. I think apartments is probably a different ball game on shared ownership because by the time you have added in the mortgage payments, the rent on the unsold equity, service charges, is it affordable? A number of years ago we did a couple of schemes where we tried the selling properties at 80% of market value as an affordable housing option, although I don't think it is particularly defined in PPS3 as affordable. Developers I think like that scheme because they get 80% of the open market value. It has its complications then on further sales because I still get people selling properties saying 'who owns the other 20%'. Well no one owns it basically you have just got to sell for 80% when you sell. It is probably a complicated method of doing it. Intermediate rent, again we have just done some of that on a new estate that's 44 units. Just above social rented but below market rent.

EM: How much below market rent?

INT: I presume we would want to see sort of evidence, but we don't always get involved with the rent setting we just work with our RSL partners and presume they will go out and study the market. But shared ownership is pretty untested in St. Helens and I think we have had to go on a journey of trying to get people to understand that. I think it can be confusing because you have got lots of these different models out there. I think obviously the customer in the end needs to know that they can afford it. Social rented is obviously one we do go a lot down that road.

EM: So do you deliver more social rented than intermediate products?

INT: I think what the housing needs study says was that if we are asking for 30% on a site, that 30% should really be an equal split between rent and shared ownership. Whether we always get that I don't know. I think that a thing where we are a bit sort of pragmatic and just see what works really, perhaps we want more shared ownership on some sites.

EM: Is there one tenure that is more successful?

INT: Not particularly. If we are going down the road of delivering housing with RSLs through national affordable housing programmes it's all about grant rates etc. I think the securing of affordable housing through section 106 agreements is more difficult isn't it.

EM: How do you define 'affordable housing'?

INT: I think in terms of when we are trying to secure affordable housing through the planning we work towards the government guidelines set out in PPS3. I suppose really we have our own interpretation of what is affordable and again how we measure affordability is probably a personal thing to or local area. Obviously strap lines in housing strategy etc is about giving everyone the opportunity to live in a home that they can afford really. So that's I suppose how we approach it, but certainly in terms of securing affordable housing we have to work to what the government set out as affordable.

EM: How do you define 'housing affordability'?

INT: I am not sure we have got a specific definition really. I don't think we do as such. The housing needs study may well go into incomes and those sorts of things and probably gives an indication of disposable income and will probably then give an indication of how much people can raise on a mortgage. We did used to subscribe to the Home Track system which gave you a lot of data and you could pull of lots of nice graphs and pictures of affordability in your Borough and you could work out, on three times income that you still had X percentage who were priced out of buying a three bed house. So that was really useful, but unfortunately due to finance climates we haven't continued that subscription. Perhaps we didn't use it as often as we could to get our monies worth. So I would say we don't have a defined definition of affordability in those terms to the customer.

EM: Do you make assessments of affordability for different neighbourhood areas?

INT: We probably don't really. We have looked at St. Helens and in different studies, like I say the Liverpool City Region put St. Helens in with Halton as its own sort of defined housing market. I think internally and historically we do know that certain wards within the Borough are more deprived than others. We have all the sort of SOA [super output areas], so we know that affordability will be a bigger issue in some wards more than others. Obviously we can probably get stats around incomes by wards, but I don't think we do huge amounts on analysing affordability across the Borough.

EM: Are housing affordability and sustainability issues are tackled together within the council?

INT: Yes I think we probably do. As planning applications or pre-applications come through to the authority the sustainability of the site is quite key. Obviously there is not a great deal of point in putting affordable housing, social rented, on a site where there is no employment or no bus routes, no local schools; how would people get to the services they need? So obviously yes I think we do look at the sustainability of the neighbourhood as well.

EM: Would affordable housing be considered for development in an area that is not well connected to key services?

INT: Whether or not that would be a material consideration, if there is employment in the area, I think we need to be mindful of that. We need to have a think about the site coming in. I think we are getting applications now coming in on former, or what still may be deemed as employment land. However, because perhaps the industry isn't there anymore that sites not been used for three/four years. But then if you actually look at the site it could be surrounded by a huge band of industrial land and you think is that really the best housing site. If you put affordable housing on there then how can people get to services? So I think that is something we will consider yes.

EM: Does new affordable housing need to meet any sustainability standards?

INT: I think if we hadn't perhaps had the credit crunch it might have been an agenda that we could have forced more; perhaps we could have said we are pushing for minimum code level four or five and even sit on some sites. But I think we have to be realistic. Obviously I think the Homes and Communities Agency, and that's going through a period and change and we are not certain how that will look in the future, we are not sure what funding will be available, we have always promoted and supported schemes of RSLs who say they can deliver the code for sustainable homes to four/five. I think generally three is the average and they have to deliver to level three to get the funding. I know they start looking at things like water harvesting and those sorts of environmental issues when they are granting those sorts of permissions on sites now.

EM: Do you think it is important for affordable housing to be sustainable?

INT: Definitely, we have always said is that we don't want affordable housing on a bigger site to basically stick out like a saw thumb. The affordable housing shouldn't sit at the back corner basically and look of a lesser quality or be of a lesser quality. I presume for the builder it must be just as easy to build it to the same standard and spec as they are building for the rest of the homes. So it is quite important and it would probably be wrong of a local authority to support that knowing that in 20 years time that affordable housing would not be fit for purpose again and the RSL would be looking to clear that. So it is quite important that what we are building is of a good quality and also affordable in terms of running the property. So obviously we are quite interested in if it's carbon neutral and those sorts of things if it can keep the costs down for the client. I suppose RSLs will argue that if they put lots of gadgets on and solar panels they don't actually reap any benefits. I am sure they will do so because they are all embracing the green agenda now themselves, but there is no actual financial recovery for them. The client gets it, brilliant that's great. There was the whole lifetime homes agenda and I think they made claims that by 2015 lots of homes would be built to lifetime homes and I think it was a target which now it has sort of slipped a bit by the waist. I think it's something still that will need to be looked at and the Homes and Communities Agency will still support that. I don't think they will start funding schemes now of a lower standard. I think what they are trying to do now is trying to drive down the grant rates now because they money isn't as available, but they will still want a high standard of product.

EM: In your opinion what criteria do you think an ideal affordability measure should take into consideration?

INT: I think there can be a tendency to try to over complicate things with affordable housing. I think if you are looking at, are the properties affordable, certainly you need to look at the open market value in the estate etc. I think from a customer's point of view it would be wrong to just look at income perhaps and say 'well you are on £20,000 a year, therefore you need affordable housing because you are not earning X amount' because you need to look at all the other incomings and outgoing of that household. I think that's why all these home buy direct schemes are quite helpful for those people who just can't quite make that just from paying a rent to paying a mortgage. I think it's about having a range of models of affordable housing, but not going to far having too many models. It's about insuring that the customer understands what they are getting into. I think shared ownership is probably one of the more simple ones, they understand that they are paying a mortgage on that and a rent on that. I think home buy direct is you are paying it back after so many years and that can be quite difficult.

EM: That concludes my questions. Thank you.

Appendix 5

Example of face-to-face interview transcript

Interview transcript

Interviewee (INT): Housing Strategy and Enabling Team Manager (one interviewee present) at Cheshire West and Chester Council

Date: 11th August 2010

EM: What policies do you have in place with regard to affordable housing?

INT: OK we have three, currently three local plans in place for Cheshire West and Chester that relate to the three former planning authorities of Value Royal, Ellesmere Port, Neston and Chester city. Within each respective local plan there are affordable housing policies. Within the Vale Royal and Chester plans there are exception site policies and within all three there are affordable housing policies which require an element of affordable housing on the back of market development. So they are the general kind of policies.

EM: How do you define affordable housing?

INT: The starting point tends to be the PPS3 definition. So it will be housing that is available to those who cannot afford to access market housing either for rent or purchase. So the starting point is always that. We have in the past tried to define it in a little bit more detail in terms of values and incomes and other bits and pieces, but it's a little bit difficult to write it in policy terms to go into that level of detail as the kind of arena and platform changes in terms of incomes and house values. The policies themselves are fairly open ended.

EM: Are these definitions specific to your council or are they adopted from other policies?

INT: Yes I mean site policies are specific to the council. For example the Vale Royal Borough council will ask and actually stipulate in their policy a proportion of affordable housing that is required in that respective policy which is 30% and Ellesmere Port does the same and talks about 25%. The former Chester City Council local plan doesn't express an explicit proportional requirement within the policy, but the policy makes reference to the housing needs assessment and the recommendations from that. So for Chester city former area the policy requirement has raised over time as housing needs information has changed, so it has changed over time. There are supplementary planning documents in place for Vale Royal and Chester and they provide a little bit more detail on incomes and house prices and bits and pieces.

EM: How do you define housing affordability?

INT: The simplest test is benchmark rents for social rented or any other, if you like, traditionally accepted method of affordable housing that Registered Social Landlords provide. I suppose on the basic presumption that if it's good enough for the TSA and HCA then why wouldn't it be good enough for local authority? There are some concerns that shared ownership properties aren't that affordable in practice. There have been cases when the market is performing particularly well and values are quite high shared ownership properties are seemingly quite expensive, but it's a tried and trusted mechanism and it's also being delivered through a regulated organisation so we'll tend to use that. We have in the past and still currently looking at other forms of affordable housing provision. So we will look at low cost discount for sale, but bearing in mind what PPS3 says about lower value properties. But we will try and take a fairly flexible approach to that in terms of how we would define the local market. We would start to look at average income levels and applying income multipliers. So it is mainly price and income.

EM: How do you measure housing affordability?

INT: Mainly by the price of housing and income. The difficulty with applying anything more sophisticated than that is obviously how you update that. If you are applying it to purchase models then how the lending institutions accept them or not as part of section 106 agreements. The more restrictions and more difficulties you might put in place associated with affordability the more nervous lending institutions tend to get. We have found over time, and certainly going into this recession, we have had to relax some affordable housing provisions. It is still affordable housing, but in terms of how we deal with them through the section106 and legal agreements we have had to alter them slightly just as lenders have got more and more nervous.

EM: What criteria do you use to evaluate housing affordability; is it just price or do you have consideration for other factors?

INT: We have a look at underlying trends and variations in house price trends by the submarket within Cheshire West and Chester. We have an instance at the moment in Tarporley where we have a recent application that has asked for permission for 10 affordable units, the applicant wants to provide low cost for sale on there for three bed semis and terraced type properties. Now the open market values for those types of properties in that location would be circa £200,000 plus. So a low cost discount for sale property would have to be significantly discounted in order for it to be affordable. So it is a bit of horses for causes and that is the difficulty with trying to entrench anything in policy. It has to reflect local variances and circumstances. The difficulty we have, as a local authority, with applying anything more sophisticated mechanisms of defining affordability is that we have very limited access to income information. We do ask it as part of SHMA but the government itself has decided to shy away from it in the last census and in this census. It doesn't help us a great deal. The income question is the thorniest issue. The only other reliable source which costs a packet is CACI paycheque data and that isn't tremendously sophisticated in terms of localised income information. So you'll end up with kind of general averages. So getting hold of that level of information is quite tricky. So unless you have got a reliable and robust source, trying to introduce it through the policy process and negotiation for affordable housing can be quite difficult.

EM: Are there any other criteria that you think affect housing affordability?

INT: In the past there used to be slightly more sophisticated models that looked at the total cost of housing, so not only how much you are paying in way of rent or mortgage but also the running costs of the house.

EM: Like a residual measure?

INT: I think if it was 30% of net income, anymore than that it was determined not to be affordable. Models like that were kicking round for quite a while. Again, because of the lack of info around on meaningful income it is very difficult to apply those. Unless you box that issue off and are very confident about that information and the sources of that information it is very difficult to get a kind of meaningful steer on anything more sophisticated really. It would be nice to have.

EM: Do you measure the affordability of different neighbourhoods?

INT: Yes I mean the strategic housing market assessment, we determined that it should report at the very least at administrative ward level. That did ask the income question and that does report at that level. There are variances between wards, some have high vales and often high incomes and other wards at the other end and extreme with low values and similarly low incomes. Again, the practicalities of applying a ward by ward negotiation process for affordable housing on individual applications can be quite difficult. We have 24 wards at the moment, when the boundary commission does what the boundary commission is about to do we will go up to double that amount of wards. In talking to the private sector they would be quite keen for us not to have blanket approaches to affordable housing and definitions of affordability and whilst I can certainly understand the rational of that and mite subscribe to it on a certain level it is very to get down to individual settlement areas on that basis, very difficult.

EM: Do you think that low cost housing that is located in rundown neighbourhoods should be considered as 'affordable housing'?

INT: Cheshire West and Chester doesn't really have, well it doesn't have any instances of obsolescence. We were never a pathfinder area and weren't going through slum clearance or anything like that. Even house prices in wards such as Blacon which is predominantly former local authority, dominated stock profile is about 50/50 split between RSL accommodation and private accommodation. Even the house values there are relatively high. So whilst they may be cheaper or arguably more affordable than other areas they are still relatively high. So we'll take an approach of, we will take affordable housing wherever we can get it on the back of development. Our headline need for affordable housing is over 1300 units per annum. There will be hotspots areas within the Borough, but that 1300 is spread across the Borough so anything that comes forward, we are desperate for affordable housing.

EM: So doesn't it matter about the location of the affordable housing here?

INT: Not particularly. We do talk to developers from time to time who may have schemes in some areas where there is a higher preponderance of social stock and there is allowance within the supplementary planning documents on affordable housing. Where that may be the case we could seek a slightly different approach, instead of seeking onsite delivery we might seek offsite delivery, whether that's progressing another site or whether that's taking a commuted sum. I have to say they are very few and far between. Most developments in the private sector tend to be in the higher value areas anyway, in which cases there is always demand for affordable housing. The difficulty we with taking offsite contributions, weather its through development of an alternative site or commuted sum is access to land. You need the land to build the houses. We are now I suppose in a luxurious position really, unlike maybe some of the inner city areas. There is so much, is having so much need luxurious? It probably isn't, but if you understand what I am saying, we could build and build and build and there would still be a housing need in this particular locality. It's hugely different to the likes of Merseyside. And I think that is reflected in our approach. I mean if the market is going to come back at any time for what was the North West region, logic dictates that it will come back here first.

EM: Do you measure access to amenities and facilities for neighbourhoods?

INT: There has been some work done. It has tended to focus more on the rural areas. There is a rural regeneration strategy which has just been commissioned. This council has taken the decision to look at its Borough and define it by four regeneration areas; Chester, Chester urban area, Ellesmere Port urban area, Weaver Valley, which is Northwich and Winsford and then the rural area which is the bit between all those other three really. The rural area has a rural regeneration manager, who is just consulting to head up a rural regeneration strategy. So they will be looking in quite some detail at things like access to services. They are also looking at access to the internet in rural communities and broadband and lots of other bits and pieces and I think it's to do with social disadvantage. We have about 65% of our land area I think is in the rural area and there is something like about 35-40% of the population in the rural area. Some of it is quite rural, some of it isn't. Some of it is surrounded by Chester. You travel to places like Antrobus and Malpas and they are more rural in that kind of context and there are some issues about isolation and separation. So there has been some work done as well about mapping access to doctors surgeries, post offices and other bits and pieces.

EM: Do you look at access and housing at the same time to determine if a location is suitable for development of affordable housing?

INT: Yes and certainly any development management colleagues and the guys dealing with planning implications will do that as a matter of course. I mean under the auspice of sustainability, whatever that means, they will consider access. So whether that is a rather clumsy mechanism to say it is too far away from a particular service or whether it is another test. They will generally look at sustainability it's called, but access to services as a determinant as to whether housing should be located there or not. They don't distinguish between market and affordable housing in terms of access. If it is not accessible, it is not accessible it doesn't matter whether it's market or affordable. So they will run tests, I think the old structure plan used to run tests of how many meters away from a bus stop and general kinds of tasks along those lines.

EM: Thank you. That is the end of my questions.

Appendix 6

Telephone interview transcript

Interview transcript

Interviewee (INT): Strategy and Commissioning Group Manager at Knowsley Council

Date: 14th October 2010

EM: Do you have an affordable housing policy in place?

INT: The Council's current development plan consists of saved Unitary Development Plan [UDP] policies, which explain our policy and strategy for the physical development of the Borough. Over the next few years, the UDP will be progressively replaced by a portfolio of documents which make up the Local Development Framework [LDF]. Adoption of the Knowsley UDP pre-dates the issuing of PPS3 [planning policy statement 3] which in November 2006 brought forward much clearer powers and obligations for the provision of affordable house through the planning system. It also pre-dates the housing needs surveys and Strategic Housing Market Assessment (completed in 2007, 2009 and 2010) which provided evidence of the current need for affordable housing in Knowsley. The UDP policies therefore do not reflect the findings of this more recent evidence and do not make adequate policy provision to fully reflect the current need for affordable housing in the Borough.

EM: Do you have any type of strategies in place with regard to affordable housing?

INT: We do have a raft of non-planning-policies that have acknowledgement for affordable housing e.g. Full Housing strategy, Interim Housing Strategy, Private Sector Housing Strategy and Empty Properties Strategy.

EM: What sort of affordable housing policy do you intend to put in place?

INT: The central part of the emerging LDF is the Core Strategy, which sets out the vision, key objectives and general thrust of the other documents within the LDF. In relation to the provision and delivery of affordable housing, Issue TH5: Affordable Housing in the councils issues and options paper, discusses the current evidence base and identified affordable housing need and how the Core Strategy should seek to deliver this within Knowsley. The consultation paper presented two potential options in delivering affordable housing; 1. Set an overall minimum affordable housing target to be applied on all developments (subject to a minimum site threshold), and: 2. As number.1, but with varied targets between each township to meet identified local need. Knowsley is still exploring these two options. Planning Policy Statement 3 Housing outlines the key role that the planning system has in the delivery of affordable housing. Therefore, Knowsley's LDF and its constituent Core Strategy will play a key role in providing affordable housing. This will require working closely with regional bodies to develop and reflect regional strategies, and with delivery partners, including Registered Social Landlords and private developers, to ensure quality, value for money and efficient delivery.

EM: Will the policy be developed from scratch or will it be inspired from elsewhere?

INT: Best practice will be researched from other local authorities who have adopted an affordable housing policy. Close links have been forged with sub regional partners and advice and guidance will be sort by government offices and regional bodies to make sure the policy will be viable and robust.

EM: How do you define 'affordable housing'?

INT: Affordable housing includes social rented and intermediate housing, provided to specified eligible households whose needs are not met by the market. Affordable housing should meet the needs of eligible households including availability at a cost low enough for them to afford, determined with regard to local incomes and local house prices. It should include provision for the home to remain at an affordable price for future eligible households or, if these restrictions are lifted, for the subsidy to be recycled for alternative affordable provision.

EM: How do you define 'housing affordability'?

INT: Whether house prices be it for ownership or rental are affordable and sustainable in relation to incomes.

EM: Are these definitions specific to your council or are they adopted from other policies?

INT: Knowsley uses government defined definitions from PPS3.

EM: Do you evaluate housing affordability, if so, what criteria do you use?

INT: We currently monitor affordability by House Price to earning ratio via a Housing Intelligence system called Hometrack. This approach to measuring affordability allows us to give a general indication of whether house prices are affordable in relation to incomes. This indicator is often termed the house price to income ratio, and the government's preferred version is the ratio of the lower quartile house price to annual lower quartile earnings. This simple indicator can be used at national, regional, sub-regional and local spatial scales and is particularly useful in making comparisons over time or between areas. We will however also be using our recent Strategic Housing Market Assessment findings which analyses affordability based on two indicators. For measuring the affordability of home ownership, where a household can be considered able to afford to buy a home if it costs 3.5 times the annual gross household income for a single earner household or 2.9 times the gross household income for dual-income households; and measuring the affordability of private renting, a household can be considered able to afford market renting where the rent payable is up to 25 per cent of their gross household income.

EM: Are there any other criteria that you think affect the affordability of housing?

INT: There are obviously other important factors to consider. In particular I think things such as decent homes quality and the stock age, sustainable design, the location of housing to industry and employment, and good communication links with the ability to access good public transport services are important.

EM: In your opinion, what criteria should an ideal affordability measure take into consideration?

INT: The ability to maintain a property is key. Simply being able to afford to secure a mortgage does not mean that a property can be sustained and maintained going forward. In this time of recession and decline, large swathes of the population are unable to maintain their properties up to the decent homes standard resulting in detrimental health conditions, possible repossession, child poverty and deprivation. Housing solutions that people choose that may not necessarily be affordable, i.e. renting or mortgage at high proportion of income, using housing benefit in private rented sector.

EM: Do you measure the affordability of different neighbourhoods?

INT: The Strategic Housing Market Assessment has assessed housing demand and affordability by location including Area Partnership level

EM: That concludes the interview. Thank you very much for your time and participation.

Appendix 14

Normalized matrix for WSM (all positive criteria)

	Criteria i	Z	Weight	Alternatives j									
				1	2	3	4	5	6	7	8	9	10
1	House prices in relation to incomes	+	0.063135	0.1214	0.0881	0.0929	0.0881	0.0833	0.1095	0.0905	0.1190	0.1143	0.0929
2	Rental costs in relation to incomes	+	0.063135	0.1304	0.0826	0.1087	0.0913	0.0913	0.1087	0.0870	0.0826	0.1130	0.1043
3	Interest rates and mortgage availability	+	0.058055	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
4	Availability of rented accommodation	+	0.058055	0.1847	0.0568	0.0455	0.1165	0.0426	0.0852	0.0142	0.1563	0.0994	0.1989
5	Availability of low cost homeownership products	+	0.051524	0.1111	0.0556	0.0556	0.0556	0.1111	0.1111	0.1667	0.1667	0.0556	0.1111
6	Availability of market value home ownership products	+	0.04717	0.0505	0.2414	0.1983	0.2328	0.2328	0.2155	0.1121	0.0948	0.1983	0.2586
7	Crime	+	0.044267	0.0394	0.1364	0.1172	0.1343	0.1182	0.1192	0.1101	0.0394	0.0859	0.1000
8	Access to employment	+	0.053701	0.1034	0.1034	0.1034	0.1034	0.1034	0.0690	0.1034	0.1034	0.1034	0.1034
9	Access to public transport	+	0.049347	0.0909	0.0682	0.0909	0.1136	0.0909	0.0909	0.0909	0.1136	0.1136	0.1364
10	Access to good quality schools	+	0.050073	0.1020	0.1224	0.1020	0.1020	0.0816	0.0816	0.0612	0.1020	0.1224	0.1224
11	Access to shopping facilities	+	0.045718	0.1429	0.0476	0.0952	0.0952	0.1429	0.0476	0.0952	0.1429	0.0476	0.1429
12	Access to health services	+	0.047896	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
13	Access to child care	+	0.046444	0.1017	0.1017	0.1017	0.0847	0.1017	0.1017	0.1017	0.1017	0.1017	0.1017
14	Access to leisure	+	0.039913	0.1333	0.0667	0.1111	0.1111	0.0889	0.1111	0.0889	0.1111	0.0889	0.0889
15	Access to open green public space	+	0.043541	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
16	Presence of environmental problems	+	0.044267	0.0874	0.1690	0.0682	0.1600	0.0979	0.1041	0.1168	0.1273	0.0054	0.0638
17	Quality of housing in area	+	0.055152	0.0917	0.0890	0.0875	0.1006	0.1092	0.1139	0.0982	0.0922	0.1128	0.1050
18	Energy efficiency of housing in area	+	0.05225	0.0993	0.0911	0.0944	0.0877	0.0944	0.1060	0.1043	0.1093	0.1010	0.1126
19	Waste management in area	+	0.04209	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
20	Deprivation in area	+	0.044267	0	0.1639	0.1636	0.1673	0.1728	0.1041	0.0250	0.0069	0.0628	0.1337
WSM			0.1015	0.1025	0.1006	0.1106	0.1065	0.1037	0.0928	0.1045	0.0976	0.1191	0.1015
Rank			7	6	8	2	3	5	10	4	9	1	7

Appendix 15

Normalized matrix for WPM (all positive criteria)

	Criteria i	Z	Weight	Alternatives j									
				1	2	3	4	5	6	7	8	9	10
1	House prices in relation to incomes	+	0.063135	0.1214	0.0881	0.0929	0.0881	0.0833	0.1095	0.0905	0.1190	0.1143	0.0929
2	Rental costs in relation to incomes	+	0.063135	0.1304	0.0826	0.1087	0.0913	0.0913	0.1087	0.0870	0.0826	0.1130	0.1043
3	Interest rates and mortgage availability	+	0.058055	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
4	Availability of rented accommodation	+	0.058055	0.1847	0.0568	0.0455	0.1165	0.0426	0.0852	0.0142	0.1563	0.0994	0.1989
5	Availability of low cost homeownership products	+	0.051524	0.1111	0.0556	0.0556	0.0556	0.1111	0.1111	0.1667	0.1667	0.0556	0.1111
6	Availability of market value home ownership products	+	0.04717	0.0505	0.1284	0.1055	0.1239	0.1239	0.1147	0.0596	0.0505	0.1055	0.1376
7	Crime	+	0.044267	0.0394	0.1364	0.1172	0.1343	0.1182	0.1192	0.1101	0.0394	0.0859	0.1000
8	Access to employment	+	0.053701	0.1034	0.2000	0.2000	0.2000	0.2000	0.1333	0.2000	0.2000	0.2000	0.2000
9	Access to public transport	+	0.049347	0.0909	0.0682	0.0909	0.1136	0.0909	0.0909	0.0909	0.1136	0.1136	0.1364
10	Access to good quality schools	+	0.050073	0.1020	0.1224	0.1020	0.1020	0.0816	0.0816	0.0612	0.1020	0.1224	0.1224
11	Access to shopping facilities	+	0.045718	0.1429	0.0476	0.0952	0.0952	0.1429	0.0476	0.0952	0.1429	0.0476	0.1429
12	Access to health services	+	0.047896	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
13	Access to child care	+	0.046444	0.1017	0.1017	0.1017	0.0847	0.1017	0.1017	0.1017	0.1017	0.1017	0.1017
14	Access to leisure	+	0.039913	0.1333	0.0667	0.1111	0.1111	0.0889	0.1111	0.0889	0.1111	0.0889	0.0889
15	Access to open green public space	+	0.043541	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
16	Presence of environmental problems	+	0.044267	0.0874	0.1690	0.0682	0.1600	0.0979	0.1041	0.1168	0.1273	0.0054	0.0638
17	Quality of housing in area	+	0.055152	0.0917	0.0890	0.0875	0.1006	0.1092	0.1139	0.0982	0.0922	0.1128	0.1050
18	Energy efficiency of housing in area	+	0.05225	0.0993	0.0911	0.0944	0.0877	0.0944	0.1060	0.1043	0.1093	0.1010	0.1126
19	Waste management in area	+	0.04209	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
20	Deprivation in area	+	0.044267	0.0002	0.1638	0.1635	0.1672	0.1725	0.1041	0.0251	0.0071	0.0629	0.1336

Appendix 16

Weighted normalized matrix for WPM (all positive criteria)

	Criteria *i*	Z	Alternatives *j*									
			1	2	3	4	5	6	7	8	9	10
1	House prices in relation to incomes	+	0.8754	0.8578	0.8607	0.8578	0.8548	0.8697	0.8593	0.8743	0.8720	0.8607
2	Rental costs in relation to incomes	+	0.8793	0.8543	0.8693	0.8597	0.8597	0.8693	0.8571	0.8543	0.8714	0.8670
3	Interest rates and mortgage availability	+	0.8749	0.8749	0.8749	0.8749	0.8749	0.8749	0.8749	0.8749	0.8749	0.8749
4	Availability of rented accommodation	+	0.9066	0.8466	0.8357	0.8827	0.8326	0.8668	0.7812	0.8978	0.8746	0.9105
5	Availability of low cost homeownership products	+	0.8930	0.8616	0.8616	0.8616	0.8930	0.8930	0.9118	0.9118	0.8616	0.8930
6	Availability of market value home ownership products	+	0.8686	0.9077	0.8993	0.9062	0.9062	0.9029	0.8755	0.8686	0.8993	0.9107
7	Crime	+	0.8666	0.9156	0.9095	0.9150	0.9098	0.9101	0.9069	0.8666	0.8970	0.9031
8	Access to employment	+	0.8853	0.9172	0.9172	0.9172	0.9172	0.8974	0.9172	0.9172	0.9172	0.9172
9	Access to public transport	+	0.8884	0.8759	0.8884	0.8982	0.8884	0.8884	0.8884	0.8982	0.8982	0.9064
10	Access to good quality schools	+	0.8920	0.9002	0.8920	0.8920	0.8821	0.8821	0.8695	0.8920	0.9002	0.9002
11	Access to shopping facilities	+	0.9149	0.8701	0.8981	0.8981	0.9149	0.8701	0.8981	0.9149	0.8701	0.9149
12	Access to health services	+	0.8956	0.8956	0.8956	0.8956	0.8956	0.8956	0.8956	0.8956	0.8956	0.8956
13	Access to child care	+	0.8993	0.8993	0.8993	0.8917	0.8993	0.8993	0.8993	0.8993	0.8993	0.8993
14	Access to leisure	+	0.9227	0.8976	0.9160	0.9160	0.9079	0.9160	0.9079	0.9160	0.9079	0.9079
15	Access to open green public space	+	0.9046	0.9046	0.9046	0.9046	0.9046	0.9046	0.9046	0.9046	0.9046	0.9046
16	Presence of environmental problems	+	0.8977	0.9243	0.8879	0.9221	0.9023	0.9047	0.9093	0.9128	0.7939	0.8853
17	Quality of housing in area	+	0.8765	0.8751	0.8743	0.8810	0.8850	0.8871	0.8798	0.8768	0.8866	0.8831
18	Energy efficiency of housing in area	+	0.8863	0.8823	0.8840	0.8806	0.8840	0.8893	0.8886	0.8908	0.8871	0.8922
19	Waste management in area	+	0.9076	0.9076	0.9076	0.9076	0.9076	0.9076	0.9076	0.9076	0.9076	0.9076
20	Deprivation in area	+	0.6822	0.9230	0.9230	0.9239	0.9252	0.9047	0.8495	0.8032	0.8848	0.9148
	WPM		0.0765	0.0956	0.0965	0.1066	0.1016	0.1007	0.0841	0.0939	0.0865	0.1145
	Rank		10	6	5	2	3	4	9	7	8	1

Appendix 17

Normalized matrix for Revised AHP approach 1 (all positive criteria)

Criteria i		Z	Weight	Alternatives j									
				1	2	3	4	5	6	7	8	9	10
1	House prices in relation to incomes	+	0.063135	1	0.7255	0.7647	0.7255	0.6863	0.9020	0.7451	0.9804	0.9412	0.7647
2	Rental costs in relation to incomes	+	0.063135	1	0.6333	0.8333	0.7	0.7	0.8333	0.6667	0.6333	0.8667	0.8
3	Interest rates and mortgage availability	+	0.058055	1	1	1	1	1	1	1	1	1	1
4	Availability of rented accommodation	+	0.058055	0.9286	0.2857	0.2286	0.5857	0.2143	0.4286	0.0714	0.7857	0.5	1
5	Availability of low cost homeownership products	+	0.051524	0.6667	0.3333	0.3333	0.3333	0.6667	0.6667	1	1	0.3333	0.6667
6	Availability of market value home ownership products	+	0.04717	0.1951	0.9333	0.7667	0.9000	0.9	0.8333	0.4333	0.3667	0.7667	1
7	Crime	+	0.044267	0.2889	1	0.8593	0.9852	0.8667	0.8741	0.8074	0.2889	0.6296	0.7333
8	Access to employment	+	0.053701	1	1	1	1	1	0.6667	1	1	1	1
9	Access to public transport	+	0.049347	0.6667	0.5	0.6667	0.8333	0.6667	0.6667	0.6667	0.8333	0.8333	1
10	Access to good quality schools	+	0.050073	0.8333	1	0.8333	0.8333	0.6667	0.6667	0.5	0.8333	1	1
11	Access to shopping facilities	+	0.045718	1	0.3333	0.6667	0.6667	1	0.3333	0.6667	1	0.3333	1
12	Access to health services	+	0.047896	1	1	1	1	1	1	1	1	1	1
13	Access to child care	+	0.046444	1	1	1	1	1	1	1	1	1	1
14	Access to leisure	+	0.039913	1	0.5	0.8333	0.8333	0.6667	0.8333	0.6667	0.8333	0.6667	0.6667
15	Access to open green public space	+	0.043541	1	1	1	1	1	1	1	1	1	1
16	Presence of environmental problems	+	0.044267	0.5172	1	0.4034	0.9464	0.5794	0.6159	0.6910	0.7532	0.0322	0.3777
17	Quality of housing in area	+	0.055152	0.8053	0.7820	0.7686	0.8832	0.9588	1	0.8621	0.8098	0.9911	0.9221
18	Energy efficiency of housing in area	+	0.05225	0.8824	0.8088	0.8382	0.7794	0.8382	0.9412	0.9265	0.9706	0.8971	1
19	Waste management in area	+	0.04209	1	1	1	1	1	1	1	1	1	1
20	Deprivation in area	+	0.044267	0	0.9488	0.9467	0.9682	1	0.6025	0.1445	0.0400	0.3637	0.7736
Revised AHP (approach 1)				0.8019	0.7812	0.7816	0.8320	0.8121	0.7937	0.7407	0.8131	0.7682	0.8884
Rank				5	8	7	2	4	6	10	3	9	1

Appendix 18

Normalized matrix for Revised AHP approach 2 (negative criteria incorporated as negative weights)

Criteria *i*		Z	Weight	Alternatives *j*									
				1	2	3	4	5	6	7	8	9	10
1	House prices in relation to incomes	-	-0.17262	0.6863	0.9608	0.9216	0.9608	1	0.7843	0.9412	0.7059	0.7451	0.9216
2	Rental costs in relation to incomes	-	-0.17262	0.6333	1	0.8000	0.9333	0.9333	0.8	0.9667	1	0.7667	0.8333
3	Interest rates and mortgage availability	-	-0.15873	1	1	1	1	1	1	1	1	1	1
4	Availability of rented accommodation	+	0.15873	0.9286	0.2857	0.2286	0.5857	0.2143	0.4286	0.0714	0.7857	0.5	1
5	Availability of low cost homeownership products	+	0.14087	0.6667	0.3333	0.3333	0.3333	0.6667	0.6667	1	1	0.3333	0.6667
6	Availability of market value home ownership products	+	0.12897	0.3667	0.9333	0.7667	0.9	0.9	0.8333	0.4333	0.3667	0.7667	1
7	Crime	-	-0.12103	1	0.2889	0.4296	0.3037	0.4222	0.4148	0.4815	1	0.6593	0.5556
8	Access to employment	+	0.14683	1	1	1	1	1	0.6667	1	1	1	1
9	Access to public transport	+	0.13492	0.6667	0.5	0.6667	0.8333	0.6667	0.6667	0.6667	0.8333	0.8333	1
10	Access to good quality schools	+	0.13691	0.8333	1	0.8333	0.8333	0.6667	0.6667	0.5	0.8333	1	1
11	Access to shopping facilities	+	0.12500	1	0.3333	0.6667	0.6667	1.0000	0.3333	0.6667	1.0000	0.3333	1.0000
12	Access to health services	+	0.13095	1	1	1	1	1	1	1	1	1	1
13	Access to child care	+	0.12698	1	1	1	0.8333	1	1	1	1	1	1
14	Access to leisure	+	0.10913	1	0.5000	0.8333	0.8333	0.6667	0.8333	0.6667	0.8333	0.6667	0.6667
15	Access to open green public space	+	0.11905	1	1	1	1	1	1	1	1	1	1
16	Presence of environmental problems	-	-0.12103	0.5150	0.0322	0.6288	0.0858	0.4528	0.4163	0.3412	0.2790	1	0.6545
17	Quality of housing in area	+	0.15079	0.8053	0.7820	0.7686	0.8832	0.9588	1	0.8621	0.8098	0.9911	0.9221
18	Energy efficiency of housing in area	+	0.14286	0.8824	0.8088	0.8382	0.7794	0.8382	0.9412	0.9265	0.9706	0.8971	1
19	Waste management in area	+	0.11508	1	1	1	1	1	1	1	1	1	1
20	Deprivation in area	-	-0.12103	1	0.0512	0.0533	0.0318	0	0.3975	0.8555	0.9600	0.6363	0.2264
Revised AHP (approach 2)				0.9222	0.8434	0.8445	0.9824	0.9278	0.8775	0.7326	0.9308	0.8079	1.1365
Rank				5	8	7	2	4	6	10	3	9	1

Appendix 19

Weighted normalized matrix for COPRAS and Modified COPRAS and results

	Criteria i	Z	Alternatives j									
			1	2	3	4	5	6	7	8	9	10
1	House prices in relation to incomes	-	0.0050	0.0070	0.0067	0.0070	0.0073	0.0057	0.0069	0.0052	0.0055	0.0067
2	Rental costs in relation to incomes	-	0.0046	0.0073	0.0058	0.0068	0.0068	0.0058	0.0070	0.0073	0.0056	0.0061
3	Interest rates and mortgage availability	-	0.0058	0.0058	0.0058	0.0058	0.0058	0.0058	0.0058	0.0058	0.0058	0.0058
4	Availability of rented accommodation	+	0.0107	0.0033	0.0026	0.0068	0.0025	0.0049	0.0008	0.0091	0.0058	0.0115
5	Availability of low cost homeownership products	+	0.0057	0.0029	0.0029	0.0029	0.0057	0.0057	0.0086	0.0086	0.0029	0.0057
6	Availability of market value home ownership products	+	0.0024	0.0061	0.0050	0.0058	0.0058	0.0054	0.0028	0.0024	0.0050	0.0065
7	Crime	-	0.0080	0.0023	0.0034	0.0024	0.0034	0.0033	0.0038	0.0080	0.0053	0.0044
8	Access to employment	+	0.0056	0.0056	0.0056	0.0056	0.0056	0.0037	0.0056	0.0056	0.0056	0.0056
9	Access to public transport	+	0.0045	0.0034	0.0045	0.0056	0.0045	0.0045	0.0045	0.0056	0.0056	0.0067
10	Access to good quality schools	+	0.0051	0.0061	0.0051	0.0051	0.0041	0.0041	0.0031	0.0051	0.0061	0.0061
11	Access to shopping facilities	+	0.0065	0.0022	0.0044	0.0044	0.0065	0.0022	0.0044	0.0065	0.0022	0.0065
12	Access to health services	+	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048
13	Access to child care	+	0.0047	0.0047	0.0047	0.0039	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047
14	Access to leisure	+	0.0053	0.0027	0.0044	0.0044	0.0035	0.0044	0.0035	0.0044	0.0035	0.0035
15	Access to open green public space	+	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044
16	Presence of environmental problems	-	0.0052	0.0003	0.0063	0.0009	0.0045	0.0042	0.0034	0.0028	0.0100	0.0066
17	Quality of housing in area	+	0.0051	0.0049	0.0048	0.0055	0.0060	0.0063	0.0054	0.0051	0.0062	0.0058
18	Energy efficiency of housing in area	+	0.0052	0.0048	0.0049	0.0046	0.0049	0.0055	0.0054	0.0057	0.0053	0.0059
19	Waste management in area	+	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042
20	Deprivation in area	-	0.0105	0.0005	0.0006	0.0003	0	0.0042	0.0090	0.0101	0.0067	0.0024

COPRAS Results										
$Sj+$	0.0742	0.0599	0.0623	0.0679	0.0673	0.0649	0.0622	0.0761	0.0662	0.0820
$Sj-$	0.0391	0.0233	0.0287	0.0233	0.0278	0.0290	0.0360	0.0391	0.0388	0.0320
Qj	0.0990	0.1015	0.0961	0.1096	0.1021	0.0982	0.0891	0.1009	0.0912	0.1123
Nj %	88.1148	90.3738	85.5369	97.6349	90.9224	87.4886	79.3509	89.8782	81.1890	100
Rank	6	4	8	2	3	7	10	5	9	1
Modified COPRAS Results										
$Sj+$	0.0742	0.0599	0.0623	0.0679	0.0673	0.0649	0.0622	0.0761	0.0662	0.0820
$Sj-$	0.0391	0.0233	0.0287	0.0233	0.0278	0.0290	0.0360	0.0391	0.0388	0.0320
Modified Qj	0.0351	0.0366	0.0336	0.0447	0.0394	0.0358	0.0262	0.0370	0.0274	0.05
Modified Nj %	70.1	73.1	67.1	89.4	78.9	71.6	52.4	74.1	54.8	100.0
Rank	7	5	8	2	3	6	10	4	9	1

Appendix 20

Weighted normalised matrix for TOPSIS

Criteria *i*		Alternatives *j*									
		1	2	3	4	5	6	7	8	9	10
1	House prices in relation to incomes	-0.01373	-0.01922	-0.01844	-0.01922	-0.02001	-0.01569	-0.01883	-0.01412	-0.01491	-0.01844
2	Rental costs in relation to incomes	-0.01261	-0.01992	-0.01593	-0.01859	-0.01859	-0.01593	-0.01925	-0.01992	-0.01527	-0.01660
3	Interest rates and mortgage availability	-0.01587	-0.01587	-0.01587	-0.01587	-0.01587	-0.01587	-0.01587	-0.01587	-0.01587	-0.01587
4	Availability of rented accommodation	0.02931	0.00902	0.00721	0.01849	0.00676	0.01353	0.00225	0.02480	0.01578	0.03157
5	Availability of low cost homeownership products	0.01565	0.00783	0.00783	0.00783	0.01565	0.01565	0.02348	0.02348	0.00783	0.01565
6	Availability of market value home ownership products	0.00651	0.01656	0.01361	0.01597	0.01597	0.01479	0.00769	0.00651	0.01361	0.01775
7	Crime	-0.02179	-0.00629	-0.00936	-0.00662	-0.00920	-0.00904	-0.01049	-0.02179	-0.01436	-0.01210
8	Access to employment	0.01519	0.01519	0.01519	0.01519	0.01519	0.01013	0.01519	0.01519	0.01519	0.01519
9	Access to public transport	0.01227	0.00920	0.01227	0.01533	0.01227	0.01227	0.01227	0.01533	0.01533	0.01840
10	Access to good quality schools	0.01397	0.01676	0.01397	0.01397	0.01118	0.01118	0.00838	0.01397	0.01676	0.01676
11	Access to shopping facilities	0.01786	0.00595	0.01190	0.01190	0.01786	0.00595	0.01190	0.01786	0.00595	0.01786
12	Access to health services	0.01310	0.01310	0.01310	0.01310	0.01310	0.01310	0.01310	0.01310	0.01310	0.01310
13	Access to child care	0.01291	0.01291	0.01291	0.01076	0.01291	0.01291	0.01291	0.01291	0.01291	0.01291
14	Access to leisure	0.01455	0.00728	0.01213	0.01213	0.00970	0.01213	0.00970	0.01213	0.00970	0.00970
15	Access to open green public space	0.01190	0.01190	0.01190	0.01190	0.01190	0.01190	0.01190	0.01190	0.01190	0.01190
16	Presence of environmental problems	-0.01415	-0.00088	-0.01727	-0.00236	-0.01244	-0.01144	-0.00937	-0.00766	-0.02747	-0.01798
17	Quality of housing in area	0.01383	0.01343	0.01320	0.01516	0.01646	0.01717	0.01480	0.01390	0.01702	0.01583
18	Energy efficiency of housing in area	0.01419	0.01301	0.01348	0.01254	0.01348	0.01514	0.01490	0.01561	0.01443	0.01608
19	Waste management in area	0.01151	0.01151	0.01151	0.01151	0.01151	0.01151	0.01151	0.01151	0.01151	0.01151
20	Deprivation in area	-0.02873	-0.00147	-0.00153	-0.00091	0	-0.01142	-0.02458	-0.02759	-0.01828	-0.00651

Appendix 21

Distance from ideal solution (TOPSIS)

	Criteria *i*	Alternatives *j*									
		1	2	3	4	5	6	7	8	9	10
1	House prices in relation to incomes	0	3.0166 7E-05	2.21633 E-05	3.0166 7E-05	3.9401 3E-05	3.84779 E-06	2.6011 E-05	1.5391 2E-07	1.3852 E-06	2.2163 3E-05
2	Rental costs in relation to incomes	0	5.3335 3E-05	1.10197 E-05	3.5703 8E-05	3.5703 8E-05	1.10197 E-05	4.4078 8E-05	5.3335 3E-05	7.0526 1E-06	1.5868 4E-05
3	Interest rates and mortgage availability	0	0	0	0	0	0	0	0	0	0
4	Availability of rented accommodation	5.0835 8E-06	0.0005 08358	0.00059 2949	0.0001 71012	0.0006 15114	0.00032 5349	0.0008 59126	4.5752 3E-05	0.0002 49096	0
5	Availability of low cost homeownership products	6.1250 6E-05	0.0002 45002	0.00024 5002	0.0002 45002	6.1250 6E-05	6.12506 E-05	0	0	0.0002 45002	6.1250 6E-05
6	Availability of market value home ownership products	0.0001 26346	1.3999 6E-06	1.71495 E-05	3.1499 E-06	3.1499 E-06	8.74973 E-06	0.0001 01147	0.0001 26346	1.7149 5E-05	0
7	Crime	0.0002 40003	0	9.40115 E-06	1.0416 8E-07	8.4376 E-06	7.52613 E-06	1.7604 4E-05	0.0002 40003	6.5104 9E-05	3.3750 4E-05
8	Access to employment	0	0	0	0	0	2.56333 E-05	0	0	0	0
9	Access to public transport	3.7610 8E-05	8.4624 2E-05	3.76108 E-05	9.4026 9E-06	3.7610 8E-05	3.76108 E-05	3.7610 8E-05	9.4026 9E-06	9.4026 9E-06	0
10	Access to good quality schools	7.8064 1E-06	0	7.80641 E-06	7.8064 1E-06	3.1225 6E-05	3.12256 E-05	7.0257 7E-05	7.8064 1E-06	0	0
11	Access to shopping facilities	0	0.0001 4172	3.54301 E-05	3.5430 1E-05	0	0.00014 172	3.5430 1E-05	0	0.0001 4172	0
12	Access to health services	0	0	0	0	0	0	0	0	0	0
13	Access to child care	0	0	0	4.6322 4E-06	0	0	0	0	0	0
14	Access to leisure	0	5.2927 6E-05	5.88085 E-06	5.8808 5E-06	2.3523 4E-05	5.88085 E-06	2.3523 4E-05	5.8808 5E-06	2.3523 4E-05	2.3523 4E-05
15	Access to open green public space	0	0	0	0	0	0	0	0	0	0
16	Presence of environmental problems	0.0001 75948	0	0.00026 8601	2.1721 9E-06	0.0001 33515	0.00011 1359	7.2068 1E-05	4.5963 6E-05	0.0007 06922	0.0002 9229

17	Quality of housing in area	1.1169 2E-05	1.4010 6E-05	1.57787 E-05	4.0209 E-06	4.9928 4E-07	0	5.6077 4E-06	1.0664 4E-05	2.3341 3E-08	1.7870 7E-06
18	Energy efficiency of housing in area	3.5802 6E-06	9.4541 3E-06	6.76893 E-06	1.2586 9E-05	6.7689 3E-06	8.95065 E-07	1.3985 4E-06	2.2376 6E-07	2.7411 4E-06	0
19	Waste management in area	0	0	0	0	0	0	0	0	0	0
20	Deprivation in area	0.0008 25659	2.1669 1E-06	2.34373 E-06	8.3296 1E-07	0	0.00013 0486	0.0006 0433	0.0007 60993	0.0003 3426	4.2333 7E-05

Appendix 22

Distance from anti/negative ideal solution (TOPSIS) and overall results

	Criteria i	Alternatives j									
		1	2	3	4	5	6	7	8	9	10
1	House prices in relation to incomes	3.94013E-05	6.15646E-07	2.46258E-06	6.15646E-07	0	1.86233E-05	1.3852E-06	3.46301E-05	2.6011E-05	2.46258E-06
2	Rental costs in relation to incomes	5.33353E-05	0	1.58684E-05	1.76315E-06	1.76315E-06	1.58684E-05	4.40788E-07	0	2.15986E-05	1.10197E-05
3	Interest rates and mortgage availability	0	0	0	0	0	0	0	0	0	0
4	Availability of rented accommodation	0.000732036	4.57523E-05	2.46045E-05	0.000263533	2.03343E-05	0.00012709	0	0.000508358	0.000183009	0.000859126
5	Availability of low cost homeownership products	6.12506E-05	0	0	0	6.12506E-05	6.12506E-05	0.000245002	0.000245002	0	6.12506E-05
6	Availability of market value home ownership products	0	0.000101147	5.03985E-05	8.95973E-05	8.95973E-05	6.85979E-05	1.39996E-06	0	5.03985E-05	0.000126346
7	Crime	0	0.000240003	0.000154403	0.000230107	0.000158439	0.000162528	0.000127606	0	5.51048E-05	9.37511E-05
8	Access to employment	2.56333E-05	2.56333E-05	2.56333E-05	2.56333E-05	2.56333E-05	0	2.56333E-05	2.56333E-05	2.56333E-05	2.56333E-05
9	Access to public transport	9.40269E-06	0	9.40269E-06	3.76108E-05	9.40269E-06	9.40269E-06	9.40269E-06	3.76108E-05	3.76108E-05	8.46242E-05
10	Access to good quality schools	3.12256E-05	7.02577E-05	3.12256E-05	3.12256E-05	7.80641E-06	7.80641E-06	0	3.12256E-05	7.02577E-05	7.02577E-05
11	Access to shopping facilities	0.00014172	0	3.54301E-05	3.54301E-05	0.00014172	0	3.54301E-05	0.00014172	0	0.00014172
12	Access to health services	0	0	0	0	0	0	0	0	0	0
13	Access to child care	4.63224E-06	4.63224E-06	4.63224E-06	0	4.63224E-06	4.63224E-06	4.63224E-06	4.63224E-06	4.63224E-06	4.63224E-06
14	Access to leisure	5.29276E-05	0	2.35234E-05	2.35234E-05	5.88085E-06	2.35234E-05	5.88085E-06	2.35234E-05	5.88085E-06	5.88085E-06
15	Access to open green public space	0	0	0	0	0	0	0	0	0	0
16	Presence of environmental problems	0.000177515	0.000706922	0.000104018	0.000630721	0.000225995	0.000257132	0.000327563	0.000392371	0	9.00887E-05

17	Quality of housing in area	3.9716 6E-07	5.2517 8E-08	0	3.8691 8E-06	1.0664 4E-05	1.5778 7E-05	2.5733 7E-06	4.9928 4E-07	1.4588 3E-05	6.9454 8E-06
18	Energy efficiency of housing in area	2.7411 4E-06	2.2376 6E-07	8.9506 5E-07	0	8.9506 5E-07	6.7689 3E-06	5.5941 6E-06	9.4541 3E-06	3.5802 6E-06	1.2586 9E-05
19	Waste management in area	0	0	0	0	0	0	0	0	0	0
20	Deprivation in area	0	0.0007 4323	0.0007 40023	0.0007 74043	0.0008 25659	0.0002 99679	1.7232 2E-05	1.3183 5E-06	0.0001 09234	0.0004 94078

TOPSIS results

	Alternatives *j*									
	1	2	3	4	5	6	7	8	9	10
S*i**	0.00149	0.00114	0.00128	0.00057	0.00100	0.00090	0.00190	0.00131	0.00180	0.00049
S*i*-	0.00133	0.00194	0.00122	0.00215	0.00159	0.00108	0.00081	0.00146	0.00061	0.00209
C*i**	0.47130	0.62904	0.48892	0.79087	0.61475	0.54445	0.29903	0.52705	0.25199	0.80918
Rank	8	3	7	2	4	5	9	6	10	1